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Final

Work Plan
and
Sampling and Analysis Plan
Remedial Investigation and Feasibility Study
Pesticide Disposal Site (Site 5) and
Preliminary Assessment/Site Investigation
Building W-316 PCB Waste Work Area (Site 21)

Norfolk Naval Base
Norfolk, Virginia

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Contract No. N62470-95-D-6007
CTO-0003

August 15, 1996

Prepared by

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Section 1

Introduction

This work plan describes the work necessary to conduct a remedial investigation and feasibility study (RI/FS) of the Pesticide Disposal Site (Site 5) and a preliminary assessment and site investigation (PA/SI) of the Building 316 PCB Waste Work Area (Site 21) at Naval Base, Norfolk, Virginia. This work plan is based on a scope of work provided by Naval Facilities Engineering Command (NFEC) LANTDIV on 26 January 1996 as part of Navy contract N62470-95-D-6007, Navy Comprehensive Long-Term Environmental Action Navy (C.L.E.A.N.), District III, Contract Task Order - 003, and the technical approach as documented in CH2M HILL's implementation plan (IP) submitted to LANTDIV on March 4, 1996.

The general background and physical setting of Naval Base, Norfolk, are described in Section 2 of this work plan. Section 3 presents initial evaluations of Site 5 and Site 21, which are based on the results of previous investigations and an initial site visit and on the rationale that supports the sampling tasks. Section 4 describes the technical approach to RI/FS and PA/SI work plan tasks, and Section 5 presents general information on project management and staff organization. Section 6 documents the anticipated subcontract services required for completing tasks documented in this work plan, and Section 7 presents the schedule for completing the tasks. A list of project-related acronyms is presented in Table 1-1.

Table 1-1 Naval Base, Norfolk List of Acronyms	
AFFF	Aqueous Fire Fighting Foam
AFSC	Armed Forces Staff College
AOC	Area Of Concern
BN	Building Identifier
BOA	Basic Ordering Agreements
BTEX	Benzene, Toluene, Ethybenzene, And Xylene
CA	Building Identifier
CBU	Construction Battalion Unit
CD	Building Identifier
CEP	Building Identifier
CERCLA	Comprehensive Environmental Response, Compensation, And Liability Act
CONEX	A Type Of Metal Container Measuring 16 Feet By 8 Feet By 8 Feet
DDD	p,p′-dichlorodiphenyldichloroethane
DDT	p,p′-dichlorodiphenyltrichloroethane
DFM	Distillate Fuel Marine
DRMO	Defense Reutilization And Marketing Office
DS	Building Identifier
EP	Extraction Procedure
FMFLANT	Camp Elmore
FSP	Field Sampling Plan
FTC	Fleet Training Center
HRSD STP	Hampton Roads Sanitation District Sewage Treatment Plant
HSP	Health and Safety Plan
HSWA	Hazardous And Solid Waste Amendments
IAS	Initial Assessment Study
IDWMP	Investigation Derived Waste-Management Plan
IRP	Installation Restoration Program
IWTP	Industrial Wastewater Treatment Plant
KBB	Building Identifier

Table 1-1 Naval Base, Norfolk List of Acronyms	
KCC	Building Identifier
LAFB	Building Identifier
LAG	Building Identifier
LF	Building Identifier
LP	Building Identifier
MCA	Building Identifier
MCE	Building Identifier
MEK	methyl ethyl ketone
MIBK	methyl isobutyl ketone
MTO	Motor Transport Operations
NADEP	Naval Aviation Depot
NARF	Naval Air Rework Facility
NAS	Naval Air Station
NAVAIREWORKFAC	Naval Air Rework Facility
NAVSTA	Naval Station
NH	Building Identifier
NM	Building Identifier
NNB	Norfolk Naval Base
NOB	Hampton Roads Naval Operating Base
NPDES	National Pollutant Discharge Elimination System
NPPSO	Naval Publications And Printing Services
NRMC	Navy Regional Medical Center
NSC	Naval Supply Center
NSC-CI	Naval Supply Center-Craney Island
OBA	Oxygen Breathing Apparatus
PCB	Polychlorinated Biphenyl
POL	Petroleum, Oil, And Lubricants
POTW	Publically Owned Treatment Works
PR	Preliminary Review
PWC	Public Works Center

Table 1-1 Naval Base, Norfolk List of Acronyms	
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation And Recovery Act
RFA	RCRA Facility Assessment
RI/FS	Remedial Investigation/Feasibility Study
SAA	Satellite Accumulation Area
SAP	Sampling and Analysis Plan
SDA	Building Identifier
SIMA	Shore Intermediate Maintenance Activity
SP	Building Identifier
SQL	Sample Quantitation Limit
SWCB	State Water Control Board
SWMU	Solid Waste Management Unit
SWOB	Sewage Waste Oil Barge
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VDEQ	Virginia Department of Environmental Quality
VDWM	Virginia Department Of Waste Management
VHWMR	Virginia Hazardous Waste Management Regulations
VSI	Visual Site Inspections
VWCB	Virginia Water Control Board

Section 2

Site Background and Physical Setting

Available site-background information is documented in this section. Information was obtained primarily from the Naval Base, Norfolk, Resource Conservation and Recovery Act (RCRA) facility assessment report (RFA) prepared by A.T. Kearney, Inc., 1992, and the site management plan (SMP) prepared by Baker Environmental, Inc., 1995.

Location and Surrounding Land Use

Naval Base, Norfolk, is on 4,631 acres of land directly northwest of Norfolk, Virginia. The facility is bounded on the north by Willoughby Bay, on the west by the junction of the Elizabeth River and the James River (forming Hampton Roads), and on the south and east by Norfolk. Part of the east boundary of the facility is formed by Mason Creek (Figure 2-1). The Base includes approximately 4,000 buildings and an airfield. The western part of the Base is a developed waterfront area that contains piers and facilities for loading, unloading, and servicing naval vessels.

Land use surrounding the Base is industrial and residential. The waterfront area south of the site provides shipping facilities for several large industries. Residential land use is south and east of the Base. Willoughby Spit, a low-density residential area northeast of Base, also is used for recreational activities.

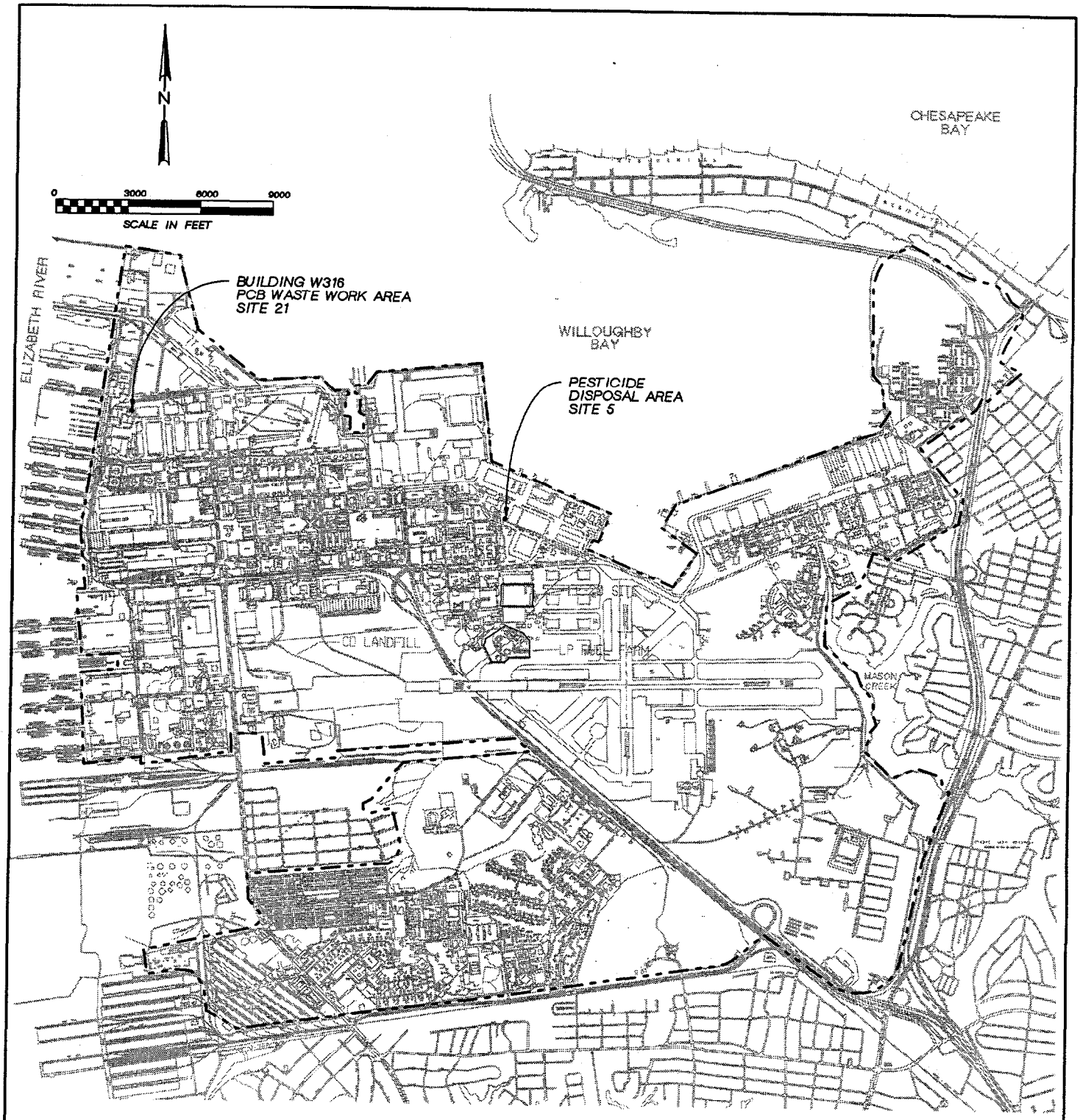
A large concentration of military installations is within a 25-mile radius of the Base. They include Fort Monroe and Langley Air Force Base on the north, Naval Amphibious Base and Fort Story on the east, Naval Air Station Oceana on the southeast, Norfolk Naval Shipyard and St. Juliens Creek Annex on the south, and Naval Supply Center-Craney Island Fuel Terminal on the southwest.

Facility History and Mission

Naval Base, Norfolk, began operations in 1917 when the U.S. Navy acquired 474 acres of land to develop a naval base for supporting World War I activities. Bulkheads were built along the coast to extend available land. After dredge and fill operations, the total land under Navy control was 792 acres.

An additional 143 acres of land were acquired in 1918 and officially commissioned for the Naval Air Station (NAS). From 1936 to 1940, improvements to the piers and expansion of supply- and material-handling facilities were completed.

During World War II (1940 to 1945), major construction projects were completed, including a hospital, a power plant, numerous runways and hangars, a tank farm, and several barracks and housing complexes. During that time, the area of the Base expanded to more than 2,100 acres as the scope of Base activities grew to support U.S. involvement in World War II. After World War II, the Base continued to acquire land through various types of land transfers and dredge and fill operations conducted in parts of the Mason Creek and



LEGEND

— - - — INSTALLATION PROPERTY BOUNDARY

Figure 2-1
INSTALLATION LOCATION MAP
Naval Base, Norfolk

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Bousch Creek basins and Willoughby Bay. During its history, the Base has expanded to become the world's largest naval installation. In 1995, the Base had 15 piers handling 3,100 ship movements annually.

The mission of Naval Base, Norfolk, is to provide fleet support and readiness for the U.S. Atlantic Fleet. The mission is fourfold: (1) command assigned naval shore activities; (2) coordinate support to afloat units, their air arms, and other naval activities; (3) act as regional area coordinator; and (4) act as senior officer present afloat (SOPA) for administration in the Hampton Roads area.

Processes and Operations

Naval Base, Norfolk, provides shore facilities and logistics support for U.S. military vessels and aircraft. The facility operates in various capacities, such as providing housing, hospital care, recreation, and training for military personnel; providing supplies to the fleet; serving as a repair site for aircraft, naval vessels, and associated equipment; and transporting, disposing of, and recycling wastes generated at the Base and at other federal facilities within a 50-mile radius.

Service and maintenance of homeported ships or visiting ships include defueling, refueling, utility hookup, onboard intermediate maintenance, and coordination of ship movements in the harbor. Industrial functions are unloading, offloading, and handling of fuels and oils used aboard the vessels. Maintenance and repair functions include repair and sandblasting of ship hulls, parts cleaning and testing, and painting. Aircraft repair and maintenance operations include stripping, patching, parts cleaning, repainting of fiberglass hulls, engine overhauls, and installation of new electronic gear and metal plating of nickel, silver, and chrome. Other industrial operations carried out by tenants include firefighting training, laboratory analyses, asbestos removal, printing, pest control, and construction-related activities.

Climate and Meteorology

The Norfolk region has a maritime climate that is characterized by long, temperate summers and mild winters. The average annual temperature is 60.7° Fahrenheit (F). July is the warmest month, temperatures averaging 78.7°F; January is the coolest month, temperatures averaging 43.1°F. Freezing temperatures are infrequent in the region. Precipitation averages 43 inches annually and is distributed evenly over the year. Precipitation increases slightly from June to August because of the prevalence of convective thunderstorms. The average annual snowfall is 8.8 inches. Winds are generally in easterly and moderate, ranging from 6 to 11 knots.

Topography, Surface Drainage, and Soil

The topography of Naval Base, Norfolk, is nearly level. Surface elevations at the site range from sea level to 15 feet, the latter being in the central section of the Base.

Four major surface water features surround the greater Norfolk area: the James and Elizabeth rivers and Willoughby and Chesapeake bays, all of which are tidal.

The majority of surface water on the Base flows either to Mason Creek or to the remnants of Bousch Creek. The northernmost channel of Bousch Creek traverses the base and empties into Willoughby Bay through a subgrade aqueduct. The main channel of Mason Creek was filled in and replaced by a network of drainage ditches during the development of the Base. These narrow drainage channels are interspersed throughout the central part of the facility. Both Mason Creek and the drainage ditches are tidal throughout the site. Both creeks discharge to Willoughby Bay and ultimately to Chesapeake Bay. Some surface water from the Base discharges directly into the Elizabeth River.

The reported 100-year static-water flood elevation throughout the Base site is 8.5 feet mean sea level (MSL). Therefore, parts of the Base adjacent to Willoughby Bay and the Elizabeth River are within the 100-year floodplain.

Soil at the Base generally consists of fine sands and silts at a thickness of 20 to 40 feet low to moderate in permeability. This upper layer of soil typically is underlain by relatively impermeable sediment composed of silt, clay, and sandy clay. Together, these strata have a combined thickness of approximately 60 feet. The average permeability of soil in Norfolk County is less than 2.5 inches per hour.

Geology and Hydrogeology

Naval Base, Norfolk is located in the outer Atlantic Coastal Plain Physiographic Province which is characterized by low elevations and gently sloping relief. The Base is underlain by over 2,000 feet of gently dipping sandy sediments, ranging in age from Recent to Lower Cretaceous. Table 2-1 contains a stratigraphic column and hydrogeologic units of southeast Virginia.

The uppermost geologic unit is the Columbia Group, composed of Holocene deposits and undifferentiated Pleistocene deposits. The Columbia Group is approximately 60 feet thick. The upper 20 to 40 feet consist of unconsolidated fine sands and silts. These sediments possess low to moderate permeabilities and comprise the unconfined Columbia aquifer. The lower 20 to 40 feet consist of relatively impermeable silt, clay, and sandy clay.

The Chesapeake Group underlies the Columbia Group. The uppermost unit in the Chesapeake Group is the Yorktown Formation. It is capped by the Yorktown confining unit that separates the Columbia aquifer from underlying Yorktown aquifer. The Yorktown formation is approximately 90 to 100 feet thick in the vicinity of the Base and is composed of marine silt and clay and moderately consolidated coarse sand and gravel with abundant shell fragments. The Chesapeake Group is composed of several additional older formations that comprise deeper aquifers and confining units. These overlie the Tertiary Pamunkey Group and Cretaceous stratigraphy.

The two significant shallow aquifer systems in the area are the Columbia aquifer located in the upper 20 to 40 feet of the Columbia Group, and the underlying Yorktown Aquifer. The Columbia aquifer comprises the water table aquifer is reportedly thin and consists of discontinuous heterogeneous sand and shell lenses. The depth to the water table is usually less than 8 feet. The Yorktown Aquifer is semi-confined beneath a clay layer in the upper Yorktown Formation. Water bearing zones in the Yorktown Aquifer consist of fine to coarse sand, gravel, and shells.

Table 2-1
Stratigraphic and Hydrogeologic Units
of Southeast Virginia
(From Harsh and Laczniak, 1990)

Geologic Age		Group	Stratigraphic Formation	Hydrogeologic Unit
Period	Epoch			
Quaternary	Holocene	Columbia	Holocene Deposits	Columbia Aquifer
	Pleistocene		Undifferentiated Deposits	
Tertiary	Pliocene	Chesapeake	Yorktown Formation	Yorktown Confining Unit
				Yorktown- Eastover Aquifer
	Miocene		Eastover Formation	
			St. Mary's Formation	St. Mary's Confining Unit
			Choptank Formation	St. Mary's-Choptank Aquifer
			Calvert Formation	Calvert Confining Unit
	Oligocene	Pamunkey	Old Church Formation	Chickahominy-Piney Point Aquifer
	Eocene		Chickahominy Formation	
			Piney Point Formation	
			Nanjemoy Formation	Nanjemoy-Marlboro Clay Confining Unit
			Marlboro Clay	
	Paleocene		Aquia Formation	Aquia Aquifer
			Brightseat Formation	Brightseat-Upper Potomac Confining Unit
Cretaceous	Late Cretaceous		Potomac Formation	Brightseat-Upper Potomac Aquifer
				Middle Potomac Confining Unit
	Early Cretaceous			Middle Potomac Aquifer
				Lower Potomac Confining Unit
				Lower Potomac Aquifer

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Environmental History

Information on previous and ongoing basewide hazardous waste investigations is documented below. The Installation Restoration Program (IRP) is described first. Then summary information from previous basewide hazardous waste investigations is documented. Finally, ongoing basewide hazardous waste investigations are summarized.

Installation Restoration Program

Naval Base, Norfolk, is not on the United States Environmental Protection Agency (USEPA) National Priorities List (NPL). Therefore, the Navy is acting as the lead agency in environmental investigations at the Base. The environmental condition of the Base is being investigated through the United States Department of Defense (DOD) IRP. The IRP at Naval Base, Norfolk, has been conducted in accordance with applicable federal and state environmental regulations and requirements. In addition, the Navy has solicited involvement and comments from federal and state regulatory agencies (USEPA and the Virginia Department of Environmental Quality [VDEQ]) throughout the IRP process by submitting documents for their review.

In 1975, DOD began a program for assessing past hazardous-material and toxic-material storage and disposal activities at military installations. The goals of the program, now known as the IRP, were to identify environmental contamination resulting from past hazardous-material management practices, assess the effects of the contamination on public health and the environment, and develop corrective measures as required to mitigate adverse effects on public health and the environment.

In 1976, RCRA was passed by Congress to address potentially adverse human health and environmental effects of management and disposal practices for hazardous waste. RCRA was legislated to manage the present and future disposal of hazardous wastes. In 1980, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), or "Superfund," was passed to investigate and remediate areas resulting from past hazardous-waste management practices. The program is administered by USEPA or state agencies.

In 1981, DOD's IRP was reissued, additional responsibilities and authorities specified in CERCLA being delegated to the Secretary of Defense. The Navy subsequently restructured the IRP to match the terminology and structure of the USEPA CERCLA Program. The current IRP is consistent with CERCLA and applicable state environmental laws.

Previous Basewide Investigations

Previous basewide investigations completed through the IRP include the initial assessment study (IAS), dated February 1983; the IRP remedial investigation - interim report (IRPRI), dated March 1988; and a draft RFA, completed for Naval Base, Norfolk, in February 1991 and revised in March 1992.

The purpose of the 1983 IAS was to identify and assess sites that posed a potential threat to human health or the environment because of contamination from past handling of and operations involving hazardous materials. A total of 18 potentially contaminated sites, designated Site 1 through Site 18, were identified on the basis of information obtained from historical records, photographs, site inspections, and personnel interviews. Each of the 18

sites was evaluated for type of contamination, migration pathways, and pollutant receptors. The IAS concluded that 6 of the 18 sites posed sufficient threats to human health or the environment to warrant further evaluation in a confirmation study. Sampling and analyses were not performed as part of the IAS. During the confirmation study, sampling and monitoring would be performed at the site to confirm or refute the existence of the suspected contamination.

A confirmation study subsequently was performed for the six sites that were recommended for further investigation in the IAS. The effort for five of the six sites was documented in the 1988 IRPRI report. An independent confirmation study was performed by the Navy on Site 6, the CD Landfill. The objectives of the confirmation study were to determine the extent of contamination, develop and evaluate economically feasible remedial alternatives, and recommend a remedial action at the following five sites:

- Site 1: Camp Allen Landfill
- Site 2: NM Area Slag Pile
- Site 3: Q-Area Drum Storage Yard
- Site 4: Transformer Storage Area P-71
- Site 5: Pesticide Disposal Site

Since the 1983 IAS, four additional IRP sites (19 through 22) have been identified and added to the IRP. The status of the 22 IRP sites is summarized in Table 2-2.

During the ongoing IRP at Naval Base, Norfolk, several site-specific RIs, FSs, removal actions, and site remediations have been completed or are in progress. Remediations have been completed or are in progress at six sites (1, 4, 11, 16, 17, and 19), as shown in Table 2-2.

A draft RFA was completed for Naval Base, Norfolk, in February 1991. This study was a basewide inventory of existing solid waste management units (SWMUs) and other Areas of Concern (AOCs) on the Base. A total of 274 SWMUs and 10 AOCs tentatively were identified in this study. The Navy has selected three of the SWMUs for investigation and evaluation under the IRP. The potential sites were reviewed comprehensively before the RFA was made final in March 1992.

A SMP was developed for Naval Base, Norfolk, by Baker Environmental, Inc., in 1995. The SMP gave LANTDIV a management tool for planning, scheduling, and prioritizing environmental remedial response activities to be conducted at the Base in 1995-1996.

Current Basewide Investigations

NFEC LANTDIV has awarded the Navy C.L.E.A.N. II Contract to CH2M HILL. Under the contract, several contract task orders (CTOs) for investigations at Naval Base, Norfolk, have been issued as of the date of preparing this work plan. They are the following:

- CTO-3 Remedial Investigation/Feasibility Study of the Pesticide Disposal Site (Site 5) and Preliminary Assessment/Site Investigation of the Building 316, PCB Waste Work Area (Site 21)
- CTO-5 Remedial Action Design Package for the LP-20 Site
- CTO-7 Remedial Action Design Package for the CD Landfill Site

Table 2-1
CURRENT STATUS SUMMARY IRP SITES
NAVAL BASE NORFOLK SITE MANAGEMENT PLAN

Site	PA or IAS	SI or CS	TBA	Work Plans	RI	FS	PRAP	ROD	RD	RA	Comments
1. Camp Allen Landfill	1983*	1988**		1991	1994	1994	1995	1995	√	√	Removal action (soil) completed. Long-term groundwater pump & treat being implemented.
2. NM Slag Pile	1983*	1988**		0	0	0	0	0			Limited sampling program revealed only minimal contamination.
3. Q-Area Drum Storage	1983*	1988**		1991	√	√	√	√	√	0	Soil contamination - TPH, VOCs, pesticides. VOC-contaminated groundwater. Remedial Design in progress.
4. P-71 Transformer Storage	1983*	1988**		1991	1991	1991	1991	1992	1991	1992	Cleanup completed. Groundwater monitoring completed in 1995.
5. Pesticide Disposal Site	1983*	1988**		0	0	0	0	0			Pesticide-contaminated soil. No documented groundwater contamination. RI/FS planned.
6. CD L:andfill	1983*	1991		1993	√	√	0	0	0	0	Heavy metal-contaminated soil/groundwater. RI/FS in progress.
7. Insert Chemical Landfill	1983*		0								State-approved, non-hazardoius waste landfill. No further action recommended per IAS.
8. Asbestos Landfill	1983*		0								State-approved, non-hazardoius waste landfill. No further action recommended per IAS.
9. Q-Area Landfill	1983*		0								Construction debris only landfill. Nor further action recommended per IAS.
10. Apollo Disposal Sites	1983*		0								Apollo fuel component has most likely biodegraded. No further action recommended per IAS.
11. Repair Shop Drains	1983*		0							X	Cleanup completed. No further action recommended per IAS.
12. Mercury Disposal Site	1983*		0								No evidence of mercury disposal found. No further action recommended per IAS.
13. Past Wastewater Outfalls	1983*		0								Industrial wastewater rerouted to treatment plant. No further action recommended per IAS.
14. Oil Spill - Piers 4, 5, 7	1983*										Site being addressed under the UST Program - no longer an IRP Site.
15. Oil Spill - Piers 20, 21, 22	1983*										Site being addressed under the UST Program - no longer an IRP Site.
16. Fire, Building X-136	1983*		0							X	Cleanup completed. No further action recommended per IAS.
17. Fire, Building SDA-215	1983*		0							X	Cleanup completed. No further action recommended per IAS.
18. Former NM Waste Storage	1983*		0								State landfill permit issued. No further action recommended per IAS.
19. Buildings V-60/V-90	1988	1988		1989	1989	1989	1989	1990	1989	1991	Cleanup completed. No further action recommended per IAS.
20. LP-20 Site	1991	1991		1994	√	√	0	0			PA/SI documented TPH and chlorinated solventsin groundwater. RI/FS in progress.
21. Building W-316	0	0									PA/SI planned.
22. Camp Allen Salvage Yard	1994	1994		0	0	0	0	0			PA/SI documented soil and groundwater contaminatiuon. RI/FS scheduled.

LEGEND:

1993 - Year Activity Completed
X - Activity Completed (date unknown)
√ - Activity In Progress
0 - Activity Planned
PA - Preliminary Assessment
IAS - Initial Assessment Study
SI - Site Inspection
CS - Confirmation Study

RI - Remedial Investiagion
FS - Reasibility Study
PRAP - Proposed Remedial Action Plan
ROD - Record of Decision or Decision Document
RD - Remedial Design
RA - Remedial Action
TBA - To Be Addressed

* Refers to "Initial Assessment Study of Sewells Point Naval Complex," dated February 1983.
** Refers to "Installation Restoratieon Program Remedial Investigation Interim Report," dated march 1988.

- CTO-8 Remedial Investigation/Feasibility Study of the NM Slag Pile (Site 2)
- CTO-11 Camp Allen Landfill, Post Remediation Ecological Monitoring
- CTO-12 Solid Waste Management Unit Investigation (SWMUs 1, 4, 6, and 8)

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Section 3

Initial Evaluation and Work Plan Rationale

This section presents an initial evaluation of available background information and existing conditions for the RI/FS Site 5, the Pesticide Disposal Site, and for the PA/SI for Site 21, Building W-316 PCB Waste Work Area. The results and conclusions of previous investigations of these sites are documented in this section as justification for completing RI/FS and PA/SI tasks documented in this work plan. Sampling techniques and analytical methods proposed for the Site 5 RI/FS and the Site 21 PA/SI are documented in Section 4.

Pesticide Disposal Site RI/FS: Background Information

Site 5 consists of a french drain located southeast of Building V-95. The french drain, which consists of a 28-inch-diameter culvert placed vertically into a 26-foot-deep gravel-filled hole, was used for disposing of pesticide waste generated in the former pest control shop (Bldg. V-95). This shop was in operation from the late 1960s until 1973, and the french drain has not been used for pesticide disposal since 1973. Reportedly, 100 gallons per week of pesticide rinse water were disposed of in the french drain, along with intermittent discharges of overage concentrated pesticides. Pesticides used in this pest control shop reportedly included chlordane, malathion, DDT, DDD, and dieldrin. This area currently is fenced off and used for storage of other materials.

Site 5 is addressed in the documentation of four previous investigations. A summary of the intent, findings, and recommendations of the investigations is documented below. Findings of the CH2M HILL visual site inspection (VSI) also are described.

Initial Assessment Study

Environmental Science and Engineering, Inc. (ESE), conducted an IAS of the Sewell's Point Naval Complex (now part of Naval Base, Norfolk) to identify and assess sites that pose a potential threat to human health or the environment because of contamination from past operations involving hazardous materials. Site 5 was one of the sites characterized by the study. Site 5 was evaluated for contamination characteristics, migration pathways, and pollutant receptors. The findings of the IAS of Site 5 are documented in *Initial Assessment Study of the Sewell's Point Naval Complex, Norfolk, Virginia*, dated February 1983.

IAS Findings and Recommendations

The IAS summarized site history and usage as documented above. The IAS documented the following recommendations. Five soil samples should be collected in close proximity to the french drain from 1-foot intervals within a vertical core. The samples should be analyzed for EPA priority-pollutant pesticides. If contamination is detected, a monitoring well should be installed and sampled.

Remedial Investigation

Malcolm Pirnie, Inc., completed an RI of five sites at Naval Base, Norfolk, under the IRP. The purpose of the RI was to determine whether past disposal practices for specific toxic or hazardous materials had resulted in site contamination. Site 5 was one of the sites characterized by the study. The findings of the RI of Site 5 are documented in *Installation Restoration Program Remedial Investigation - Interim Report, Naval Base, Norfolk, Virginia*, dated March 1988.

Figure 3-1 depicts the approximate locations of the monitoring well that was installed and the soil samples that were collected as part of the RI.

Soil and Groundwater Sampling: Methods

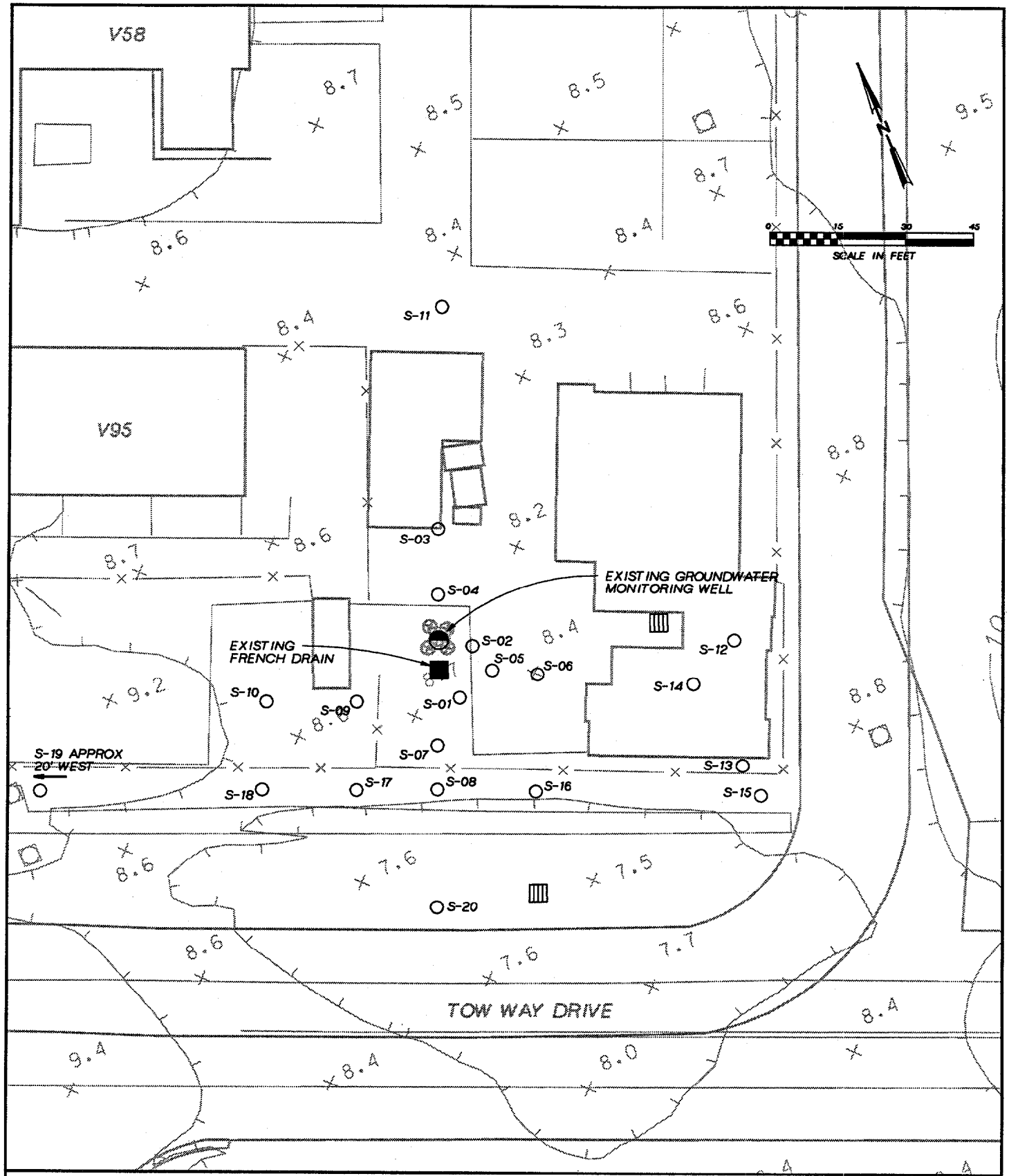
Pirnie personnel installed three soil borings with continuous sampling and one groundwater-monitoring well (05GW-01). The soil and groundwater samples were analyzed for 128 EPA priority pollutants and a 5-peak base-neutral organic constituent library of 5 additional pollutants. Pirnie personnel installed eight additional soil borings with continuous sampling. Forty soil samples were collected and analyzed for EPA priority-pollutant base-neutral extractable organics, pesticides, polychlorinated biphenyls (PCBs), a dioxin screen, and a 5-peak base-neutral library search.

A third sampling event was conducted during which a groundwater sample was collected from the monitoring well and analyzed for EPA priority-pollutant base-neutral extractable organics, pesticides, PCBs, xylene, methylethyl ketone (MEK), and methyl isobutyl ketone (MIBK). Ten surface soil samples were collected and analyzed for EPA priority-pollutant base-neutral extractable organics. A fourth confirmatory sampling event included collecting a groundwater sample from the monitoring well and analyzing for xylene, MEK, and MIBK.

Soil and Groundwater Sampling: Results

Results of the groundwater analyses at well 05GW-01 indicate that no priority-pollutant organic constituents exceeded analytical detection limits during the three groundwater sampling events. Several inorganic constituents were identified that slightly exceeded some of the referenced water-quality criteria during one or more sampling events. The values were not considered significant for the potential risk for human exposure because groundwater at Site 5 was not used as a potable source and reported concentrations were for total metals (unfiltered) that represent the total metals in solution and bound up by particulate matter.

Soil samples collected and analyzed during the investigation indicated that elevated concentrations of two pesticides, DDT and DDD, were detected at several depths in soil directly adjacent to the french drain. Concentrations of DDD ranged from 20 to 36 milligrams per kilogram (mg/kg) near the ground surface and diminished with depth. Elevated concentrations of chlordane and dieldrin also were identified. These pesticides were not detected in groundwater samples, but DDD and DDT are not water-soluble. DDD was identified in a surface sample (0-2 feet) collected 15 feet east of the french drain but was not detected in deeper samples. Chlordane and dieldrin also were identified in this surface soil sample. Pesticides were not detected in soil at sample locations 15 feet north, west, or south of the french drain.



LEGEND

- EXISTING GROUNDWATER MONITORING WELL
- SOIL SAMPLING LOCATION
- EXISTING FRENCH DRAIN

Figure 3-1
APPROXIMATE SOIL AND GROUNDWATER SAMPLING LOCATIONS - PIRNIE RI
SITE 5 - PESTICIDE DISPOSAL AREA
Naval Base, Norfolk

CH2M HILL

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Several base-neutral compounds also were identified in the surface soil at many sampling locations during the second and third sampling events. The source of the base-neutral compounds was interpreted to be from surface runoff from aboveground scraping and refinishing operations rather than from operations related to the use of the french drain. No base-neutral compounds were identified in site groundwater, and no imminent threat of migration exists.

RI Recommendations

DDD and DDT are considered toxic for ingestion, inhalation, and skin absorption. These pesticides are not strongly biodegradable and will diminish very slowly over time. Site data indicate that the pesticides are fixed to the soil and are not transported by groundwater. The following remedial actions were recommended to reduce the risk of human exposure:

- Install an impermeable hard surface over the entire area to remove the potential for surface exposure to pesticides and detected base-neutral compounds.
- Extend the security fence to enclose the area.
- Post an excavation warning sign about subsurface pesticide contaminants in subsurface soil.

RCRA Facility Assessment

A.T. Kearney, Inc., completed an RFA of multiple hazardous waste sites, SWMUs, and other AOCs at the Base. The purpose of the RFA was to conduct a preliminary review of available and relevant documents, visual inspections, and, if appropriate, sampling visits. Site 5 was one of the sites characterized by the RFA. Findings are documented in *Revised Final Phase II RCRA Facility Assessment of the Norfolk Naval Base - Sewell's Point, Norfolk, Virginia,* dated March 1992.

RFA Findings and Recommendations

The RFA summarized site history and usage as documented above. In addition, the RFA mentions that varying levels of DDT have been detected in the monitoring well in the area where the french drain was located. Therefore, the release potential to soil and groundwater is high. The RFA documented the following recommendation. Because release to the soil/groundwater has been documented, a RCRA Facility Investigation (RFI) was suggested for this unit. Sufficient groundwater-monitoring wells should be put in place to determine the nature and extent of contamination. Note that CH2M HILL has not encountered data to support the detection of DDT in site groundwater.

1995 Site Management Plan

Baker Environmental, Inc., completed an SMP for the years 1995-1996 to give LANTDIV and Activity personnel a management tool for planning, scheduling, and prioritizing environmental response activities through a site-ranking system at the Base. Site 5 was one of the sites ranked by the SMP. Findings are documented in *Final 1995 Site Management Plan, Naval Base, Norfolk, Virginia,* dated June 20, 1995.

SMP Findings

The SMP described background information as documented above. The SMP also identified the pesticides chlordane, malathion, DDD, DDT, and dieldrin as known site contaminants and noted that some small spillage of fuel oils has occurred directly adjacent to the site. The SMP authors concluded that additional investigation is required to adequately characterize the extent of contamination at the site. The environmental response ranking system rated Site 5 as the 7th site in the priority ranking of 15 sites.

CH2M HILL VSI Findings

In March 1996, CH2M HILL personnel conducted a VSI of the Pesticide Disposal Area. The french drain and nearby monitoring well 05GW-01 were located. Several large cargo containers cover the surface of most of the site. The northern half of the site's surface is covered with asphalt, and the southern half is covered with gravel. Sites for monitoring well, soil boring, and surface soil sampling tentatively were identified. RI/FS sampling is slated for the summer of 1996.

Building W-316 PCB Waste Work Area PA/SI: Background Information

The Building W-316 PCB Waste Work Area is outdoors in the northwest part of the base, directly south of the W-316 PCB Debris Storage Area (SWMU-8). This unit is used by the Navy Public Works Center to store various electrical components. The building and small storage yard adjacent to the building were used for storing out-of-service PCB transformers received from throughout the Base. The transformers were picked up by a contractor for offsite disposal. The unit began operation in 1982 or earlier and is still in operation. The unit is an approximately .25-acre fenced area underlain by soil, asphalt, and concrete. Transformers are stored on pallets in the area.

On April 25, 1990, PCB transformer #31419-1 stored in this unit was ruptured by a forklift during maintenance operations. Approximately 35 gallons of 108 parts per million (ppm) PCB oil was released to a 15x30-foot section of asphalt within the fenced area. The transformer was plugged, pumped out, and wiped down with kerosene. A total of 85 gallons of PCB oil was pumped. The spill was diked and contained with pig blankets, and absorbent was poured on the asphalt. Contaminated soil, sand, and absorbent material were shoveled into 55-gallon steel drums. The contaminated asphalt and underlying soil were excavated to a depth of 6 inches, and new asphalt was poured in the spill area.

Site 21 is addressed in documentation of two previous investigations. A summary of the intent, findings, and recommendations of the investigations is documented below. Findings of the CH2M HILL USI are also described.

RCRA Facility Assessment

A.T. Kearney, Inc., completed an RFA of multiple hazardous waste sites, SWMUs, and other AOCs at Naval Base, Norfolk. The purpose of the RFA was to conduct a preliminary review of available and relevant documents, visual inspections, and, if appropriate, sampling visits. Site 21 was characterized by the RFA. Findings are documented in *Revised*

Final Phase II RCRA Facility Assessment of the Norfolk Naval Base - Sewell's Point, Norfolk, Virginia, dated March 1992.

RFA Findings and Recommendations

The RFA documented that there is a high potential for release of PCBs to the soil and groundwater if residual contamination exists at the unit. The RFA authors suggested that soil sampling should be conducted to determine whether hazardous constituents have been released. Soil samples should be collected from areas of past releases and from surrounding areas. Soil from the substrate of the original excavation should be sampled and analyzed for PCBs.

1995 Site Management Plan

Baker Environmental, Inc., completed a SMP for the years 1995-1996 to give LANTDIV and Activity personnel a management tool for planning, scheduling, and prioritizing environmental response activities through a site-ranking system at the Base. Site 21 was included in the SMP. Findings are documented in the *Final 1995 Site Management Plan, Naval Base, Norfolk, Virginia,* dated June 20, 1995.

SMP Findings

The SMP described background information as documented above. The SMP also identified PCBs as known site contaminants. The SMP authors documented that additional investigation is planned for adequately characterizing the extent of contamination at the site. The environmental response ranking system rated Site 5 as the 8th site in the priority ranking of 15 sites.

CH2M HILL VSI Findings

In March 1996, CH2M HILL personnel conducted a VSI of Site 21. The facility is still used for storage and has been fenced and posted with signs warning of PCB contamination. The northern part of the W-316 PCB Transformer Storage Area was graded recently and covered with a concrete slab. PA/SI sampling is slated for the summer of 1996.

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Section 4

Technical Approach and Investigation Procedures

This section details the technical approach developed to perform RI/FS activities at Site 5 and PA/SI activities at Site 21. The tasks included in the technical approach are listed below. The remainder of this section contains detailed discussions of each task. Certain tasks are specific to either the RI/FS or the PA/SI, as noted. Other tasks apply to both investigations.

Task 1:	Project Planning
Task 2:	Fieldwork Support
Task 3:	Field Investigation
Task 4:	Sample Analysis and Data Validation
Task 5:	Risk Assessment
Task 6:	RI and PA/SI Report
Task 7 :	Feasibility Study
Task 8:	Feasibility Study Report
Task 9:	PRAP and ROD Reporting

Task 1: Project Planning

This task consists of preparing this work plan, the sampling and analysis plan (SAP), and the health and safety plan (HSP). Meetings and project management activities also are documented.

RI/FS and PA/SI Work Plan

This task consists of developing this work plan for performing all activities associated with the RI/FS of Site 5 and the PA/SI of Site 21.

Sampling and Analysis Plan

This task consists of preparing a SAP, which consists of a field sampling plan (FSP), a quality assurance project plan (QAPP), and an investigation-derived waste management plan (IDWMP). The sampling plan will be developed in compliance with all requirements of the U.S. Navy QA/QC Program Manual.

The FSP will be referenced during field activities as procedural guidance for all sampling and data collection. The FSP includes the following sections: "Site Background," "Sampling Objectives," "Sample Locations and Frequency," "Sample Designations," "Sampling Equipment and Procedures," and "Sample Handling and Analysis." The FSP is attached to this work plan.

CH2M HILL has prepared a QAPP that meets requirements specified by the Navy. The QAPP describes the quality assurance and quality control (QA/QC) procedures used for

conducting soil and groundwater sampling at Site 5 and Site 21. The QAPP is attached to this work plan.

CH2M HILL will not begin field sampling at each site until the Naval Technical Representative (NTR) receives confirmation that the requirements of the laboratory quality assurance plan (LQAP) have been met for that site. The subcontracted analytical laboratory will conform to the Navy's approved LQAP. The LQAP will be submitted as soon as CH2M HILL Basic Ordering Agreements (BOAs) are in place for analytical laboratories.

The investigation-derived waste management plan (IDWMP) describes the procedures used for handling and disposing of waste materials generated during the RI field program. The waste materials will include health and safety disposable items, soil, and fluids. The plan also describes the chemical analyses that will be performed to characterize the IDW materials and the potential means of disposal. The potential disposal sites also will be identified.

PCBs are not RCRA-listed hazardous wastes. However, the pesticides chlordane and DDT, known to be handled at the Site 5 location, are RCRA U-listed hazardous wastes. These products, as detected at the site, could be classified as discarded commercial products and container residues that have been applied to the land in a manner other than their intended use. Therefore, for planning purposes, all Site 5 IDW will be considered hazardous waste.

Health and Safety Plan

A site-specific HSP has been prepared and is attached to this work plan. The HSP contains guidance for the health and safety of CH2M HILL employees during all RI/FS and PA/SI fieldwork. The HSP includes health and safety assessments for identifying problem areas where exposure to hazardous substances in water, soil, and air may occur. The assessments address safe working procedures, restrictions that will apply to the site work, and potential human exposure to hazardous substances and the toxicological effects of the substances.

The HSP will be used by CH2M HILL personnel and subcontractors during fieldwork associated with the project. All Site 5 and Site 21 investigations will proceed under Level D personal protection, and will be upgraded to Level C if field conditions warrant. However, upgrade to a higher level of protection will be considered an additional out-of-scope cost and will not be undertaken without prior authorization.

Meetings

Two meetings are planned during which issues related to both sites will be discussed. Before the draft-final reports are submitted, a 1-day meeting will be held to discuss the contents of the draft RI/FS and PA/SI reports and site-specific recommendations for both sites. CH2M HILL personnel also will attend one Restoration Advisory Board (RAB) meeting to discuss issues relating to both sites. The meeting will include a preparatory meeting with the RPM/NTR and the COMNAVBASE representative. CH2M HILL will submit the minutes of both meetings to LANTDIV and Naval Base, Norfolk.

Project Management

The activities involved in project management include daily technical support and guidance, budget and schedule review and tracking, preparation and review of invoices,

personnel-resource planning and allocation, subcontractor coordination, preparation of monthly progress reports, and communication and coordination of events with LANTDIV and the Base. Project management will be conducted over the duration of the project, which is estimated for completion in 21 months.

Task 2: Fieldwork Support

This task includes subcontractor procurement, mobilization and demobilization, and utility clearance procedures.

Subcontractor Procurement

As part of the initial fieldwork at Site 5 and Site 21, CH2M HILL will procure drilling, surveying, analytical laboratory, data validation, and waste management services. The analytical laboratory will meet Navy Level D quality control.

CH2M HILL is in the process of securing BOAs with established CLEAN I subcontractors approved by LANTDIV. In cases where BOAs are not in place for services required under this task order, CH2M HILL will provide subcontractor services in accordance with procedures that will be established by CH2M HILL's contract administrator and LANTDIV's contracting officer.

Mobilization and Demobilization

Mobilization includes the procurement and initial transport of field equipment to the site. Equipment and supplies will be transported during the CH2M HILL field team's mobilization for field activities.

Demobilization includes time for IDW sampling and general site restoration before the field equipment and crew leave. Field equipment will be recalibrated and stored after the fieldwork. IDW generated during field activities will be put in 55-gallon drums. Equipment decontamination water and development and purge water also will be put in 55-gallon drums for storage. The 55-gallon drums will be properly labeled and properly stored at a location designated by the LANTDIV and the Base before disposal. The disposal method will depend on the results of characterization analysis.

Navy Clean Daily Field Reports must be completed and submitted within 7 days of the end of field activities.

Utility Clearances

Utility clearances will be performed before the start of subsurface investigations at the site. CH2M HILL will coordinate subsurface utility clearances with the "Miss Utility" office and the Public Works Center (PWC) at the base. CH2M HILL will be responsible for ensuring that all appropriate contacts have been made with Base personnel and that clearances have been given for proposed drilling locations, including marking of utilities near the areas of potential drilling, before field operations begin.

Task 3: Field Investigation

The field investigation includes all RI/FS activities associated with monitoring-well installation and collection of soil and groundwater samples at Site 5 and the PA/SI activities at Site 21. The task also includes surveying of sample locations. The activities are described below.

RI Monitoring-Well Installation

Two shallow monitoring wells will be installed using hollow-stem augers at Site 5. Figure 4-1 provides the approximate proposed locations of the wells. The existing monitoring well (05GW-01) appears to be directly adjacent to and hydraulically downgradient of the french drain.

One new monitoring well will be installed 20 feet hydraulically downgradient of the existing monitoring well to determine if groundwater contamination has migrated from the proximity of the french drain. A second monitoring well will be installed 15 feet east of the existing well where pesticide contamination was previously detected in site soil. Both wells will be constructed with 2-inch-diameter PVC risers with 10-foot screens. The screens will span the water-table. Both wells will be approximately 25 deep. Geologic and well-construction logs will be prepared for each well. New monitoring-well locations identified in this work plan are subject to change because of utility clearance problems or other unforeseen circumstances. Monitoring-well installation is described in detail in a standard operating procedure (SOP) in Attachment A of the FSP.

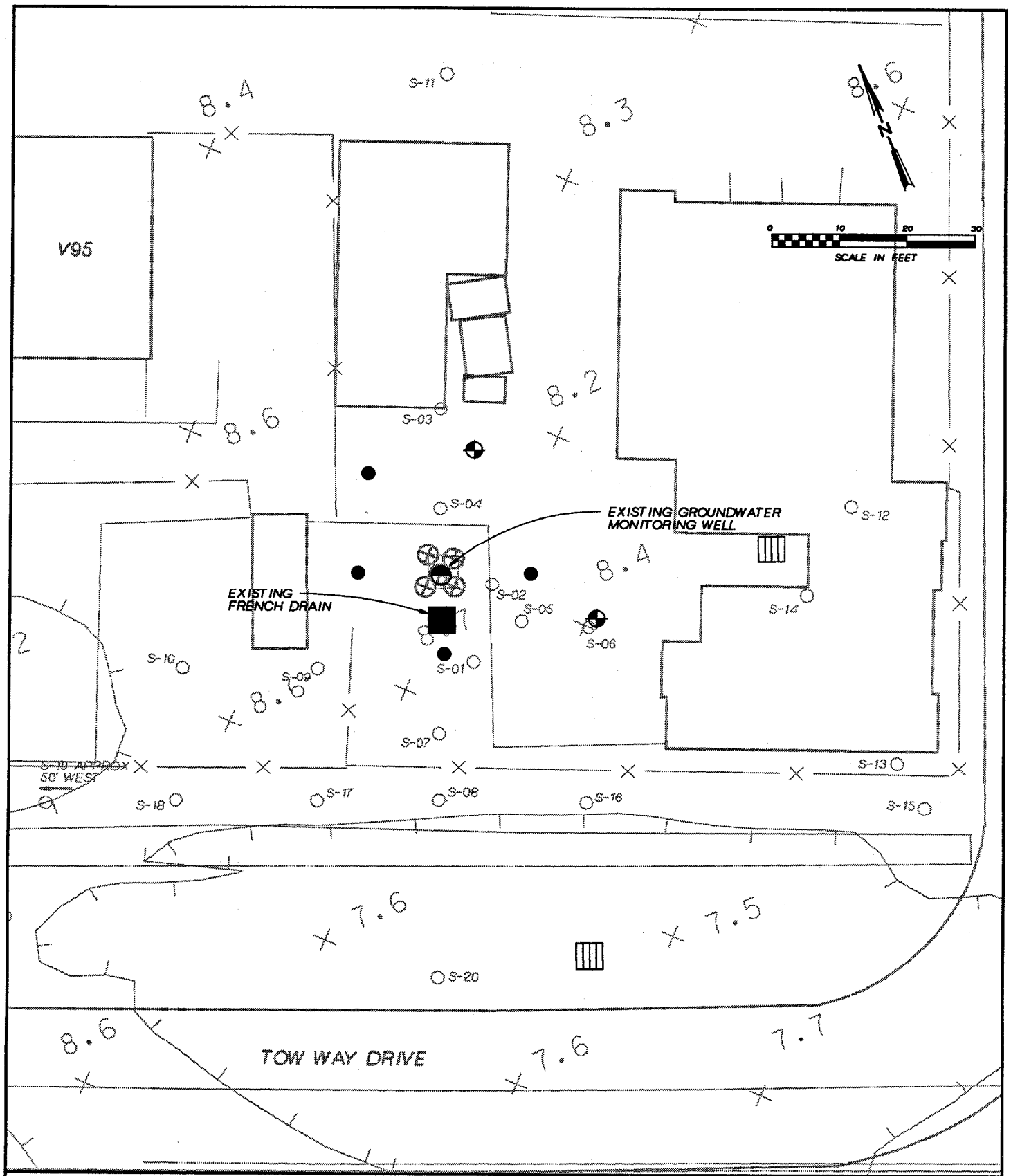
One round of water-level measurements will be performed at Site 5 after the water levels in both wells have reached an equilibrium state in relation to the water-table aquifer. Water levels will be recorded in both new wells and in the existing monitoring well. The results will be used to approximate the piezometric surface of the water-table aquifer at Site 5.

RI Groundwater Sampling

The two new monitoring wells and the existing monitoring well will be sampled after the new wells are installed. Groundwater-sampling methods are documented below. First, the locations and numbers of groundwater samples and sample analytical methods are documented. Then, groundwater sampling techniques are described.

Groundwater-Sample Numbers and Locations

The two new monitoring wells and the one existing well will be sampled and the samples will be analyzed for Target Compound List (TCL) organics (including semivolatiles, pesticides, and PCBs) and Target Analyte List (TAL) inorganics (including metals and cyanide). In order to achieve the lower detection limits required for the risk assessment associated with the Site 5 RI/FS, the volatile fraction of the organic sample will be analyzed by the EPA Contract Laboratory Program (CLP) Statement of Work (SOW) for Low Concentration Water (OLC02). A risk assessment has to contain considerations of risks involved in drinking water that might be contaminated. One consideration of risk is the comparison of groundwater contaminant concentrations detected at a site with federal drinking water standards, the maximum



LEGEND

- PROPOSED GROUNDWATER MONITORING WELL LOCATION
- EXISTING GROUNDWATER MONITORING WELL LOCATION
- SOIL SAMPLING LOCATION - PIRNIE RI
- PROPOSED SOIL SAMPLING LOCATION
- FRENCH DRAIN

Figure 4-1
PROPOSED MONITORING WELL
AND SOIL SAMPLING LOCATIONS
SITE 5 - PESTICIDE DISPOSAL AREA
Naval Base, Norfolk

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contaminant levels (MCLs) permissible in tap water. MCLs for vinyl chloride (2 μg/L) 1,1,2-trichloroethane (5 μg/L), trichloroethene (5 μg/L), tetrachloroethene (5 μg/L), 1,2-dichloroethane (5 μg/L), and 1,1-dichloroethene (7 μg/L), which are chlorinated solvents commonly found on sites contaminated with volatile solvents, are below the EPA CLP volatile detection limit of 10 μg/L. Low concentration volatile method OLC02 has a detection limit of 1 μg/L for each of these compounds and offers reliable proof that the compounds are either present or not present at levels that exceed 1 μg/L. Low concentration method OLC02 is appropriate for groundwater samples only, not for surface water, sediment, or soil.

Standard EPA methods will be followed during sample analysis. Table 4-1 documents the groundwater-sample designations and analyses performed for each sample. Figure 4-1 depicts the locations of the samples listed in Table 4-1.

Groundwater-Sampling Techniques

The two newly installed wells and existing well 05GW-01 will be developed after the grout has cured for at least 24 hours. Development will be performed by removing at least three to five borehole volumes of groundwater until temperature, pH, and specific conductivity have stabilized or until the well has been pumped or bailed dry multiple times. The new and existing monitoring wells will be sampled at the end of the development period.

Groundwater samples will be collected from the two newly installed monitoring wells and the existing well by using a Grundfos® Redi-Flo2 sampling pump. The groundwater-sampling techniques are explained briefly below. Descriptions of monitoring-well sampling techniques are described in more detail in an SOP in Attachment A of the FSP.

Monitoring Well Sampling

Before sampling, groundwater will be purged from each well. The volume of groundwater in the monitoring well will be calculated by using values for the depth of the well, the depth to water, and the well diameter. Purging will be performed until a minimum of three well volumes of water have been removed and the temperature, specific conductance, and pH have stabilized within 10 percent for three consecutive readings. Sampling will begin when the parameter measurements have stabilized. Wells that are pumped dry during purging will be allowed to recover before sampling. The sample will be obtained as soon as a sufficient volume of groundwater to fill all sample containers has entered the well. The IDWMP discusses treatment and disposal of purge water.

Samples will be placed in containers and preserved according to Navy Level D protocol and will be analyzed within the proper holding time. For volatile organic analysis (VOA) the bottles will be filled to minimize aeration of the samples. Sample vials will be filled completely and will be capped to prevent the entrapment of air bubbles in the vial.

The bottle cap should be removed carefully from the laboratory-cleaned sample bottle. The cap should not be laid down, and the inside should not be touched. At no time should the inside of the bottle come into contact with anything other than the sample.

All appropriate preservatives will be added to the sample containers by the contracted laboratory before the containers are shipped to the CH2M HILL field team. Low concentration VOA samples will be preserved with hydrochloric acid (HCl), TAL metals samples will be preserved with nitric acid (HNO_3), and cyanide samples will be preserved with sodium hydroxide (NaOH). All samples will be kept cool at 4°C by using bagged ice.

Table 4-1
SUMMARY OF GROUNDWATER SAMPLES TO BE SUBMITTED FOR ANALYSIS - SITE 5

Matrix	Laboratory Parameter	Samples	Field Duplicates[1]	Field Blanks[2]	Trip Blanks[3]	Matrix Spikes[4]	Equipment Blanks[5]	Matrix Total
Groundwater	Low Concentration Volatiles	3	1	1	1	0	2	8
	TCL Semivolatiles	3	1	1	0	1	2	8
	TCL Pesticides/PCBs	3	1	1	0	1	2	8
	TAL Metals (filtered)	3	1	1	0	1	2	8
	TAL Metals (unfiltered)	3	1	1	0	1	2	8
	TAL Cyanide	3	1	1	0	1	2	8
SUMMARY OF GROUNDWATER SAMPLES TO BE SUBMITTED FOR ANALYSIS - SITE 21								
Groundwater	TCL PCBs (filtered)	2	1	1	0	1	1	6
	TCL PCBs (unfiltered)	2	1	1	0	1	1	6

Notes:
[1]Field duplicates are collected at a frequency of 1 per 10.
[2]Field blanks are collected at a frequency of 1 per source per event.
[3]Trip blanks are shipped with water samples submitted for volatiles analysis. Trip blanks are used to monitor contamination that could be introduced during transportation. Trip blanks are collected at a frequency of 1 per cooler of volatiles samples.
[4]Matrix spike/matrix spike duplicates (MS/MSD) are collected at a frequency of 1 per 20. MS/MSDs represent samples for which extra volume must be collected for the laboratory to perform required QC analyses. Triple the normal volumes will be collected for all analyses. MS/MSD analysis not required when analyzing samples using the Low Concentration Volatile method.
[5]Equipment blanks are collected at a frequency of 1 every day.
Note: This table is based on Navy Level D QA/QC requirements.

The appropriate number of field QA/QC samples, including field blanks, rinsate blanks, and duplicates, will be analyzed in addition to laboratory QA/QC samples, including matrix spike and matrix spike duplicate samples.

RI Soil Sampling

Soil samples will be collected at Site 5. The locations, numbers, and depths of soil samples and sample-analysis methods are documented below. A description of soil-sampling techniques follows. New soil-sampling locations identified in this work plan are subject to change in the event of utility clearance problems or other unforeseen circumstances.

Soil-Sample Numbers and Locations

During monitoring-well installation, three soil samples will be collected from each boring by using a split-spoon sampler. Soil samples will be collected from depths of 0-1 foot, 3-4 feet, and 6-7 feet below ground surface in each well boring. Soil borings will be logged in the field to establish a physical description of the subsurface.

Four additional surface-soil samples will be collected from 0-1 foot below ground surface by using a hollow-stem auger drill rig with a split-spoon sampler. The sampling locations will be distributed across the site at locations not covered by asphalt.

The soil samples will be analyzed for TCL organics (includes volatiles, semivolatiles, pesticides, and PCBs) and TAL inorganics. Standard EPA methods, including Contract Laboratory Program (CLP) statement of work (SOW) procedures, will be followed. Table 4-2 documents the sample designations and analyses performed for each sample. Figure 4-1 depicts the locations of the soil borings and the surface soil samples listed in Table 4-2.

The analytical data collected during the 1988 RI will be considered during our investigation. However, the 1988 data will not be validated or incorporated into the risk assessment.

Soil-Sampling Techniques

The RI/FS and the PA/SI will involve collecting soil samples. Soil borings and surface-soil samples will be collected by using a hollow-stem auger drill rig equipped with a split-spoon sampler. Two sampling techniques will be used during the soil-sampling phase of this investigation: split-spoon sampling and manual sampling with a stainless steel trowel. Both sampling techniques are explained briefly below. SOPs for collecting soil samples are located in Attachment A of the FSP.

Split-Spoon Sampling

Techniques for split-spoon sampling will be used at locations where samples are being collected from several different depths, from beneath asphalt or concrete, or where compaction of the soil has made manual sample collection impossible. A drill rig will be used to advance 6 1/4-inch hollow-stem augers to the top of the desired sampling interval. A stainless steel split-spoon sampling device will be attached to the proper length of drilling rod and inserted through the hollow-stem augers. A 140-pound hammer will be used to advance the split-spoon sampling device the additional 2 feet required for sample collection. If necessary, several samples within a 1-foot-diameter area will be collected at each location to acquire the volume of sample needed to fill all sample containers. The

Table 4-2
SUMMARY OF SOIL SAMPLES TO BE SUBMITTED FOR ANALYSIS - SITE 5

Matrix	Laboratory Parameter	Samples	Field Duplicates[1]	Field Blanks[2]	Trip Blanks[3]	Matrix Spikes[4]	Equipment Blank[5]	Matrix Total
Soil	TCL Volatiles	10	1	1	5	1	2	20
	TCL Semivolatiles	10	1	1	0	1	2	15
	TCL Pesticides/PCBs	10	1	1	0	1	2	15
	TAL Metals and Cyanide	10	1	1	0	1	2	15
SUMMARY OF SOIL SAMPLES TO BE SUBMITTED FOR ANALYSIS - SITE 21								
Soil	TCL PCBs	14	2	1	0	1	1	19

Notes:
[1]Field duplicates are collected at a frequency of 1 per 10.
[2]Field blanks are collected at a frequency of 1 per source per event.
[3]Trip blanks are shipped with samples submitted for volatiles analysis. Trip blanks are used to monitor contamination that could be introduced during transportation. Trip blanks are collected at a frequency of 1 per cooler of volatiles samples.
[4]Matrix spike/matrix spike duplicates (MS/MSD) are collected at a frequency of 1 per 20. MS/MSDs represent samples for which extra volume must be collected for the laboratory to perform required QC analyses. Triple the normal volumes will be collected for all analyses.
[5]Equipment blanks are collected at a frequency of 1 every day.
Note: This table is based on Navy Level D QA/QC requirements.

split-spoon sampler then will be retrieved, and the sample will be extruded. When the sample is collected from the surface (0-1 foot) the split spoon will be advanced without using augers.

The VOC sample containers will be filled with soil first. The soil sample will be placed directly in the VOC sample container to minimize the volatilization of organic compounds. The remaining soil sample will be placed in a stainless steel bowl and will be mixed thoroughly. After mixing, all other soil-sample containers will be filled.

Soil-boring sampling holes will be backfilled with grout and asphalt. Concrete surfaces will be repaired with like material as necessary.

Stainless Steel Trowel

A stainless steel trowel will be used to collect shallow soil samples in areas where manual soil sampling is appropriate. The trowel will be used to transfer the soil or sediment from the sampling location into the sample containers. The VOC sample containers will be filled first. The sample will be placed directly in the VOC sample container to minimize the volatilization of organic compounds. The remaining sample volume will be placed into a stainless steel bowl and will be mixed thoroughly. After mixing, all other sample containers will be filled.

All soil samples will be placed in clean glass containers provided by the laboratory. Any sample that is split for duplicate analysis will be mixed thoroughly before being split (except for VOCs).

The appropriate number of field QA/QC samples, including field blanks, rinsate blanks, and duplicates, will be analyzed in addition to laboratory QA/QC samples, including matrix spike and matrix spike duplicate samples.

Preliminary Assessment/Site Investigation

Activities associated with PA/SI field activities are documented below. Detailed descriptions of activities common to both the RI/FS (documented above) and the PA/SI are referenced below but are not repeated.

Preliminary Assessment

The PA of Site 21 (the Building 316 PCB Waste Work Area) will consist of gathering and reviewing information from various sources. Categories of base personnel to be interviewed, questions to be asked, and sources of historical documentation will be identified before the PA begins. This part of the investigation will include the following components:

- Review of site management practices using available site documents and interviews with base personnel
- Analysis of photographs and historical aerial photographs
- Site visit for determining the existing potential for release

Site Investigation

The SI of Site 21 will consist of well drilling, groundwater and soil sampling, and surveying. Drilling and sampling locations are described below. The descriptions of drilling and sampling techniques and surveying operations, previously described as RI activities above, will not be repeated.

SI Monitoring-Well Installation

Two shallow monitoring wells will be installed by using hollow-stem auger drilling with split-spoon sampling at Site 21. Figure 4-2 shows the approximate proposed locations of the wells. One monitoring well will be installed at the suspected center of the documented April 25, 1990, PCB oil spill to monitor groundwater quality in the suspected contaminated zone. A second monitoring well will be installed 30 feet hydraulically downgradient toward Willoughby Bay, to determine if groundwater contamination has migrated from the proximity of the spill. Both wells will be constructed with 2-inch-diameter PVC risers with 10-foot screens. The screens will span the water-table. Both wells will be approximately 25 feet deep. Geologic and well-construction logs will be prepared for each well.

One round of water-level measurements will be performed at Site 21 after the water levels in both wells have reached an equilibrium state in relation to the water-table aquifer. Monitoring-well locations at Site 21 are subject to change after completion of an interviewwith Base personnel about the location and extent of the PCB oil spill and potential utility clearance problems or other unforeseen circumstances.

SI Groundwater Sampling

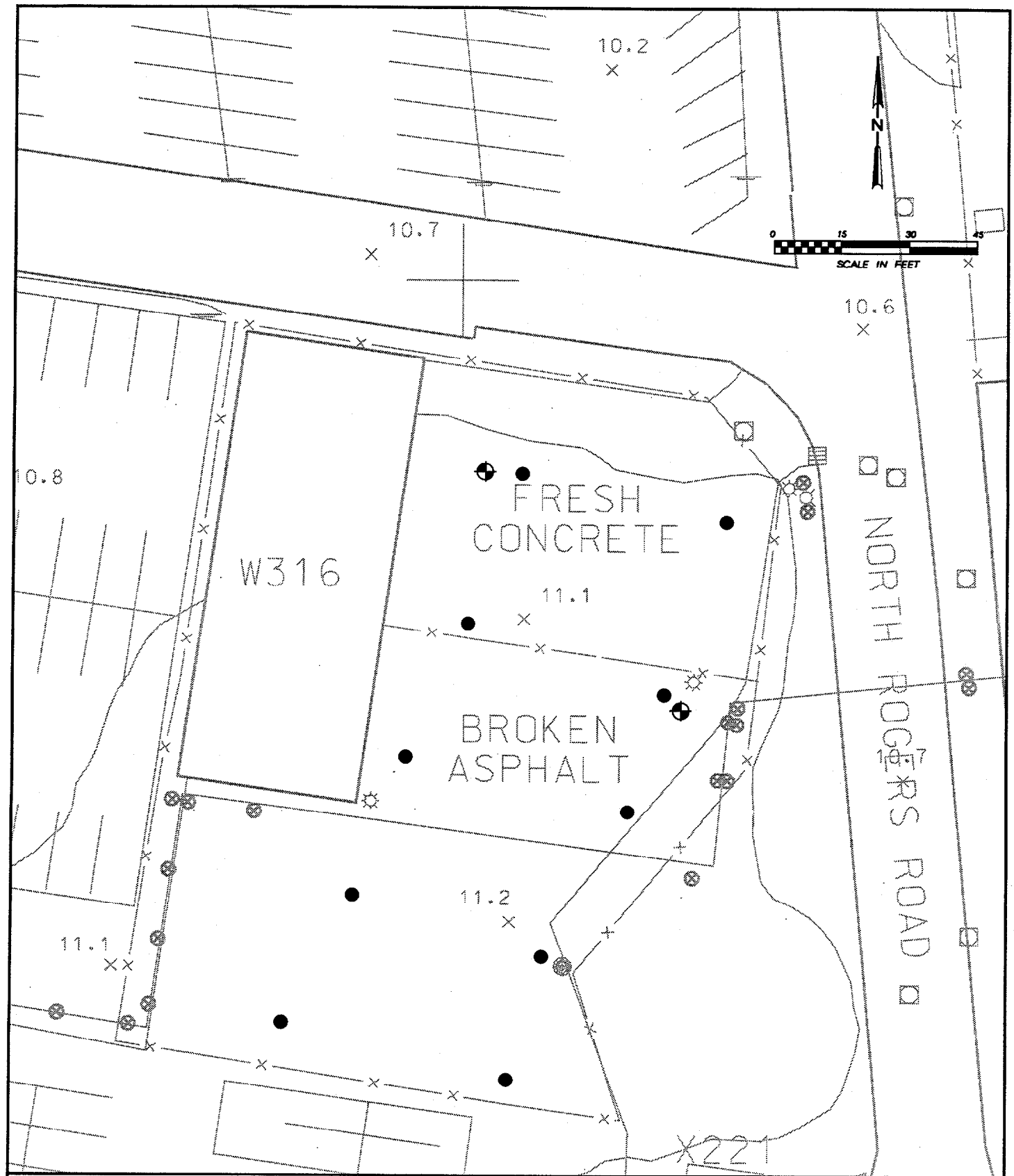
Groundwater samples will be collected from the two newly installed monitoring wells approximately 2 weeks after installation using a Grundfos® Redi-Flo2 sampling pump. Filtered and unfiltered groundwater samples will be collected and analyzed for PCBs. Filtering of PCB samples may result in contaminant losses because of sorption, and this potential for PCB losses in the filtered sample will be taken into account during data validation. Standard EPA methods, including CLP SOW procedures, will be followed during sample analysis. The appropriate number of field QA/QC samples, including field blanks, rinsate blanks, and duplicates, will be analyzed in addition to laboratory QA/QC samples, including matrix spike and matrix spike duplicate samples. Water-level elevations will be measured from both wells before sampling.

Table 4-1 documents the sample designations and analyses to be performed for each sample. Figure 4-2 depicts the locations of the wells and samples listed in Table 4-1. These locations will be modified once additional information on the location of the PCB oil spill is obtained.

SI Soil Sampling

During monitoring-well installation, two soil samples will be collected from each boring by using a drill rig equipped with a split-spoon sampler. Soil samples will be collected from depths of 3 and 6 feet below ground surface in each well boring. Soil borings will be logged in the field to establish a physical description of the subsurface.

Soil-sampling locations at Site 21 are subject to change after completion of an interview with Base personnel about the location and extent of the PCB oil spill and potential utility clearance problems or other unforeseen circumstances. Surface-soil samples will be



LEGEND

- PROPOSED GROUNDWATER MONITORING WELL LOCATION*
- PROPOSED SOIL SAMPLING LOCATION*

* LOCATIONS SUBJECT TO CHANGE BASED UPON INTERVIEW WITH BASE PERSONNEL

Figure 4-2
PROPOSED MONITORING WELL AND SOIL SAMPLING LOCATIONS
SITE 21 - BUILDING W316, PCB WASTE WORK AREA
Naval Base, Norfolk

CH2M HILL

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collected from 10 locations during the SI activities to determine whether PCBs are in soil in the vicinity of Building W-316. Three of 10 soil samples will be collected around the location of the April 25, 1990, PCB oil spill (a monitoring well with soil borings will be installed at the suspected center of the spill site). Because the location of the spill was not known by CH2M HILL at the time this work plan was drafted, Figure 4-2 does not show this monitoring well and cluster of soil sampling locations. The remaining seven soil-sampling locations will be distributed around the site. The data will allow a preliminary characterization of the nature and distribution of PCB contamination at the site.

Soil borings and surface-soil samples will be analyzed for PCBs. Standard EPA methods, including CLP SOW procedures, will be followed. Table 4-2 lists the sample designations and the analyses to be performed for each sample. Figure 4-2 depicts the locations of the soil borings and surface-soil samples listed in Table 4-2.

Surveying

A subcontracted surveyor licensed in the State of Virginia will provide horizontal and vertical coordinates for the newly installed monitoring wells and horizontal coordinates for the soil-sampling locations for the RI/FS and PA/SI.

The top of the PVC casing in the monitoring wells and ground-surface elevations will be established during this task. Where necessary, the survey contractor will convert the base sea-level datum to the U.S. Geological Survey (USGS) mean sea-level datum. In addition, permanent landmarks (e.g., building corners) will be surveyed as appropriate.

Task 4: Sample Analysis and Data Validation

CH2M HILL will be responsible for tracking sample analyses and obtaining results from the laboratory. The analytical data generated during the RI/FS and PA/SI field programs will be validated by an independent data validation subcontractor according to standard EPA procedures.

Sample Analysis

All analyses of soil and groundwater will be conducted at a contracted laboratory that fulfills all requirements of the U.S. Navy's QA/QC Program Manual and EPA's CLP. A signed certificate of analysis will be provided with each laboratory analysis, along with a certificate of compliance certifying that all work was performed in accordance with applicable federal, state, and local regulations. All analyses will be performed following the Navy's guidance for Level D.

Field QC Procedures

Quality control duplicate samples and blanks are used to provide a measure of the internal consistency of the samples and to provide an estimate of the components of variance and the bias in the analytical process. Table 10-1 in the QAPP is a summary of the collection frequencies of the field QC samples.

Blanks

Blanks provide a measure of cross-contamination sources, decontamination efficiency, and other potential errors that can be introduced from sources other than the sample. ASTM Type II water will be used for blanks. Three types of blanks will be generated during sampling activities: trip blanks, field blanks, and equipment blanks.

One trip blank will be included in each cooler containing samples for VOC analysis. Preprepared trip blanks will be obtained from the laboratory, if possible. Otherwise, the trip blanks will be prepared before each sampling event, shipped or transported to the field with the sampling bottles, and sent to the laboratory unopened for analysis. Trip blanks will not be prepared or handled in the field. Trip blanks will indicate if contamination occurred during shipment to the field, field storage, or shipment from the field to the analytical laboratory.

One field blank will be collected per source, per sampling event, or daily during windy or dusty conditions. The field blanks will indicate if contaminants were introduced during the handling of the sample containers in the field or during sample analysis at the laboratory. The sample container will be filled with ASTM Type II water in the field at the time of sampling. Prepreserved bottles will be obtained from the laboratory, if possible. Otherwise, preservatives will be added in the field. Field blank sample containers will be capped, packed, and shipped with the samples.

One equipment blank will be collected and analyzed every day during sampling activities. The equipment blanks will indicate the efficiency of equipment decontamination procedures. Prepreserved bottles will be obtained from the laboratory, if possible. Otherwise, preservatives will be added in the field. Field blank sample containers will be capped, packed, and shipped with the samples.

Duplicates

Field duplicate samples will be collected at a frequency of 1 per 10 field samples per matrix. The location from which the duplicates are taken will be selected randomly. The duplicate sample will be submitted for analysis as an independent sample. The sample and its duplicate will be numbered nonsequentially.

Matrix Spike/Matrix Spike Duplicate (MS/MSD)

Matrix spike/matrix spike duplicate (MS/MSD) samples will be collected at a frequency of 1 per 20 field samples. Analytical results of these samples indicate the effect the matrix (water and soil) has on extracting the analyte for analysis. Data validators will use these results to evaluate the accuracy of the analytical data.

Data Validation

All RI/FS and PA/SI data will be validated before the project staff performs an interpretation. The data will be validated by an independent subcontractor and will conform to the Navy's guidance for Level D. Data that should be qualified will be flagged with the appropriate symbol. Results for QA/QC samples will be reviewed, and the data will be qualified further, if necessary. Finally, the data set as a whole will be examined for consistency, anomalous results, and reasonableness.

Task 5: Risk Assessment

This task includes the preparation of a baseline risk assessment (BLRA) and a baseline ecological risk assessment (BERA) for Site 5; no risk assessments will be performed for Site 21. The risk assessments will be conducted in accordance with current EPA national and Region III guidance.

RI Baseline Human Health Risk Assessment

A BLRA will be performed for the RI of Site 5 to assess the potential human health risks posed by the site. The risk assessment will evaluate the potential effects of existing site contamination on both current and potential future exposed populations. Future risks will be based on current site conditions, assuming no additional remedial action is conducted at the site. The future use of the site is expected to remain industrial. Although groundwater beneath the site and the areas surrounding the site is not currently used as a potable water supply and groundwater in the aquifer beneath the site is classified as nonpotable, a future industrial groundwater-use scenario will be evaluated for information and decision-making. Federal and state applicable or relevant and appropriate requirements (ARARs) will be identified and compared with the RI data under this task.

The risk assessment will be completed in accordance with EPA's *Risk Assessment Guidance for Superfund (RAGS), Volume I - Human Health Evaluation Manual (Part A),* dated December 1989, *RAGS* Parts B and C dated December 1989, and EPA Region III guidance. The exposure factors in RAGS have been superseded by OSWER Directive 9285.6-03, *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors,* dated March 1991. Dermal permeability coefficients will be taken from *EPA's Interim Guidance for Dermal Exposure Assessment,* dated January 1992. Other required exposure factors may be taken from *Exposure Factors Handbook* (EPA, 1989) and the American Industrial Health Council's *Exposure Factors Sourcebook* (AIHC, May 1994). The risk assessment will contain the following major components:

- Data evaluation and identification of chemicals of potential concern
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Uncertainty analysis

The first step of the risk assessment will be to select contaminants of potential concern (COPC). The selection criteria in EPA Region III's *Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening,* January 1993, will be followed to determine which chemicals will be evaluated quantitatively. This methodology includes evaluating data quality, reducing the data set using risk-based concentrations (based on a target cancer risk of 1×10^{-6} and a target hazard index of 0.1), and further reducing the data set according to frequency of detection, comparison to background, and evaluation as human nutrients. Data collected during this investigation and data collected during previous investigations that have been validated will be evaluated for use in the risk assessment.

The second step of the risk assessment will be to identify actual or potential exposure pathways and to determine the probable magnitude of human exposure. Only plausible and complete pathways will be carried through the exposure-quantification section to the

risk characterization. A complete pathway contains a source of chemical release, a medium for environmental transport, a point of contact with the contaminated medium, and an exposure route at the point of contact. The pathways that are anticipated to be complete at Site 5 are those listed in Table 4-3. Only soil and groundwater samples have previously been collected and will be collected during this investigation, so only exposure to these media will be evaluated.

Quantification of exposure involves determining the exposure concentration and exposure parameters. The sources that will be consulted for the exposure parameters are discussed above. The exposure concentrations will be calculated for each scenario. The 95 percent upper confidence limit of the mean (95UCL) will be used as the exposure concentration for soil. The 95UCL calculation depends on the distribution of the data. A W-test will be used to determine if the data are lognormally or normally distributed. If the 95UCL is greater than the maximum detected concentration, the maximum detected concentration will be used as the exposure concentration. The exposure concentration for groundwater will be the concentration of each constituent detected in the well or group of wells that are the most contaminated or are located in the center of the plume.

For calculating the exposure concentrations for the risk assessment, the following data-handling methodology will be used. When a primary sample and a duplicate sample are collected, the maximum concentration will be used as the sample concentration. Half the sample quantitation limit (SQL) or sample detection limit (DL) will be used for cases where no detectable contaminant quantities were found in that specific sample, but the contaminant was detected in that medium for that group of samples. Data that have been qualified with a "J" (estimated value) during data validation will be treated as unqualified detected concentrations. Data qualified with an "R" (rejected) will not be used for risk assessment and will not be included in the total count of samples analyzed for a constituent. The assumption will be that the blank-related concentration of a constituent qualified with a "B" is the SQL.

The next step of the risk assessment is the toxicity assessment. The primary source of toxicological data to be used in the analysis will be EPA's Integrated Risk Information System (IRIS) database. If toxicological data for a particular constituent are not available in IRIS, EPA's *Health Effects Assessment Summary Tables* (HEAST) will be consulted. This section will include a brief discussion of the toxicological characteristics of the major site contaminants and the quantitative approach used to assess the potential effects of the carcinogenic and noncarcinogenic effects on human health.

Risk characterization is the next step in the baseline human health risk assessment. It combines the results of the exposure assessment with the critical toxicity values in the appropriate media for each COPC. For quantitative risk estimation from carcinogenic chemicals, excess lifetime cancer risks will be estimated. Potential risks from noncarcinogenic chemicals will be presented using the hazard index approach. If estimated risks approach the EPA threshold values, a Monte Carlo risk analysis will be performed.

The last section will be a discussion of uncertainty that provides the limits and assumptions for the results of the risk characterization. The discussion will include a qualitative sensitivity analysis of the exposure assumptions.

Table 4-3
Pesticide Disposal Site (Site 5), Norfolk Naval Base
Summary of Exposure Pathways and Potentially Exposed Populations

Scenario	Exposure Route	Baseline Risk Assessment
Current Site Use		
Trespasser (Adult and Child 6 - 16 years old)		
Surface Soil	Ingestion Dermal Inhalation	X X X
Worker		
Surface Soil (site worker)	Ingestion Dermal Inhalation	X X X
Future Use		
Worker		
Surface and Subsurface Soil (construction worker)	Ingestion Dermal Inhalation	X X X
Groundwater (site worker)	Ingestion Dermal Inhalation	X
X designates pathway that will be evaluated		

The results of the BLRA will be documented in the RI report. The risk assessment will be used to help determine whether remediation is necessary and to help develop preliminary remediation goals for the media of concern.

RI Baseline Ecological Risk Assessment

A BERA will be performed for the RI of Site 5. The BERA will identify and evaluate the potential effects of the contamination on biota in the area. The characterization of environmental risks will involve identifying potential exposures to the surrounding ecological receptors and evaluating potential effects associated with such exposures. The BERA will be conducted in accordance with *Risk Assessment Guidance for Superfund Volume II: Environmental Evaluation Manual* (EPA, 1989), Region III's supplementary risk assessment guidance, and other appropriate guidance.

The BERA will include the following activities:

- Collection of existing data for use in the characterization of land use, soil, topography, and flora and fauna
- Identification of habitats in potentially exposed areas through review of reports, aerial photography, contacts with resource agencies having knowledge of environmental resources in the vicinity of the site, and site reconnaissance
- Collection of existing information to determine the presence of historical or archaeological resources, threatened or endangered species, critical habitats, wetlands, or other features
- Inventory of terrestrial species
- Selection of contaminants of concern on the basis of calculation of environmental effects quotients, toxicity characteristics, bioaccumulation potential, and environmental persistence
- Determination of contaminants of concern for ecological resources by using Biological Technical Assistance Group screening criteria
- Assessment of exposure pathways and toxicity for the contaminants of concern
- Assessment of risk to ecological receptors
- Definition of issues, exposure pathways, and potential effects that might need to be addressed in future assessments

Task 6: RI and PA/SI Report

This task documents activities associated with RI and PA/SI report preparation. The RI report preparation is documented first, and a description of PA/SI report preparation follows.

RI Report

The results of the investigation and the human health and ecological risk assessment will be compiled in an RI report. This report will address sites, the Pesticide Disposal Site at Naval Base, Norfolk, and will include the following items:

- History and background of the site, including previous studies
- Features and environmental setting
- RI activities
- Sampling and analytical methods
- Presentation and evaluation of the analytical data
- Discussion of the nature and extent of contamination
- Results of the BLRA and the BERA

The RI report will include, as appropriate, site maps with sampling locations, boring logs, cross sections, raw and validated analytical data, and figures that depict the extent of soil and groundwater contamination.

The report will document recommendations and supporting information to justify the recommendations. The information collected and presented in the RI report will be used to prepare the FS. A draft, draft final, and final RI document will be prepared as part of this task.

PA/SI Report

A PA/SI report will be prepared to document the results of the soil and groundwater characterizations at Site 21. Data analyses will include evaluations of validated laboratory data and field-generated data, such as water-level measurements, soil-boring logs, and monitoring-well construction logs. The report will contain geologic cross-section diagrams and other diagrams associated with field notes or data received from the laboratory (e.g., sampling-location maps, isoconcentration maps) as applicable.

Data will be compiled into electronic form to facilitate analysis and generation of figures and tables. The results of the PA and the SI will be compiled in one report. The PA will include brief summaries of the following:

- History and background of the site
- Potential contaminant transport via groundwater
- Potential contaminant transport via surface water
- Potential contaminant transport via soil
- Potential contaminant transport via air

Draft and draft final PA reports will be produced following background investigation. The final PA report will be produced in conjunction with the final SI report. The SI report will consist of standard forms that address site information and waste-source information. Results of soil and groundwater sampling will be shown, and a hazard assessment will be presented that incorporates the results of the entire investigation. Recommendations for further action will be presented. Draft, draft final, and final SI reports will be produced.

Task 7: Feasibility Study

CH2M HILL will conduct an FS for Site 5. The FS will involve a remedial alternatives screening and a remedial alternatives evaluation. A description of the FS follows.

Remedial Alternatives Screening

CH2M HILL will develop a range of distinct alternatives for waste management that, if implemented, would potentially remediate or control contaminated media (e.g., soil, groundwater) as deemed necessary in the RI to provide adequate protection of human health and the environment. On the basis of existing information and information obtained from the RI, site-specific remedial objectives to protect human health and the environment will be developed. The objectives will specify the contaminants and media of concern, the exposure routes and receptors, and an acceptable contaminant level or range of levels for each exposure route (e.g., preliminary remediation goals, or PRGs). The PRGs will be based on readily available information, such as reference doses or chemical-specific ARARs, such as maximum contaminant levels (MCLs), and the results of the risk assessment.

General-response actions will be developed for each medium of concern. Volumes or areas to which general-response actions may apply will be identified, taking into account the requirements for protectiveness as identified in the remedial action objectives and the chemical and physical characteristics of the site.

CH2M HILL will identify and screen alternative remedial actions that will address the general-response actions. This will be a two-step process that entails identifying and screening individual technologies on the basis of a technology's ability to address contaminants at the site effectively, as well as implementability and relative cost. The identification and screening step will be followed by the conversion of applicable technologies into alternatives and screening those alternatives on a general basis for their effectiveness, implementability, and relative cost.

The cost of technologies and remedial action alternatives developed at this stage of the FS will be evaluated to facilitate the development of both RA alternatives applicable to site problems and relative order-of-magnitude costs by which the technologies or alternatives may be screened. Candidate technologies that might be applicable to site conditions will be considered in developing RA alternatives. For these technologies, means such as contacting technology vendors or previous experience on other projects will be used to generate relative order-of-magnitude costs for screening alternatives.

The following soil-remediation alternatives will be developed:

- No action
- Institutional controls
- *In situ* treatment
- Excavation and onsite or offsite treatment
- Containment and/or capping

The following groundwater remediation alternatives will be developed:

- No action
- Institutional controls with monitoring

- Air sparging or other appropriate *in situ* treatment method
- Extraction and treatment

Remedial Alternatives Evaluation

A detailed analysis will be performed on soil and groundwater remedial alternatives that pass the screening process. The analysis will consist of individual and comparative evaluations based on the criteria given on USEPA guidance 540/G-89/004, EPA Region III guidance, and other appropriate guidance, including the following:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness implementability
- Cost
- State acceptance
- Community acceptance

The results of the detailed alternatives analysis will be the formulation and documentation of recommendations for one or more feasible actions that might be implemented to address Site 5 contamination.

Task 8: Feasibility Study Report

A report will be prepared that documents the results of the FS for Site 5. All steps taken during the screening and evaluation of remedial alternatives will be described. Several remedial alternatives and their estimated costs will be provided to cover a wide range of technologies and costs.

A draft FS report will be submitted as a separate document. However, the final FS report will be submitted with the final RI report.

Task 9: PRAP and ROD Reporting

A draft, draft final, and final proposed remedial action plan (PRAP) will be prepared as part of this task. The plan will include appropriate components, as described in *Guidance for Preparing Superfund Decision Documents*, EPA/540/G-89/007, July 1989; EPA Region III guidance; and other appropriate guidance.

A draft, draft final, and final record of decision (ROD) will be prepared in accordance with USEPA guidance, as noted above. The public notice on the proposed PRAP also will be prepared.

Section 5

Staff Organization

This section presents general information on project management and staff organization.

Project Management

Project management will include the overall coordination of all work to be performed at the site. The management structure for CH2M HILL is designed in such a way that there is one central administrative point of contact, the Activity Manager, and multiple technical project managers, each of whom will manage each technical task as his or her expertise is required. The Activity Manager will maintain close contact with the LANTDIV NTR.

The Activity Manager will oversee and coordinate each project to maintain the overall project schedule and will coordinate the preparation of the monthly progress report. In addition, the Activity Manager and the technical project managers will conduct weekly internal program review meetings to update all team members on individual project status and upcoming technical needs and to discuss technical issues that might affect the course or the completion of other technical tasks. After the weekly internal review meetings the Activity Manager will relay pertinent issues to the LANTDIV NTR. The Activity Manager also will provide general program support, interact with client and regulatory agencies, and document decisions on technical issues that might affect future work at the Base.

The responsibilities of the technical project managers include such activities as the preparation and submittal of Navy Clean daily reports, daily technical support and oversight, budget and schedule review and tracking, preparation and review of invoices, personnel-resource planning and allocation, and project-specific coordination with LANTDIV, the Activity, and subcontractors.

Project-Specific Organization

The Activity Manager, Mr. Michael Tilchin, will be the primary point of contact for the project and will provide guidance to the Project Manager. The Project Manager, Mr. Jack Robinson, will be responsible for such activities as review and tracking of budget and schedule, preparation and review of invoices, planning and allocation of personnel resources, and coordination with LANTDIV, the Base, and subcontractors. The RI/FS field investigation tasks (soil, sediment, surface water, and groundwater sampling) will be performed by supporting field personnel. In addition, Mr. Doug Dronfield, Dr. Robert Root, and Mr. Steve Romanow will perform senior review during the project. The project organizational chart is depicted in Figure 5-1.

Before initiating field activities, CH2M HILL will notify LANTDIV and the Base about which CH2M HILL personnel will mobilize to the site. CH2M HILL also will notify the appropriate Base personnel to acquire site access and utility clearances. The LANTDIV

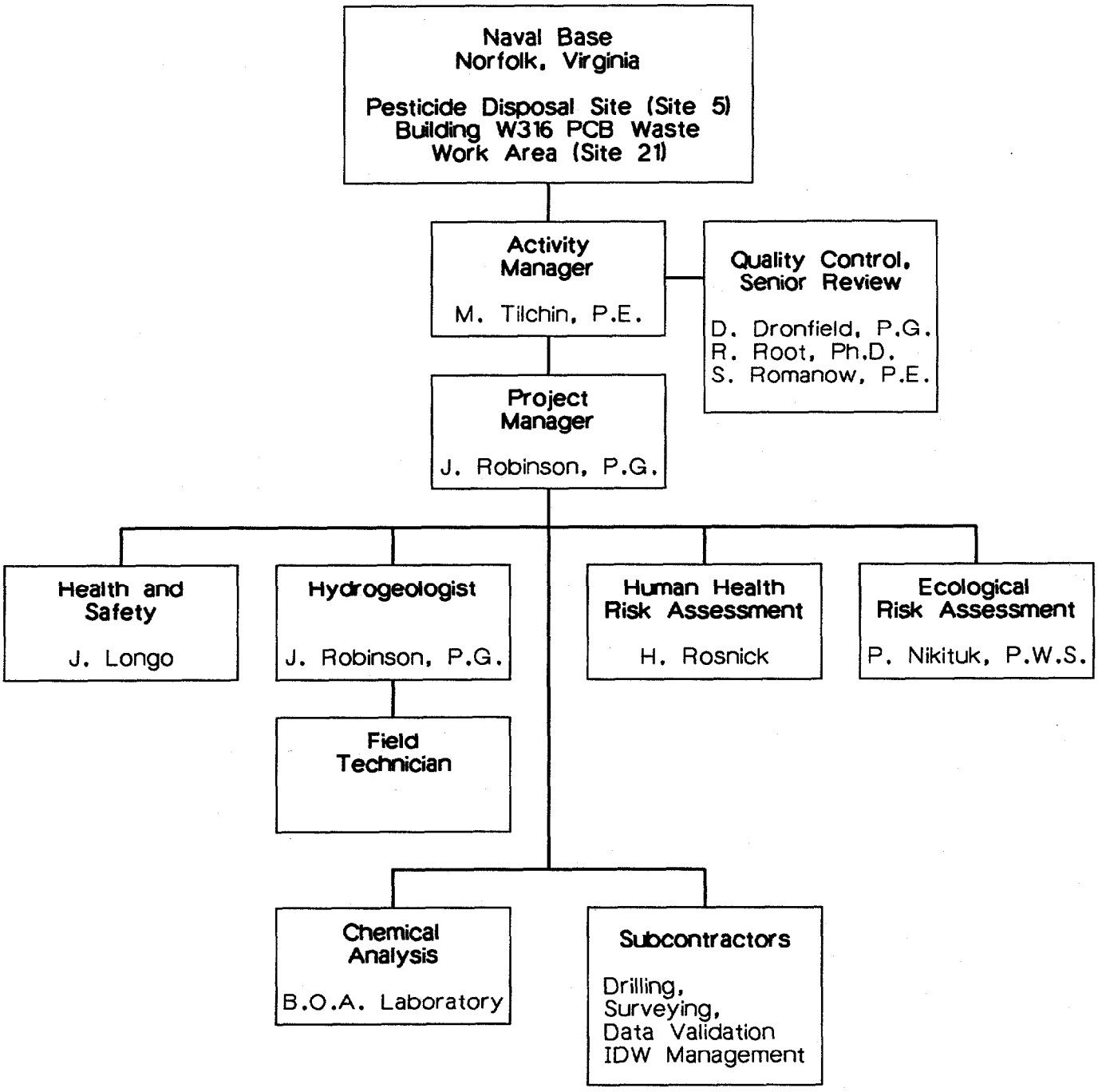

Figure 5-1
PROJECT ORGANIZATION
SITE 5 - PESTICIDE DISPOSAL AREA
SITE 21 - BUILDING W316
PCB WASTE WORK AREA
Naval Base, Norfolk

CH2M HILL

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NTR, Mr. Dave Forsythe, and the COMNAVBASE Program Manager, Ms. Dianne Bailey, will be advised of all site activities and schedules before site operations begin. The names of Naval Base, Norfolk, contacts are shown below in Table 5-1.

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Table 5-1
Naval Base, Norfolk Contact List

Contact Person	Responsibility	Department	Phone Number	Fax Number	Location on Base
Mr. Dave Forsythe	Environmental Engineer and NTR	Installation Restoration Section, LANTDIV	804-322-4783	804-322-4805	1510 Gilbert Street Norfolk, VA 23511-2699
Ms. Dianne Bailey	Program Manager, COMNAVBASE	Norfolk Naval Base Environmental	804-322-2900	804-444-3000	Suite 200 1520 Gilbert Street Norfolk, VA 23511-2979
Mr. Roger Hillers (or Mr. Rusty Carter)	Water, steam, sewage, electrical, and natural gas lines	Public Works	804-445-8558	804-445-9316	Building P71 9742 Maryland Ave. Norfolk, VA 23511-3095
Mr. Meryl Kauffman	Digging permits	Public Works	804-445-8558	804-445-9316	Building P71 9742 Maryland Ave. Norfolk, VA 23511-3095
Mr. Gonzalez	Fuel lines	Naval Base Fuel Department	804-444-3450	804-444-7333	On waterfront across from Pier 5
Mr. Romeo Santodomingo	Fuel lines	NAS Fuel Department	804-444-2625		
Mr. Jerry Fly	Communications lines	Communications	804-322-2045 804-475-6090 (Beeper)	804-445-6803	Building M51, Room 149
Mr. Paul Kidd	Survey monumentation	Code 405 (Civil/Survey)	804-322-4405	804-322-4415	Building N26, 3rd Floor

Note: The base phone numbers are in the process of being changed from 444- and 445- prefixes to a 322- prefix

Section 6

Contractual Services

This section documents the anticipated subcontract services required for completing tasks documented in this work plan. CH2M HILL is in the process of acquiring Basic Order Agreements (BOAs) with existing Navy Clean subcontractors used under the CLEAN I contract. BOAs will be negotiated with new subcontractors on as needed.

The RI/FS will require subcontract services from the following:

- Drilling Contractor
- Surveyor
- Analytical Laboratory
- Data Validation Contractor
- IDW Disposal Services

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Section 7

Project Schedule

This section documents the project schedule and the due dates of deliverables.

This project will be performed in accordance with the schedule and milestones presented in Figure 7-1. Tables 7-1 and 7-2 show a breakdown of primary-task deliverables and milestones and their respective due dates for the RI/FS and PA/SI, respectively. Government review periods also are tabulated. Periods of review that are longer than scheduled will result in an extended schedule.

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Table 7-1

PROPOSED PROJECT MILESTONES

RI/FS PESTICIDE DISPOSAL SITE (SITE 5)

CONTRACT TASK ORDER 003

Key Project Milestones	**Number of Days from Authorization**	**Interval**	**Date of Completion**
Authorization Date	0	0	3/14/96
Submit Draft Plans	30	30	4/13/96
LANTDIV/Activity Review of Draft Plans	60	30	5/13/96
Submit Draft Final Plans	75	15	5/28/96
LANTDIV/Activity/EPA/VDEQ Review of Draft Final Plans	105	30	6/27/96
Submit Final Plans	112	7	7/4/96
Notice to Proceed	113	1	7/5/96
Submit RI Risk Assessment Assumptions	118	5	7/10/96
LANTDIV/Activity Review of Draft RA Assumptions	133	15	7/25/96
LANTDIV/Activity/EPA/VDEQ Review of RI Risk Assessment Assupmtions	148	30	8/24/96
Procure Subcontractors (from Notice to Proceed)	128	15	9/8/96
RI/FS and PA/SI Fieldwork	168	40	10/18/96
Laboratory Analyses	198	30	11/17/96
Data Validation /Management	208	10	11/27/96
Submit Draft RI/FS Report	298	90	2/25/97
LANTDIV/Activity Review of Draft RI/FS Report	358	60	4/26/97
Submit Draft Final RI/FS Report	373	15	5/11/97
LANTDIV/Activity/EPA/VDEQ Review of Draft Final RI/FS Report	433	60	7/10/97
Submit Final RI/FS, Draft PRAP, Draft ROD	463	30	8/9/97
LANTDIV/Activity Review Draft PRAP, Draft ROD	493	30	9/8/97
Submit Draft Final PRAP and ROD	523	30	10/8/97
LANTDIV/Activity Review and Public Comment	553	30	11/7/97
Submit Final PRAP and ROD	583	30	12/7/97

Table 7-2

PROPOSED PROJECT MILESTONES

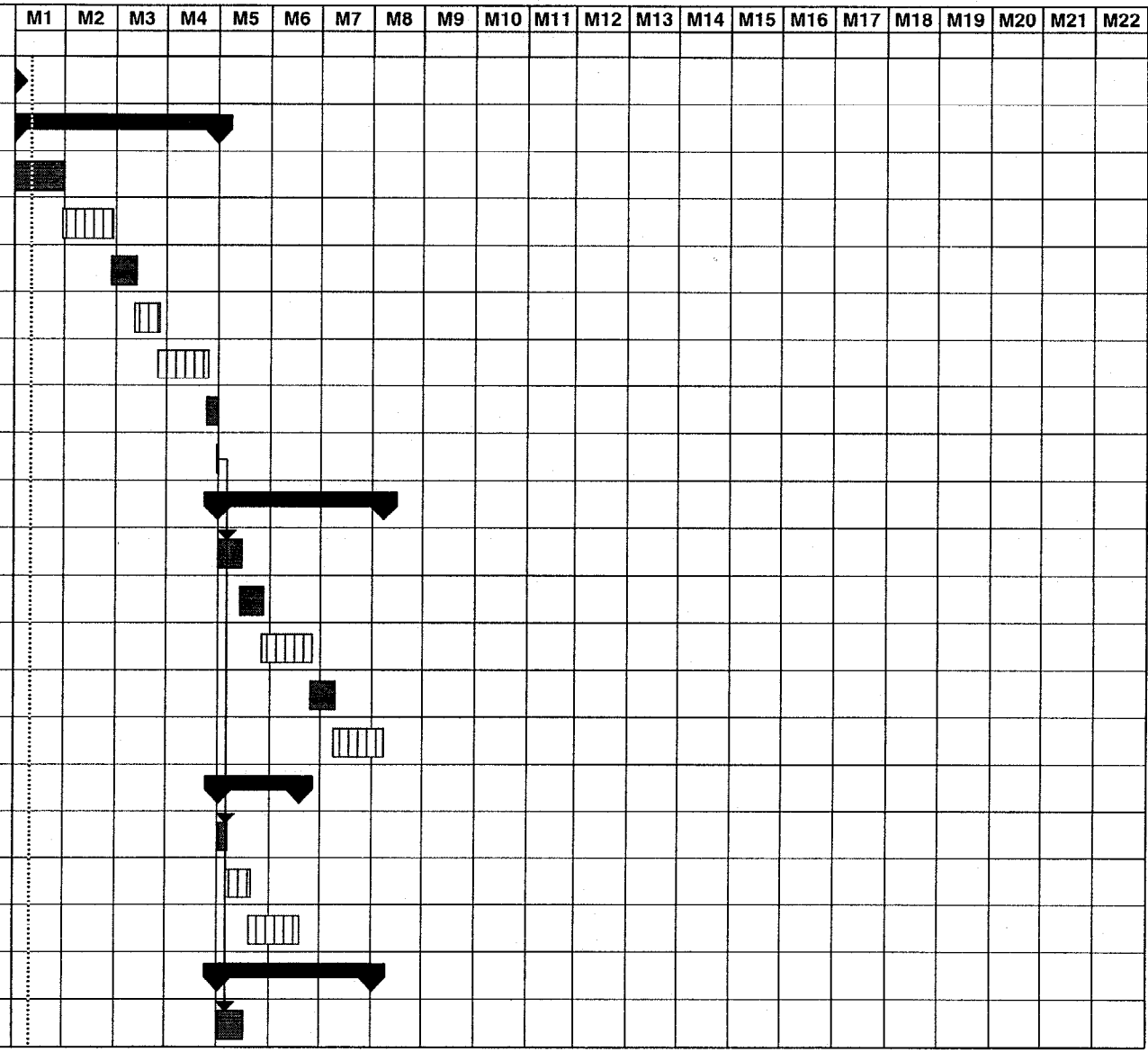
PA/SI BUILDING W-316 PCB WASTE WORK AREA (SITE 21)

CONTRACT TASK ORDER 003

Key Project Milestones	**Number of Days from Authorization**	**Interval**	**Date of Completion**
Authorization Date	0	0	3/14/96
Submit Draft Plans	30	30	4/13/96
LANTDIV/Activity Review of Draft Plans	60	30	5/13/96
Submit Draft Final Plans	75	15	5/28/96
LANTDIV/Activity/EPA/VDEQ Review of Draft Final Plans	105	30	6/27/96
Submit Final Plans	112	7	7/4/96
Notice to Proceed	113	1	7/5/96
Conduct Interviews for Preliminary Assessment (Site 21)	128	15	7/20/96
Submit Draft PA	142	14	8/3/96
LANTDIV/Activity Review of Draft PA	172	30	9/2/96
Submit Draft Final PA	187	15	9/17/96
LANTDIV/Activity/EPA/VDEQ Review of Draft Final PA	217	30	10/17/96
Procure Subcontractors (from Notice to Proceed)	128	15	11/1/96
PA/SI Fieldwork	168	40	12/11/96
Laboratory Analyses	198	30	1/10/97
Data Validation /Management	208	10	1/20/97
Submit Draft PA/SI Report	298	90	4/20/97
LANTDIV/Activity Review of Draft PA/SI Report	358	60	6/19/97
Submit Draft Final PA/SI Report	373	15	7/4/97
LANTDIV/Activity/EPA/VDEQ Review of Draft Final PA/SI Report	433	60	9/2/97
Submit Final PA/SI Report	463	30	10/2/97

FIGURE 7-1
SCHEDULE
CTO-0003 - RI/FS PESTICIDE DISPOSAL SITE (SITE 5) AND PA/SI BUILDING W-316 PCB WASTE WORK AREA (SITE 21)

ID	Milestone
1	Authorization Date
2	**Project Plans**
3	Submit Draft Plans (WP,SAP,IDWP,HASP)
4	Government Review of Draft Plans
5	Submit Draft Final Plans
6	Government Review of Draft Final Plans
7	EPA/VDEQ Review of Draft Final Plans
8	Submit Final Plans
9	Notice to Proceed
10	**Preliminary Assessment**
11	Conduct Interviews for Preliminary Assessment (PA Site 21)
12	Submit Draft PA Site 21
13	Government Review of Draft PA Site 21
14	Submit Draft Final PA Site 21
15	Government Review of Draft Final PA Site 21
16	**RI/FS Risk Assessment**
17	Submit RI Risk Assessment Assumptions (RA Site 5)
18	Government Review of Draft RA Assumption Site 5
19	EPA/VDEQ Review of RA Risk Assumptions Site 5
20	**PA/SI and RI Fieldwork**
21	Procure Subcontractors

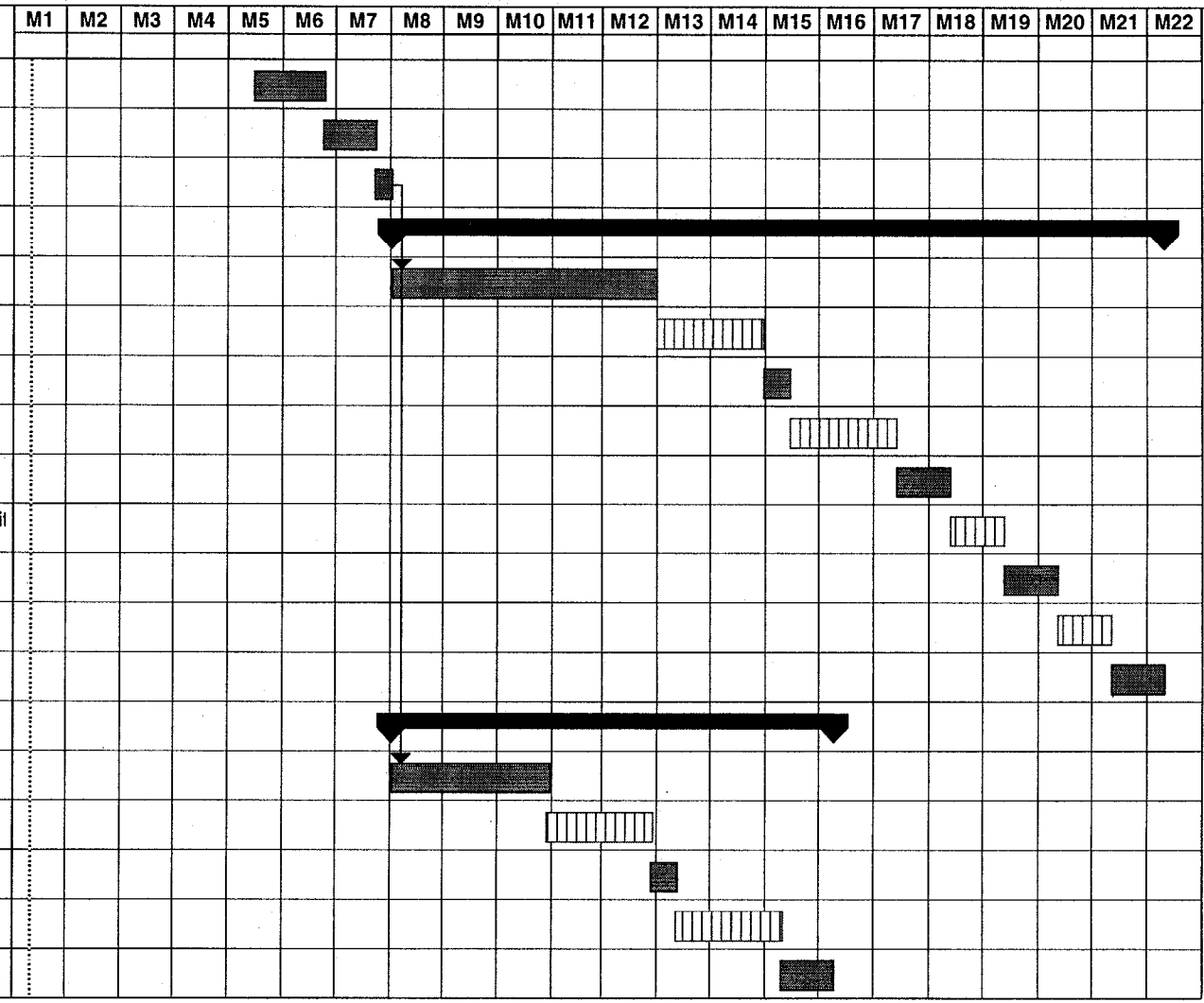


Project: CTO-0003 - RI/FS SITE 5 AND PA/SI SITE 21
NAVAL BASE, NORFOLK
DATE: 4/11/96

Government Review
Task
Summary
Milestone
Note: Timescale is in months from NTP

FIGURE 7-1
SCHEDULE
CTO-0003 - RI/FS PESTICIDE DISPOSAL SITE (SITE 5) AND PA/SI BUILDING W-316 PCB WASTE WORK AREA (SITE 21)

ID	Milestone
22	RI/FS (Site 5) and PA/SI (Site 2) Fieldwork
23	Laboratory Analyses
24	Data Validation/Management
25	**RI/FS Reporting**
26	Submit Draft RI/FS Report Site 5
27	Government Review of Draft RI/FS Report Site 5
28	Submit Draft Final RI/FS Report Site 5
29	EPA/VDEQ Review of Draft Final RI/FS Report Site 5
30	Submit Final RI/FS, Draft PRAP, Draft ROD Site 5
31	Government Review of Final RI/FS, Draft PRAP, Draft ROD Sil
32	Submit Draft Final PRAP and ROD Site 5
33	Government Review and Public Comment Period Site 5
34	Submit Final PRAP and ROD SIte 5
35	**PA/SI Reporting**
36	Submit Draft PA/SI Report Site 21
37	Government Review of Draft PA/SI Report Site 21
38	Submit Draft Final PA/SI Report Site 21
39	EPA/VDEQ Review of Draft Final PA/SI Report Site 21
40	Submit Final PA/SI Site 21



Project: CTO-0003 - RI/FS SITE 5 AND PA/SI SITE 21
NAVAL BASE, NORFOLK
DATE: 4/11/96

Government Review
Task
Summary
Milestone
Note: Timescale is in months from NTP

Final

Sampling and Analysis Plan
Remedial Investigation and Feasibility Study
Pesticide Disposal Site (Site 5)
and the
Preliminary Assessment/Site Investigation
Building W-316 PCB Waste Work Area (Site 21)

Norfolk Naval Base
Norfolk, Virginia

Contract Task Order 0003

August 15, 1996

Prepared for

Department of the Navy
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Naval Facilities Engineering Command

Under the

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Contract N62470-95-D-6007

Prepared by

CH2M HILL

Federal Group, Ltd.
Herndon, Virginia

Preface

This Sampling and Analysis Plan (SAP) is written for the Remedial Investigation/ Feasibility Study of the Pesticide Disposal Site (Site 5) and the Preliminary Site Assessment/ Site Investigation (PA/SI) of the Building 316, PCB Waste Work Area at Naval Base, Norfolk, Virginia. Specifically, this SAP focuses on the activities associated with monitoring well installation, and sampling of soil, and groundwater at Site 5 and Site 21. The SAP is comprised of four separate plans.

1. The Quality Assurance Project Plan (QAPP)—The QAPP describes the policy, organization, functional activities, and quality assurance and quality control protocols necessary to achieve Data Quality Objectives (DQOs) as dictated by the intended use of the data.

2. The Field Sampling Plan (FSP)—The FSP provides guidance for all fieldwork by defining in detail the sampling and data-gathering methods to be used during field activities.

3. The Health and Safety Plan (HASP)—The HASP for the field effort describes CH2M HILL's health and safety program for field activities. The HASP identifies potentially hazardous operations and exposures and prescribes appropriate protective measures.

4. The Investigation-Derived Waste Management Plan (IDWMP)—The IDWMP provides guidance and assigns responsibility for the disposal of investigation-derived waste (IDW). The IDWMP describes both well-site disposal and containerization and temporary storage of certain IDW.

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2-4 Summary of Groundwater Samples for Offsite Analysis

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1-3 Site 5 RI/FS - Groundwater Sampling Locations
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Appendix

A Standard Operating Procedures

Section 1

Sampling Program

This Field Sampling Plan (FSP) documents procedures and practices to be followed during the Remedial Investigation/Feasibility Study (RI/FS) of the Pesticide Disposal Site (Site 5) and Preliminary Site Assessment/Site Investigation (PA/SI) of the Building 316, PCB Waste Work Area (Site 21) at Naval Base, Norfolk, Virginia. Samples will be collected from various media, including soil and groundwater. The Base locations of Sites 5 and 21 are depicted on Figure 1-1. The following sections document the sampling program for each media. All sample analyses will be performed in accordance with standard EPA methods and procedures by a contracted laboratory that fulfills all requirements of the U.S. Navy's QA/QC Program Manual and EPA's Contract Laboratory Program. A signed certificate of analysis will be provided with each laboratory analysis, along with a certificate of compliance certifying that all work was performed in accordance with the applicable federal, state, and local regulations. All analyses will be performed following the Navy's guidance for Level D. Table 1-1 lists the analytical parameters included on EPA's Target Compound List (TCL) and Target Analyte List (TAL).

Soil Investigation

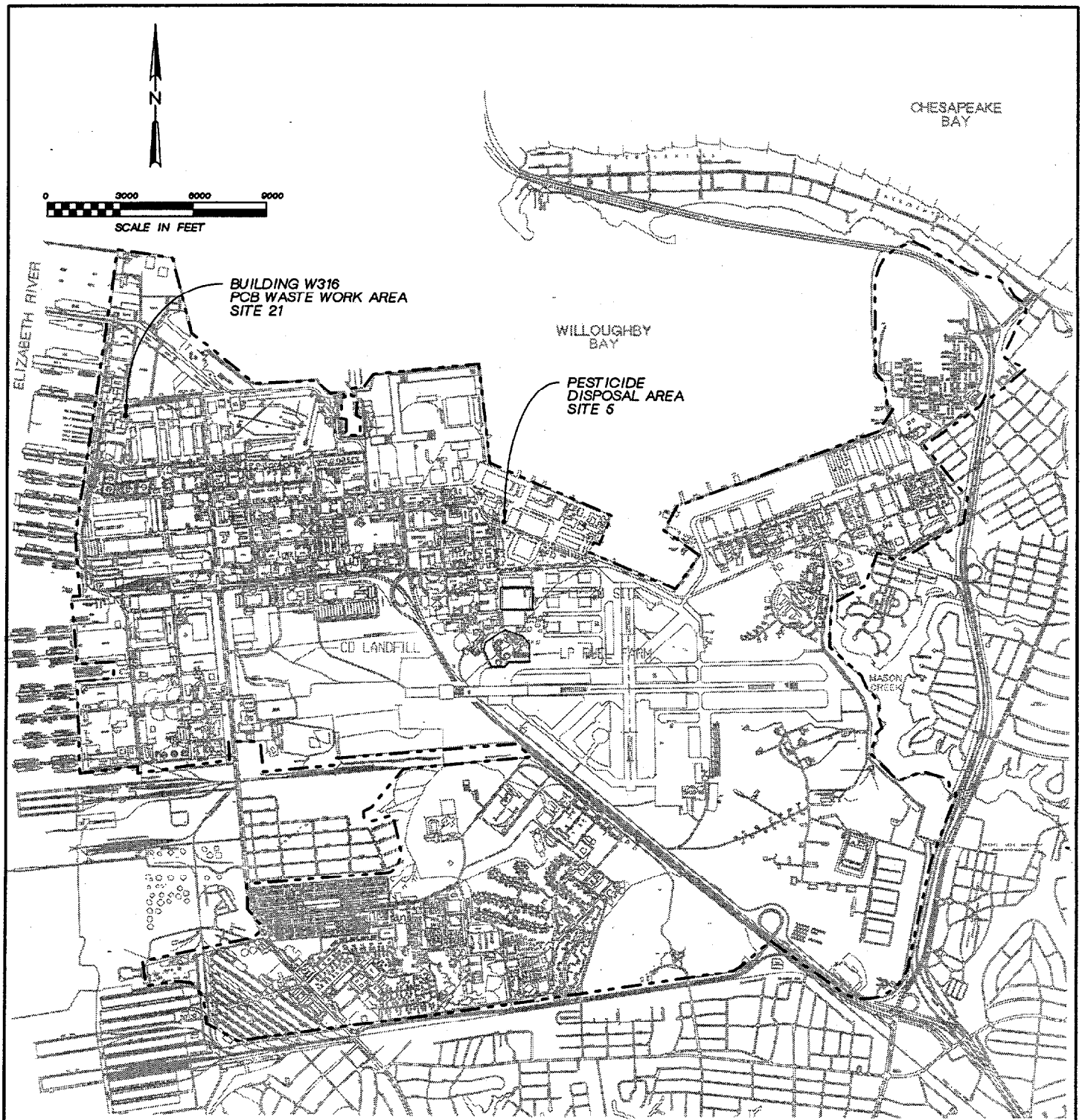
The soil sampling program includes the collection of soil samples during monitoring well installation and composite sub-surface soil samples during soil boring activities. The number of samples and specific analyses performed are outlined below. Table 1-2 summarizes the soil sampling program giving the sampling location and analyses to be performed for each sample.

Soil Sampling Site 5 RI/FS

A total of ten soil samples will be collected during the Site 5 RI/FS field activities. Six soil samples will be collected during the boring activities associated with the installation of two monitoring wells at Site 5. Three samples will be collected from each well boring at depths of 0-0.5 feet, 3-4 feet, and 6-7 feet below ground surface. Four surface soil will also be collected during the Site 5 RI/FS. The soil sampling locations are shown on Figure 1-2. All samples will be analyzed for TCL organics (volatiles, semivolatiles, and pesticides/PCBs) and TAL inorganics (metals and cyanide).

Soil Sampling Site 21 PA/SI

A total of fourteen soil samples will be collected during the Site 21 PA/SI field activities. Four soil samples will be collected during the boring activities associated with the installation of two monitoring wells at Site 21. Two samples will be collected from each well boring at depths of 3-feet and 6-feet below ground surface. Ten surface soil samples, three in the area of the April 25, 1990, PCB oil spill and seven equally distributed around the area of the site not affected by the spill, will also be collected during the Site 21 PA/SI activities. Figure 1-3 depicts the soil sampling locations. All samples will be analyzed for TCL PCBs.



LEGEND

— - - — - INSTALLATION PROPERTY BOUNDARY

Figure 1-1
INSTALLATION LOCATION MAP
Naval Base, Norfolk

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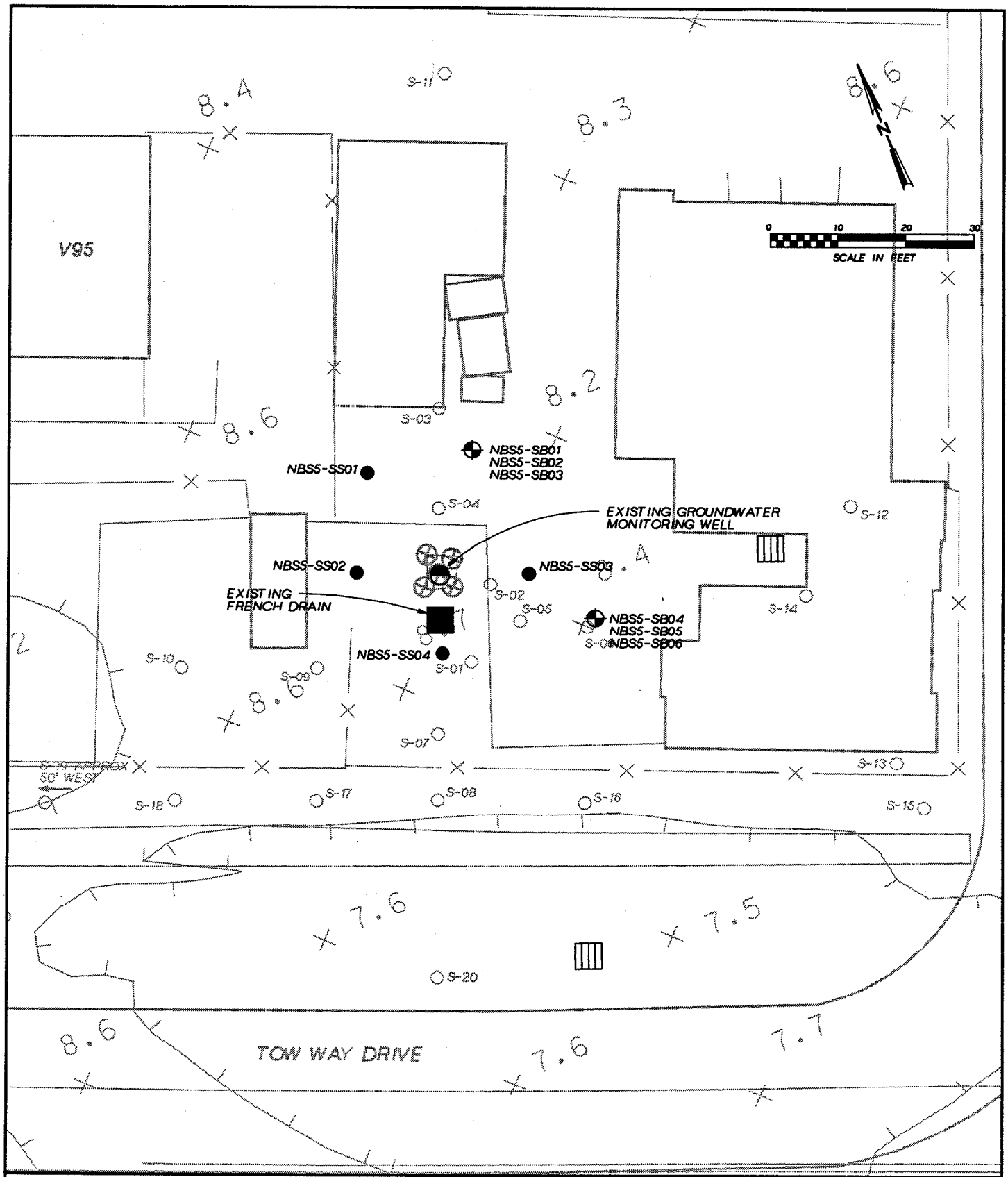
Table 1-1 ANALYTICAL PARAMETERS	
Volatile Organic Compounds on Target Compound List (TCL) (Soil Samples)	
Acetone	1,2-Dichloropropane
Benzene	cis-1,3-Dichloropropene
Bromoform	trans-1,3-Dichloropropene
Bromodichloromethane	Ethylbenzene
Bromomethane	2-Hexanone
2-Butanone	4-Methyl-2-Pentanone
Carbon Disulfide	Methylene Chloride
Carbon Tetrachloride	Styrene
Chlorobenzene	1,1,2,2-Tetrachloroethane
Chloroethane	Tetrachloroethene
Chloroform	Toluene
Chloromethane	1,1,1-Trichloroethane
Dibromochloromethane	1,1,2-Trichloroethane
1,1-Dichloroethane	Trichloroethene
1,2-Dichloroethane	Vinyl Chloride
1,1-Dichloroethene	Xylenes (total)
1,2-Dichloroethene (total)	
Volatile Organic Compounds Under Low Concentration Method OLC02 (Aqueous Samples)	
Acetone	1,1-Dichloroethene
Benzene	1,2-Dichloroethene (total)
Bromoform	cis-1,2-Dichloroethane
Bromochloromethane	trans-1,2-Dichloroethene
Bromodichloromethane	1,2-Dichloropropane
Bromomethane	cis-1,3-Dichloropropene
2-Butanone	trans-1,3-Dichloropropene
Carbon Disulfide	1,2,4-Trichlorobenzene
Carbon Tetrachloride	Ethylbenzene
Chlorobenzene	2-Hexanone
Chloroethane	4-Methyl-2-Pentanone
Chloroform	Methylene Chloride
Chloromethane	Styrene
1,2-Dibromo-3-chloropropane	1,1,2,2-Tetrachloroethane
Dibromochloromethane	Tetrachloroethene
1,2-Dibromoethane	Toluene
1,2-Dichlorobenzene	1,1,1-Trichloroethane
1,3-Dichlorobenzene	1,1,2-Trichloroethane
1,4-Dichlorobenzene	Trichloroethene
1,1-Dichloroethane	Vinyl Chloride
1,2-Dichloroethane	Xylenes (total)

Table 1-1 ANALYTICAL PARAMETERS	
Semivolatile Organic Compounds on Target Compound List (TCL)	
1,2-Dichlorobenzene	2,4-Dinitrophenol
1,3-Dichlorobenzene	4-Nitrophenol
1,4-Dichlorobenzene	Dibenzofuran
Phenol	2,4-Dinitrotoluene
bis-(2-Chloroethyl)ether	Diethylphthalate
2-Chlorophenol	4-Chlorophenyl-phenylether
2-Methylphenol	Fluorene
2,2′-oxybis(1-Chloropropane)	4-Nitroaniline
4-Methylphenol	4,6-Dinitro-2-methylphenol
N-Nitroso-di-n-propylamine	N-Nitrosodiphenylamine
Hexachloroethane	4-Bromophenyl-phenylether
Nitrobenzene	Hexachlorobenzene
Isophorone	Pentachlorophenol
2-Nitrophenol	Phenanthrene
2,4-Dimethylphenol	Anthracene
bis-(2-Chloroethoxy)methane	Di-n-butylphthalate
2,4-Dichlorophenol	Carbazole
1,2,4-Trichlorobenzene	Fluoranthene
Naphthalene	Pyrene
4-Chloroaniline	Butylbenzylphthalate
Hexachlorobutadiene	3,3′-Dichlorobenzidine
4-Chloro-3-methylphenol	Benzo(a)anthracene
2-Methylnaphthalene	Chrysene
Hexachlorocyclopentadiene	bis-(2-Ethylhexyl)phthalate
2,4,6-Trichlorophenol	Di-n-octylphthalate
2,4,5-Trichlorophenol	Benzo(b)fluoranthene
2-Chloronaphthalene	Benzo(k)fluoranthene
2-Nitroaniline	Benzo(a)pyrene
Dimethylphthalate	Indeno(1,2,3-cd)pyrene
Acenaphthylene	Dibenz(a,h)anthracene
2,6-Dinitrotoluene	Benzo(g,h,i)perylene
3-Nitroaniline	
Acenaphthene	

Table 1-1 ANALYTICAL PARAMETERS	
Pesticides and PCBs on Target Compound List (TCL)	
alpha-BHC	4,4-DDT
beta-BHC	Methoxychlor
delta-BHC	Endrin ketone
gamma-BHC (Lindane)	Endrin aldehyde
Heptachlor	alpha-Chlordane
Aldrin	gamma-Chlordane
Heptachlor epoxide	Toxaphene
Endosulfan I	Aroclor-1016
Dieldrin	Aroclor-1221
4,4'-DDE	Aroclor-1232
Endrin	Aroclor-1242
Endosulfan II	Aroclor-1248
4,4'-DDD	Aroclor-1254
Endosulfan sulfate	Aroclor-1260
Inorganics on Target Analyte List (TAL)	
Aluminum	Lead
Antimony	Magnesium
Arsenic	Manganese
Barium	Mercury
Beryllium	Nickel
Cadmium	Potassium
Calcium	Selenium
Chromium	Silver
Cobalt	Sodium
Copper	Thallium
Cyanide	Vanadium
Iron	Zinc

Table 1-2 SOIL SAMPLING PROGRAM FOR SITE 5 RI/FS AND SITE 21 PA/SI						
Site	Sampling Location	TCL VOC	TCL SVOC	TCL Pest/PCB	TCL PCB	TAL Metals and Cyanide (total)
Site 5	NBS5-SB01	X	X	X		X
Site 5	NBS5-SB02	X	X	X		X
Site 5	NBS5-SB03	X	X	X		X
Site 5	NBS5-SB04	X	X	X		X
Site 5	NBS5-SB05	X	X	X		X
Site 5	NBS5-SB06	X	X	X		X
Site 5	NBS5-SS01	X	X	X		X
Site 5	NBS5-SS02	X	X	X		X
Site 5	NBS5-SS03	X	X	X		X
Site 5	NBS5-SS04	X	X	X		X
Site 21	NBS21-SB01				X	
Site 21	NBS21-SB02				X	
Site 21	NBS21-SB03				X	
Site 21	NBS21-SB04				X	
Site 21	NBS21-SS01				X	
Site 21	NBS21-SS02				X	
Site 21	NBS21-SS03				X	
Site 21	NBS21-SS04				X	
Site 21	NBS21-SS05				X	
Site 21	NBS21-SS06				X	
Site 21	NBS21-SS07				X	
Site 21	NBS21-SS08				X	
Site 21	NBS21-SS09				X	
Site 21	NBS21-SS10				X	



LEGEND

- PROPOSED GROUNDWATER MONITORING WELL LOCATION
- EXISTING GROUNDWATER MONITORING WELL LOCATION
- SOIL SAMPLING LOCATION - PIRNIE RI
- PROPOSED SOIL SAMPLING LOCATION
- FRENCH DRAIN

Figure 1-2
PROPOSED SOIL SAMPLING LOCATIONS
SITE 5 - PESTICIDE DISPOSAL AREA
Naval Base, Norfolk

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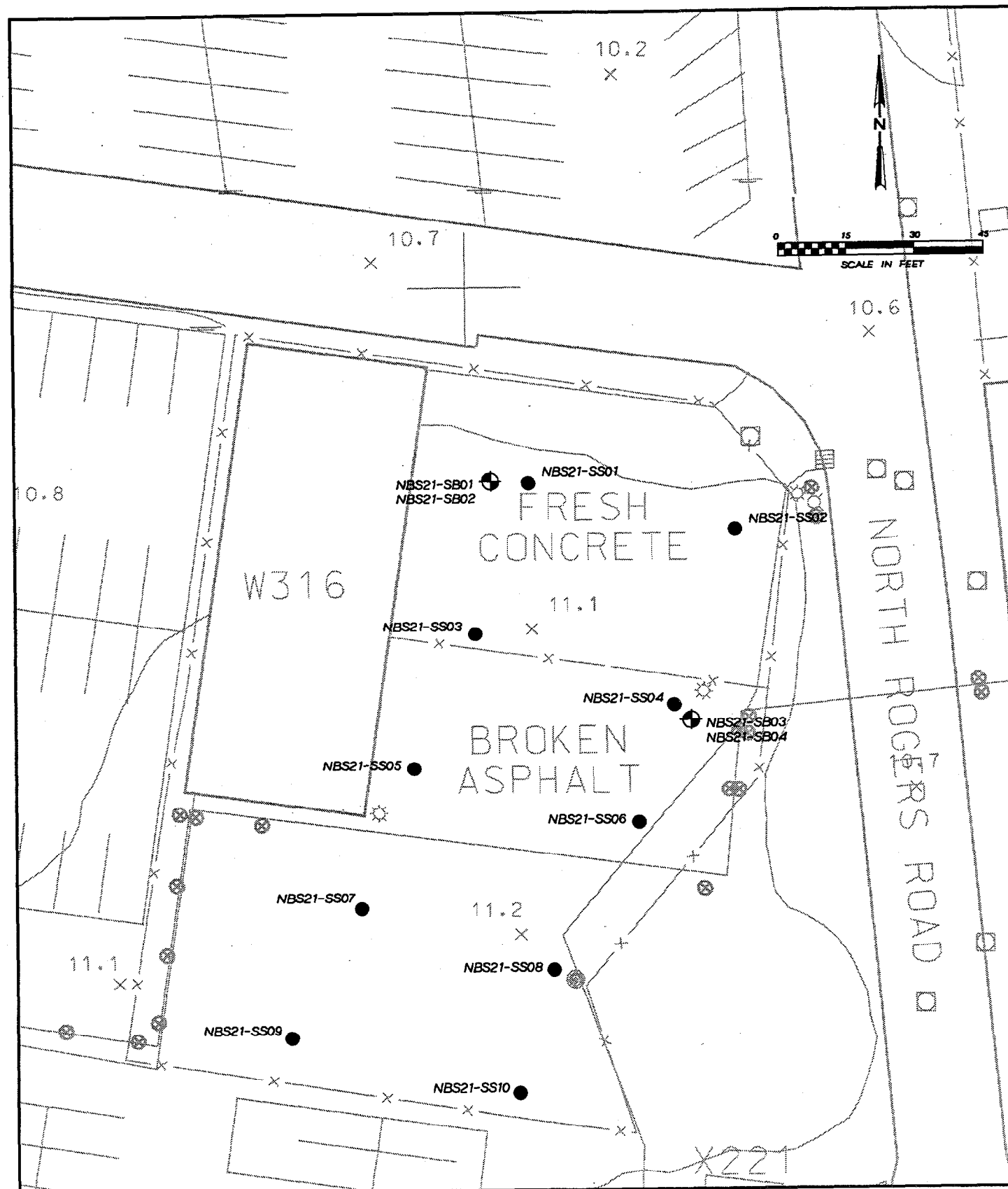

LEGEND

- PROPOSED GROUNDWATER MONITORING WELL LOCATION*
- PROPOSED SOIL SAMPLING LOCATION*

* LOCATIONS SUBJECT TO CHANGE BASED UPON INTERVIEW WITH BASE PERSONNEL

Figure 1-3
PROPOSED SOIL SAMPLING LOCATIONS
SITE 21 - BUILDING W316,
PCB WASTE WORK AREA
Naval Base, Norfolk

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Groundwater Investigation

Groundwater samples will be collected during the Site 5 RI/FS and Site 21 PA/SI field activities. The groundwater investigation activities are discussed below. Table 1-4 summarizes the number of samples and specific analyses to be performed.

In order to achieve the lower detection limits required for the risk assessment associated with the Site 5 RI/FS, the volatile fraction of the organic sample will be analyzed by the EPA Contract Laboratory Program (CLP) Statement of Work (SOW) for Low Concentration Water (OLC02). The Site 21 PA/SI does not involve the preparation of a risk assessment, therefore normal TCL analytical methods will be applied during the analysis of Site 21 groundwater and surface water samples.

Groundwater Sampling Site 5 RI/FS

Groundwater samples will be collected from the two newly installed monitoring wells and the one existing monitoring well using a Grundfos® Redi-Flo2 sampling pump. Figure 1-4 illustrates the monitoring well locations. All samples will be analyzed for CLP SOW Low Concentration Volatiles, TCL organics and TAL inorganics.

Groundwater Sampling Site 21 PA/SI

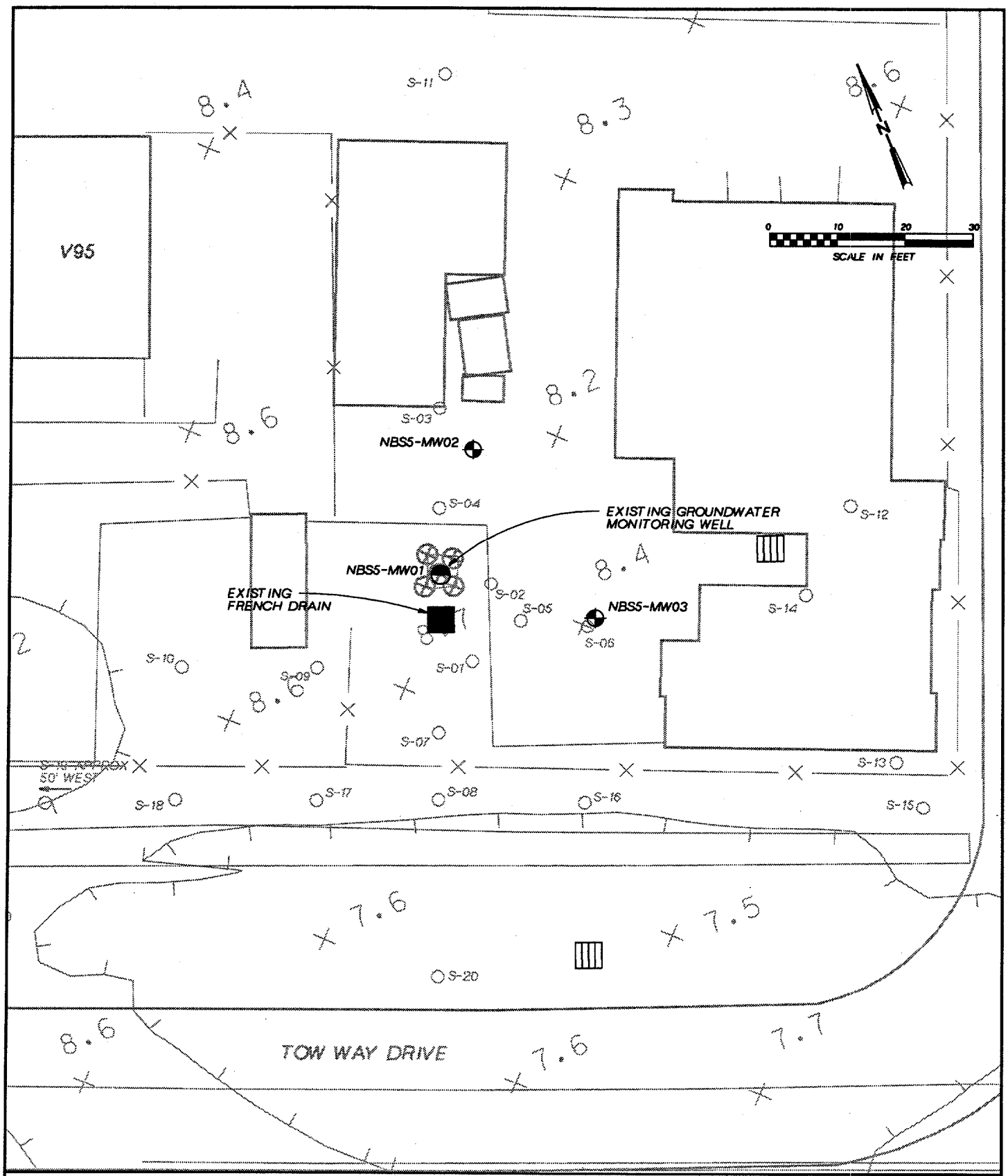
Groundwater samples will be collected from the two newly installed monitoring wells using a Grundfos® Redi-Flo2 sampling pump. Figure 1-5 illustrates the monitoring well locations. All samples will be analyzed for TCL PCBs.

Surveying

The newly installed monitoring wells will be surveyed for horizontal and vertical control by a subcontracted surveyor licensed in the State of Virginia. In addition, all soil sampling locations will be surveyed for horizontal control.

Table 1-3
GROUNDWATER AND SURFACE WATER SAMPLING PROGRAM FOR SITE 5 RI/FS AND SITE 21 PA/SI

Site	Sampling Location	TCL VOC	TCL SVOC	Pest/ PCB	PCB (filtered)	PCB (unfiltered)	TAL Metals and Cyanide (total)
Site 5	NBS5-MW01	X	X	X			X
Site 5	NBS5-MW02	X	X	X			X
Site 5	NBS5-MW03	X	X	X			X
Site 21	NBS21-MW01				X	X	
Site 21	NBS21-MW02				X	X	



LEGEND

- PROPOSED GROUNDWATER MONITORING WELL LOCATION
- EXISTING GROUNDWATER MONITORING WELL LOCATION
- SOIL SAMPLING LOCATION - PIRNIE RI
- FRENCH DRAIN

Figure 1-4
PROPOSED GROUNDWATER SAMPLING LOCATIONS
SITE 5 - PESTICIDE DISPOSAL AREA
Naval Base, Norfolk

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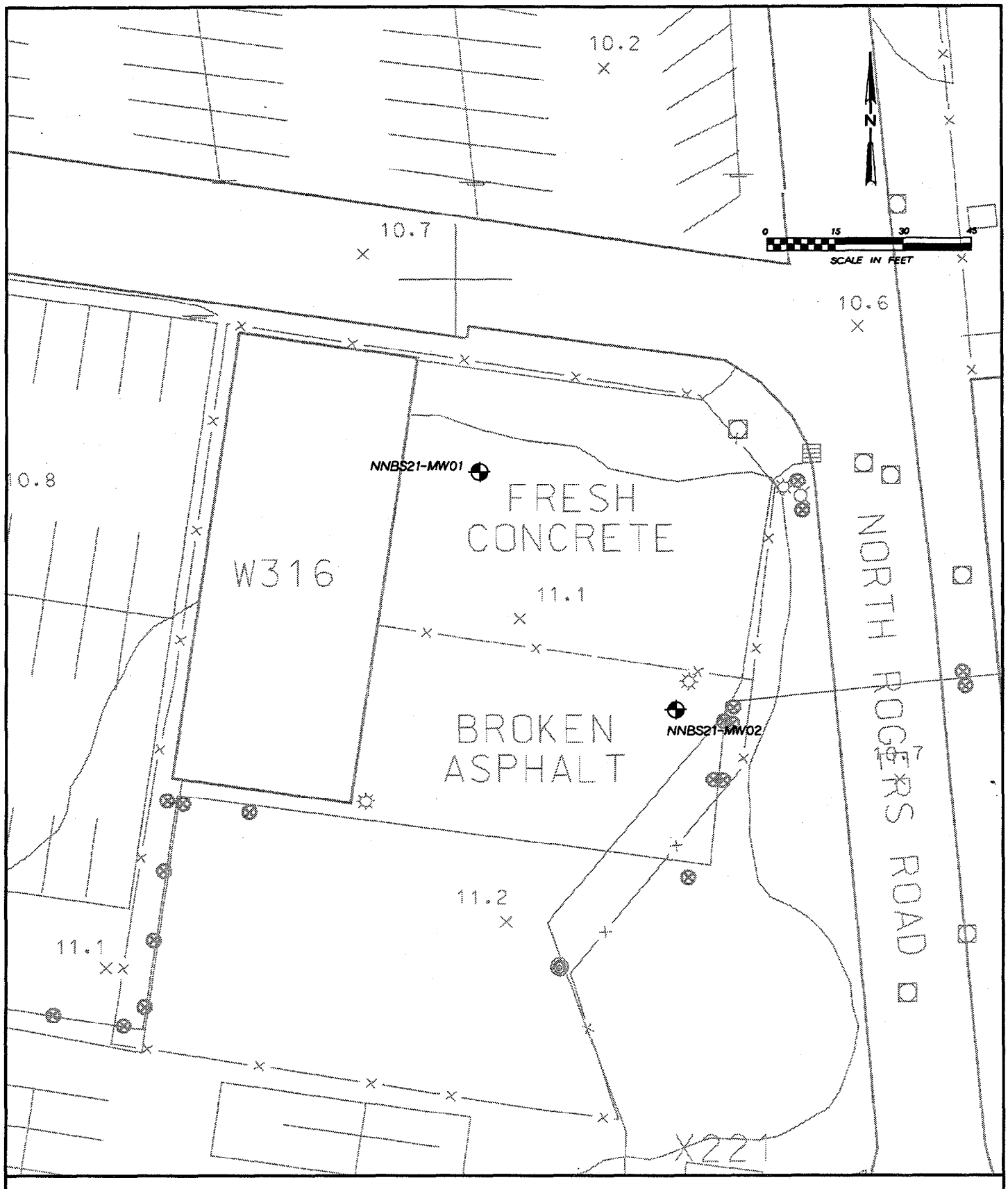

LEGEND

PROPOSED GROUNDWATER MONITORING WELL LOCATION*

* LOCATIONS SUBJECT TO CHANGE BASED UPON INTERVIEW WITH BASE PERSONNEL

Figure 1-5
PROPOSED GROUNDWATER SAMPLING LOCATIONS
SITE 21 - BUILDING W316, PCB WASTE WORK AREA
Naval Base, Norfolk

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Final

Quality Assurance Project Plan
Remedial Investigation and Feasibility Study
Pesticide Disposal Site (Site 5)
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Building W-316 PCB Waste Work Area (Site 21)

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Acronyms and Abbreviations

CLP	Contract Laboratory Program
CofC	Chain-of-Custody
DQOs	Data Quality Objectives
EPA	Environmental Protection Agency
FSP	Field Sampling Plan
HASP	Health and Safety Plan
LANTDIV	U.S. Navy Naval Facilities Engineering Command, Atlantic Division
LQAP	Laboratory Quality Assurance Plan
MS	Matrix Spike
MSD	Matrix Spike Duplicate
µg/l	Micrograms per liter
NFESC	Navy Facilities Engineering Services Command
OLC02	EPA analytical method for Organic Low Concentration Water
OVM	Organic Vapor Monitor
%R	Percent Recovery
PCB	Polychlorinated biphenyl
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RPD	Relative Percent Difference
RPM	Remedial Project Manager
RSD	Relative Standard Deviation
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SOW	Statement of Work
SVOCs	Semivolatile Organic Compounds
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCL	Target Compound List

VOA	Volatile Organic Analysis
VOCs	Volatile Organic Compounds

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Section 1

Introduction

This plan describes the Quality Assurance and Quality Control (QA/QC) procedures used for conducting soil and groundwater sampling activities at the Pesticide Disposal Site (Site 5) and the Building W-316 PCB Waste Work Area (Site 21) at the Norfolk Naval Base, Norfolk, Virginia. The Quality Assurance Project Plan (QAPP) focuses on the sampling activities for the Remedial Investigation and Feasibility Study (RI/FS) for Site 5 and the Preliminary Assessment and Site Investigation (PA/SI) for Site 21. All field sampling and laboratory analyses will be conducted in accordance with the *Navy Installation Restoration Laboratory Quality Assurance Guide,* February 1996.

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Section 2

Project Description

The Pesticide Disposal Site (Site 5) consists of a french drain located southeast of Building V-95 (formerly used as a pest control shop) in the northcentral section of the naval base at Norfolk, Virginia. The drain was used for the disposal of pesticide waste generated in Building V-95 from the late 1960s until 1973. The area is now fenced off and used for storage of other materials.

The Building W-316 PCB Waste Work Area (Site 21) is an outdoor area located in the northwest portion of the base directly south of the W-316 PCB Debris Storage Area (SWMU-8). The area is approximately one-quarter acres of soil and asphalt and is fenced. Site 21 is used by the Navy Public Works Center to store various electrical components. The building and small storage yard adjacent to the building were used for the storage of out-of-service PCB transformers received from throughout the base. The unit is and has been in operation since 1982. Transformers are stored on pallets in this area until picked up by a contractor for off-site disposal.

The work plan for the Site 5 RI/FS and Site 21 PA/SI provides a more detailed history of the site use and disposal practices, an evaluation of the data collected during previous investigations at the site, and a description of activities to be performed.

The objectives of the sampling work to be performed for Site 5 RI are to:

- Collect soil samples from two locations at three depths (0-6 inches, 3 feet, and 6 feet), for a total of six samples, to characterize the vertical contaminant profile from the ground surface to the water table. One location is directly adjacent to and downgradient of the french drain. The second location is between the first location and an existing monitoring well. The sampling will take place during the installation of shallow monitoring wells at these locations.

- Collect four surface soil samples from the unpaved portion of the site at depths from 0 to 6 inches below ground surface to determine the extent of horizontal contamination. The analytical results are to be used in the risk assessment.

- Collect groundwater samples from the two monitoring wells once the wells have been installed and developed. Groundwater analysis from the well located adjacent to the french drain will allow monitoring of the groundwater quality within the suspected contaminated zone. Analysis of water from the second well and from the existing monitoring well will determine if groundwater contamination has migrated.

- Analyze all soil samples for EPA's Target Compound List (TCL) organics (volatiles, semivolatiles, pesticide/PCBs) and Target Analyte List (TAL) inorganics (metals and cyanide). Aqueous samples will be analyzed for TCL semivolatiles and pesticide/PCBs and TAL inorganics. The volatile fraction of the groundwater and surface water samples will be analyzed by EPA's Contract Laboratory Program (CLP) Statement of Work (SOW) for Low Concentration

Water (OLC02) in order to achieve the lower detection limits necessary for risk assessment. The compound list is found in Table 1-1 of the Field Sampling Plan. All analytical results to be used in risk assessment will require Navy Level D QA/QC.

The objectives of the sampling work to be performed for Site 21 SI are to:

- Collect soil samples from two locations at two depths (3 feet and 6 feet), for a total of four samples, to determine the extent of PCB contamination. One location is at the suspected center of a PCP oil spill (April 25, 1990), and the second location is 15 feet downgradient. The sampling will take place during the installation of shallow monitoring wells at these locations.
- Collect ten surface soil samples from the vicinity of Building W-316 and the adjacent storage yard to determine whether PCBs are present in these areas.
- Collect groundwater samples from the two shallow monitoring wells after they have been installed and developed to determine if PCB contamination has infiltrated to the groundwater.
- All samples will be analyzed for TCL PCBs. Both filtered and unfiltered samples will be collected from groundwater. The compound list for PCBs is found in Table 1-1 of the Field Sampling Plan. All analytical results to be used in risk assessment will require Navy Level D QA/QC.

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Section 3

Project Organization

Mr. Michael Tilchin will serve as the activity manager and the primary contact at CH2M HILL. Mr. Tilchin will assume primary responsibility for ensuring that the work is performed in a manner that is acceptable to LANTDIV. With the activity manager's oversight, the project manager, Mr. Jack Robinson, will be responsible for such activities as budget and schedule review and tracking, preparation and review of invoices, personnel resources planning and allocation, and coordination with LANTDIV, the Naval Base, and subcontractors. Mr. Doug Dronfield, Dr. Robert Root, and Mr. Steve Romanow will provide senior review. Figure 3-1 represents a chart view of the project organization.

The RI and SI field investigation tasks for soil and groundwater will be performed by the CH2M HILL supporting field personnel. CH2M HILL will notify LANTDIV and the Norfolk Naval Base which CH2M HILL personnel will mobilize to the site prior to initiating field activities. A field task manager will be assigned to lead all field activities. This person will be responsible for assuring that the SAP is being followed, maintaining the field log book, monitoring the site for all releases, and other activities. The field staff will be responsible for collecting the samples, supervising subcontractors, completing sample paperwork, shipping samples, and the like.

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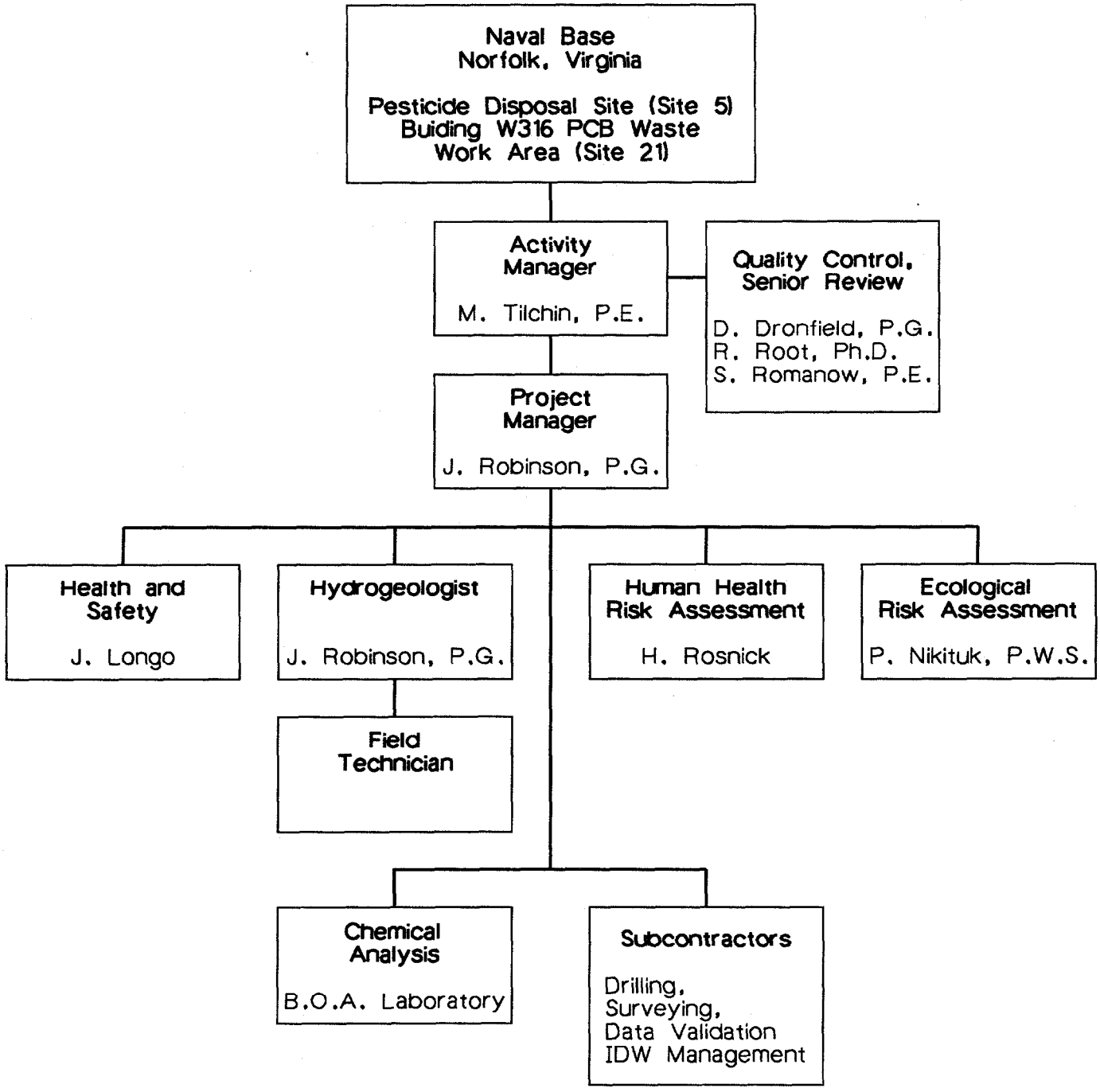

Figure 3-1
PROJECT ORGANIZATION
SITE 5 - PESTICIDE DISPOSAL AREA
SITE 21 - BUILDING W316
PCB WASTE WORK AREA
Naval Base, Norfolk

CH2M HILL

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Section 4

Quality Assurance Objectives

Data Quality Objectives (DQOs) will be established for each major sample collection effort as specified in the *Data Quality Objectives for Remedial Response Activities*, March 1987. DQOs are the quantitative and qualitative descriptions of the quality of data required to support an environmental decision or action. As target values for data quality, they are not necessarily criteria for acceptance or rejection of data. DQOs for a site vary according to the end use of the data. Everyone from the data gatherer to the analytical laboratory is involved in the DQO development process from the beginning.

The fundamental mechanisms that will be employed to achieve quality goals are:

- prevention of errors through planning, documented instructions and procedures, and careful selection and training of personnel
- assessment of data through field and laboratory audits and data validation of the analytical results
- correction of errors through a corrective action program.

The four documents in the SAP (QAPP, FSP, HASP, and IDWMP) contain the plans and procedures for safe, competent sampling and for effective management of the data. Each laboratory providing analytical data for the RI/FS or the PA/SI has developed its own Laboratory Quality Assurance Plan (LQAP). The SAP and the LQAP must address the elements of the Navy QA Program.

Audits in the field and in the laboratories will determine how the QA/QC procedures are being implemented. Any discrepancies will be addressed through the corrective action programs described in the SAP and LQAP.

The detection limits achieved by the EPA's TCL organics and TAL inorganics analyses for soil are adequate to meet the DQOs for this project. Groundwater samples for Site 5 will be analyzed for TCL semivolatiles and pesticide/PCBs and TAL inorganics. The volatile fraction will be analyzed by OLC02 to meet the low detection limit requirements of risk assessment. Site 21 analysis is for PCBs only, and the TCL pesticide method is adequate to meet the DQOs for the site. Navy D Level data validation for this project will ensure that the data obtained with the EPA protocols will be acceptable.

A risk assessment has to contain considerations of risks involved in drinking water that might be contaminated. One consideration of risk is the comparison of groundwater contaminant concentrations detected at a site with federal drinking water standards, the maximum contaminant levels (MCLs) permissible in tap water. MCLs for vinyl chloride (2 μg/L) 1,1,2-trichloroethane (5 μg/L), trichloroethene (5 μg/L), tetrachloroethene (5 μg/L), 1,2-dichloroethane (5 μg/L), and 1,1-dichloroethene (7 μg/L), which are chlorinated solvents commonly found on sites contaminated with volatile solvents, are below the EPA CLP volatile detection limit of 10 μg/L. Low concentration volatile method

OLC02 has a detection limit of 1 μg/L for each of these compounds and offers reliable proof that the compounds are either present or not present at levels that exceed 1 μg/L. Low concentration method OLC02 is appropriate for groundwater samples only, not for surface water, sediment, or soil.

DQOs are measured by the degree of precision, accuracy, representativeness, completeness, and comparability of the data that is required for the project. The project precision and accuracy objectives for laboratory analysis are included in Table 4-1. The quality objectives for field parameters are included in Appendix A of the FSP (i.e., Standard Operating Procedures for pH, conductivity, OVM).

Table 4-1

PRECISION and ACCURACY OBJECTIVES

Parameter	Precision (Relative Percent Difference)	Accuracy (% Spike Recovery)	Intended Data Use
Groundwater and Surface Water			
TCL Volatiles	< ±20	80-120	Determine extent of contamination Risk assessment
Low Concentration Volatiles	< ±20	80-120	Determine extent of contamination Risk assessment
TCL Semivolatiles	< ±20	80-120	Determine extent of contamination Risk assessment
TCL Pesticides/PCBs	< ±20	80-120	Determine extent of contamination Risk assessment
TAL Metals and Cyanide	< ±20	80-120	Determine extent of contamination Risk assessment
Soil and Sediment			
TCL Volatiles	< ±25	75-125	Determine extent of contamination Risk assessment
TCL Semivolatiles	< ±25	75-125	Determine extent of contamination Risk assessment
TCL Pesticides/PCBs	< ±25	75-125	Determine extent of contamination Risk assessment
TAL Metals and Cyanide	< ±25	75-125	Determine extent of contamination Risk assessment

Accuracy and Precision

Accuracy is a measure of the agreement between an experimental result and the true value of the parameter. Analytical accuracy can be determined using known reference materials or matrix spikes. Spiking of reference materials into the actual sample matrix is the preferred technique because it quantifies the effects of the matrix on the analytical accuracy. Accuracy can be expressed as percent recovery (%R) determined by the following equation:

$$\% R = \frac{SSR - SR}{SA} \times 100$$

where: SSR = spiked sample result
SR = sample result (native)
SA = spike added

Precision is the measure of the agreement or repeatability of a set of duplicate results obtained from repeat determinations made under the same conditions. The precision of a duplicate determination can be expressed as the relative percent difference (RPD) which is determined by the following equation:

$$RPD = \frac{|X1 - X2|}{X1 + X2} \times 200$$

where: X1 = first duplicate value

X2 = second duplicate value

For a given laboratory analysis, the duplicate RPD values are tabulated, and the mean and standard deviation of the RPD are calculated. Control limits for precision are usually plus or minus two standard deviations from the mean.

Accuracy and precision will be monitored by using field duplicate, matrix spike, and matrix spike duplicate samples. These data alone cannot be used to evaluate accuracy and precision of individual samples but will be used to assess the long-term accuracy and precision of the analytical method.

Completeness

Completeness is defined as the percentage of analytical measurements made that are judged to be valid, with validity being defined by the DQOs. Percent completeness is calculated as

the number of valid analyses divided by the total number of analyses performed multiplied by 100. The completeness goal for the project is 85 percent.

Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent parameter variations at a sampling point. Representativeness is a measure of how closely the measured results reflect the actual distribution and concentration of certain chemical compounds in the medium sampled. The FSP describes the procedures to be used to collect samples. This process will generate samples that are as representative as possible. Documentation of laboratory and field procedures, as described in the FSP, will be used to establish that protocols have been followed and that sample identification and integrity have been maintained.

Comparability

Comparability is the term that describes the confidence with which one data set can be compared to another. Comparability refers to such issues as using standard field and analytical techniques, following the same QA/QC procedures, and reporting data in the same units. This criterion becomes important if more than one field team is collecting samples or more than one laboratory is analyzing the samples. Consistency in sampling and laboratory procedures will be maintained throughout the project. (See the FSP for a discussion of sampling procedures.) In addition, accepted methodologies will be used for sample analysis, and these methods will not be changed during the project.

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Section 5

Sample Collection Procedures

A detailed description of sampling procedures is provided in the attached FSP and Appendix A of the FSP. Procedures are included that describe, at a minimum:

- Sample plan design considerations
- Sampling point selection
- Sample packing, handling, and shipment (including time considerations)
- Special conditions for sample container preparation and time requirements (tabulated)
- Preparation and use of trip blanks and field blanks
- Documentation of sampling activities

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Section 6

Sample Custody

Essential to any sampling and analytical program is maintaining the integrity of the sample from collection to data reporting. This requires tracking the possession and handling of samples from the time of collection, through analysis, to final disposal. This documentation is referred to as chain-of-custody (CofC). Figure 6-1 shows an example of a CofC form. The essential components of this CofC are described in the FSP and summarized below.

Field Custody

The sample coordinator is responsible for the care and custody of samples until they are shipped or otherwise delivered to the laboratory custodian.

Transfer of Custody

The CofC form must be completed before samples are shipped. The persons involved in relinquishing and receiving the samples will sign, date, and note the time of sample receipt on the CofC form. The first such transfer may occur between the field sampler and the sample carrier. Another transfer may occur between the sample carrier and the laboratory sample custodian. Each sample shipment will be accompanied by a CofC record that identifies the contents of the shipment.

Laboratory Custody

Laboratory custody procedures are detailed in each laboratory's Quality Assurance Plan (LQAP). The laboratory custodian will verify that the custody seals on the sample shipment or the containers are intact and that the information on the CofC matches the actual contents. The laboratory custodian will also note any anomalies, such as broken bottles, elevated temperatures, and missing labels. The project-specific procedures for sample custody are described fully in the FSP.

Sample Disposal

Unless otherwise instructed, the analytical laboratory will dispose of unused sample portions, according to Resource Conservation and Recovery Act (RCRA) regulations and the LQAP, after the analyses have been completed and any outstanding issues between the contractor and the laboratory have been resolved.

FIGURE 6-1 EXAMPLE OF A CHAIN OF CUSTODY

CH2M HILL
QUALITY ANALYTICAL LABORATORIES

CHAIN OF CUSTODY RECORD AND AGREEMENT TO PERFORM SERVICES

CH2M HILL Project #

Purchase Order #

Project Name

Company Name/CH2M HILL Office

Project Manager & Phone #
Mr. [ ]
Ms. [ ]
Dr. [ ]

Report Copy to:

Requested Completion Date:

Sampling Requirements: SDWA ☐ NPDES ☐ RCRA ☐ OTHER ____

Sample Disposal: Dispose ☐ Return ☐

Sampling Date	Sampling Time	Type COMP	Type GRAB	Matrix WATER	Matrix SOIL	CLIENT SAMPLE ID (9 CHARACTERS)	# OF CONTAINERS	LAB TEST CODES	ANALYSES REQUESTED	REMARKS	LAB 1 ID	LAB 2 ID

SHADED AREA – FOR LAB USE ONLY

Lab 1 #	Lab 2 #
Quote #	Kit Request #
Project #	
No. of Samples	Page / of
COC Rev / Login	LIMS Ver / Ack Gen

Sampled By & Title (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time
Received By (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time
Received By (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time
Received By (Please sign and print name)	Date/Time	Shipped Via: UPS BUS Fed-Ex Hand Other ____	Shipping #
Work Authorized By (Please sign and print name)	Remarks		

HAZWRAP/NESSA: Y N

QC Level: 1 2 3 Other: ____

COC Rec	ICE
Ana Req	TEMP
Cust Seal	Ph

Instructions and Agreement Provisions on Reverse Side

DISTRIBUTION: ORIGINAL - LAB, Yellow - LAB, Pink - Client

REV 11/92 FORM 340

Section 7

Equipment Calibration

Various instruments will be used in the field and in the laboratory to collect data and monitor site conditions. Proper calibration, maintenance, and use of these instruments is important for collecting quality data. A record of calibration and maintenance activities is as important as the data record itself in order to verify the delivery of quality data.

Field Equipment Calibration

The field equipment to be used during this investigation that will require calibration includes:

- pH Meter
- Conductivity Meter
- OVM
- Explosimeter

The pH meter, conductivity meter, OVM, and explosimeter will be calibrated before and during each day's use according to procedures and schedules outlined in the Health and Safety Plan (HASP) and in the FSP. The standards which will be used to calibrate these instruments are shown in Table 7-1. Standards will be purchased as necessary from appropriate vendors.

If an individual suspects an equipment malfunction, the device shall be removed from service and tagged so that it is not inadvertently used, and the equipment manager notified so that a substitute piece of equipment can be used. Backup equipment will be available in the field for use in the event of a malfunction.

Equipment that fails calibration or becomes inoperable during use shall be removed from service and tagged so that it is not inadvertently used. Such equipment shall be repaired and satisfactorily recalibrated. Equipment that cannot be repaired will be replaced.

Results of activities performed using equipment that has failed recalibration shall be evaluated. If the results are adversely affected, the outcome of the evaluation will be documented and the task manager will be notified.

Laboratory Equipment Calibration

The laboratory itself is responsible for equipment and instrument calibration and maintenance. Manufacturer's guidance shall be followed for general upkeep. Laboratory calibration procedures are outlined in the LQAP.

Table 7-1 CALIBRATION STANDARDS				
Instrument	**Calibration Standard**	**Span**	**Reading**	**Method**
OVM	100 ppm isobutylene	RF = 0.55	100 ppm	1.5 l/m reg: T-tubing
pH Meter	pH 4 and 7 Buffers	N/A	N/A	N/A
Conductivity Meter	EC 225 and 1,000 µs/cm	N/A	N/A	N/A
Explosimeter	50% LEL Pentane	N/A	0.0% LEL, 21% Oxygen	N/A

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Section 8

Analytical Procedures

All laboratory analyses will be performed by an approved laboratory meeting U.S. Navy Level D quality control. The laboratories will be procured using the Basic Ordering Agreements (BOAs). Until the BOAs with CH2M HILL are in place, the BOA laboratories from Baker will be utilized. Laboratory procedures to be used for the project are listed in Table 8-1.

Table 8-1
ANALYTICAL PROCEDURES

Analysis	Methodology
TCL Volatiles, Semivolatiles, and Pesticides/PCBs	U.S. EPA CLP Organics SOW (8/91)
Low Concentration Volatiles (for aqueous samples)	U.S. EPA CLP SOW for Low Concentration Water OLC02 (8/94)
TAL Metals and Cyanide	U.S. EPA CLP Inorganics SOW

Section 9

Data Reduction, Validation, and Record Keeping

Data reduction and reporting are steps in the overall management and use of both field and laboratory data, and data validation is a step in the overall management and use of laboratory data. Figure 9-1 shows the flow of information and sample tracking forms.

Data Reduction

Data reduction, validation, and reporting will ensure that all documents for the investigations can be accounted for when they are completed. Accountable documents include items such as logbooks, field data records, correspondence, CofC records, analytical reports, data packages, and reports.

Definition

Analytical data collected will computerized. Electronic data will be requested for all TCL and TCL analyses from the laboratory in a format agreed upon by the data manager. Other types of analytical data will be entered and then verified by spot-checking procedures. The sample manager will handle data entries that are unverified.

Background Data

Background data produced for internal records and not reported as part of the analytical data include the following: laboratory worksheets, laboratory notebooks, sample tracking system forms, maintenance records, calibration records, and associated quality control. These sources will be available for inspection and to determine the validity of data.

Data Validation

Validation of analytical data will be contracted by CH2M HILL in accordance with Navy Level D QA/QC requirements. The project, its objectives, and the intended use of the data will be discussed with the data validation personnel.

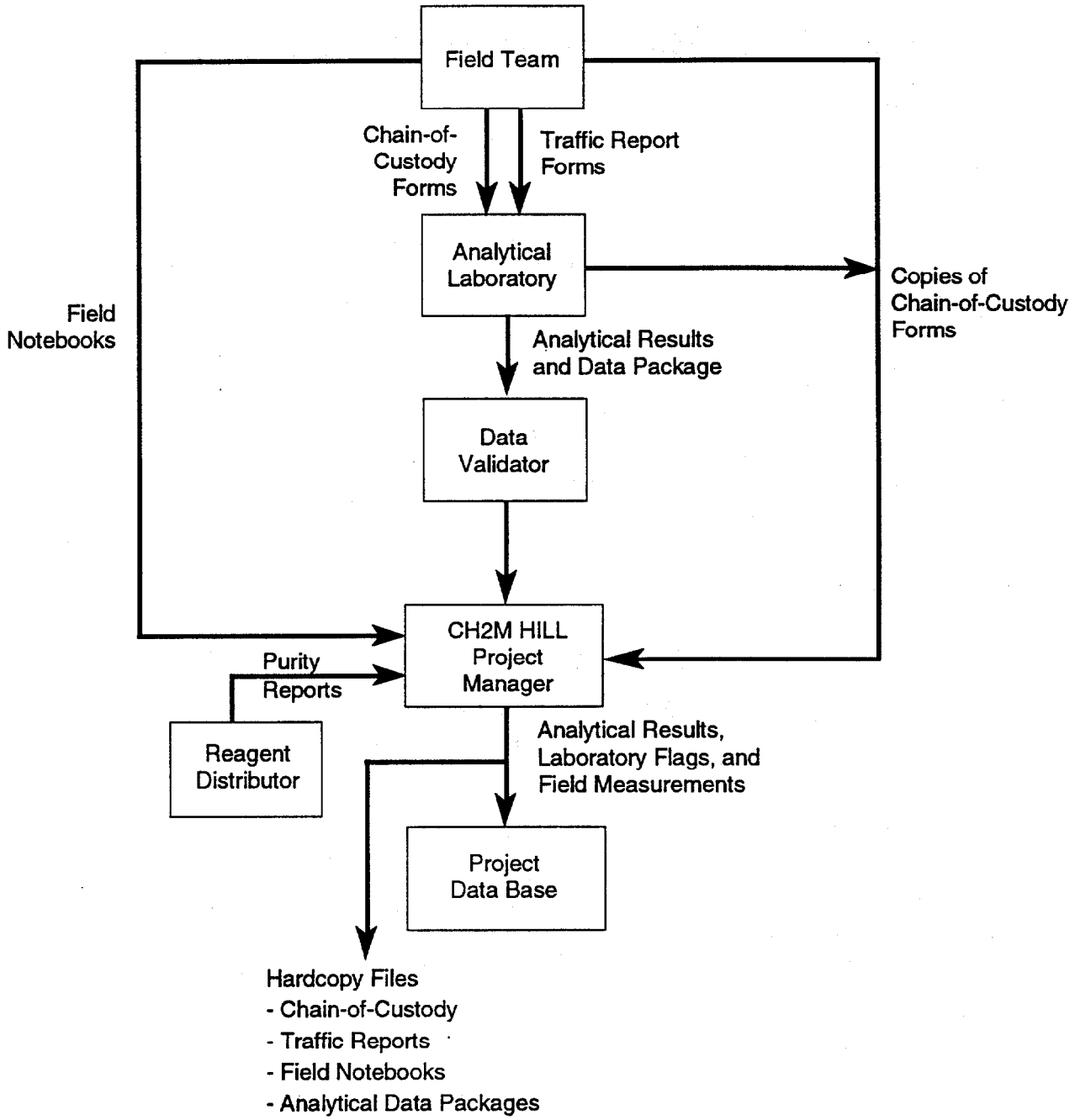

Figure 9-1
FLOW OF FORMS AND SAMPLE AND ANALYSIS INFORMATION

Data Records

The following describes procedures for maintaining the project's records:

- The task manager shall determine the records to be generated before the start of work. These records will be listed in the site-specific FSP.
- Records of field activities that support the integrity of samples shall be entered on bound and numbered pages. Such records shall be dated and signed or otherwise authenticated on the day of entry.
- Records retained on file shall be indexed. The indexing system shall include the location of records within the indexing system. (The indexing system shall be in alphabetical, chronological or numerical order, or as otherwise indicated in written procedures.)
- There shall be sufficient information in records to permit identification between the record and the item(s) or activity to which it applies. Identification of records will be by means that permit traceability.
- The records storage system shall provide for accurate retrieval of records without undue delay.

Section 10

Quality Control Checks

A number of QA/QC samples will be collected to check the adequacy of sample collection and analysis and to monitor laboratory performance. Duplicates, blanks, and spiked samples are used to determine if the sampling technique affects the analytical results, to measure the internal consistency of the samples, and to estimate any variance or bias in the analytical process. The field and laboratory QA/QC sampling procedures are described below.

Field Sampling Quality Control Procedures

Quality control duplicate samples and blanks are used to provide a measure of the internal consistency of the samples and an estimate of variance and bias. Table 10-1 shows the number of each type of field QC sample that should be collected for the number of investigative samples collected. Table 10-2 and Table 10-3 are summaries of the solid and aqueous samples (respectively) that will be collected and submitted to the laboratory. The tables show the collection frequencies of the field QC samples.

Table 10-1
QC COLLECTION FREQUENCIES FOR NAVAL BASE, NORFOLK

Type of QC Sample	Frequency Collected
Field Duplicate	One per 10 samples per matrix
Trip Blank	One per cooler containing samples for volatile analysis
Field Blank	One per week (if very windy or dusty, collect one per day)
Equipment Blank	One every other day per matrix. Collect on the first day, the third day, etc.
Matrix Spike/Matrix Spike Duplicate	One per matrix for each group of up to 20 samples sent to a single laboratory. MS/MSD is not required for low concentration organic samples.

One duplicate sample will be obtained for every 10 field samples collected. The sampling station from which the duplicate is taken will be randomly selected for each event. Each duplicate sample will be split evenly into two sample containers and submitted for analysis as two independent samples.

Table 10-2
SITE 5 - SUMMARY OF SOIL SAMPLES TO BE SUBMITTED FOR ANALYSIS

Matrix	Laboratory Parameter	Samples	Field Duplicates[1]	Field Blanks[2]	Trip Blanks[3]	Matrix Spikes[4]	Equipment Blank[5]	Matrix Total
Soil	TCL Volatiles	10	1	1	5	1	3	21
	TCL Semivolatiles	10	1	1	0	1	3	16
	TCL Pesticides/PCBs	10	1	1	0	1	3	16
	TAL Metals and Cyanide	10	1	1	0	1	3	16
SUMMARY OF SOIL SAMPLES TO BE SUBMITTED FOR ANALYSIS - SITE 21								
Soil	TCL PCBs	14	2	1	2	1	3	23

Notes:
[1]Field duplicates are collected at a frequency of 1 per 10.
[2]Field blanks are collected at a frequency of 1 per source per event.
[3]Trip blanks are shipped with samples submitted for volatiles analysis. Trip blanks are used to monitor contamination that could be introduced during transportation. Trip blanks are collected at a frequency of 1 per cooler of volatiles samples.
[4]Matrix spike/matrix spike duplicates (MS/MSD) are collected at a frequency of 1 per 20. MS/MSDs represent samples for which extra volume must be collected for the laboratory to perform required QC analyses. Triple the normal volumes will be collected for all analyses.
[5]Equipment blanks are collected at a frequency of 1 every day.
Note: This table is based on Navy Level D QA/QC requirements.

Table 10-3
SUMMARY OF GROUNDWATER SAMPLES TO BE SUBMITTED FOR ANALYSIS - SITE 5

Matrix	Laboratory Parameter	Samples	Field Duplicates[1]	Field Blanks[2]	Trip Blanks[3]	Matrix Spikes[4]	Equipment Blanks[5]	Matrix Total
Groundwater	Low Concetration Volatiles	3	1	1	5	0	2	12
	TCL Semivolatiles	3	1	1	0	1	2	8
	TCL Pesticides/PCBs	3	1	1	0	1	2	8
	TAL Metals (unfiltered)	3	1	1	0	1	2	8
	TAL Metals (filtered)	3	1	1	0	1	2	8
	TAL Cyanide	3	1	1	0	1	2	8
SUMMARY OF GROUNDWATER SAMPLES TO BE SUBMITTED FOR ANALYSIS - SITE 21								
Groundwater	TCL PCBs (filtered)	2	1	1	3	1	2	10
	TCL PCBs (unfiltered)	2	1	1	0	1	2	7

Notes:
[1]Field duplicates are collected at a frequency of 1 per 10.
[2]Field blanks are collected at a frequency of 1 per source per event.
[3]Trip blanks are shipped with water samples submitted for volatiles analysis. Trip blanks are used to monitor contamination that could be introduced during transportation. Trip blanks are collected at a frequency of 1 per cooler of volatiles samples.
[4]Matrix spike/matrix spike duplicates (MS/MSD) are collected at a frequency of 1 per 20. MS/MSDs represent samples for which extra volume must be collected for the laboratory to perform required QC analyses. Triple the normal volumes will be collected for all analyses. MS/MSD analysis not required when analyzing samples using the Low Concentration Volatile method.
[5]Equipment blanks are collected at a frequency of 1 every day.
Note: This table is based on Navy Level D QA/QC requirements.

Matrix spike/matrix spike duplicates (MS/MSD) will be collected at the rate of one for every 20 field samples collected. MS/MSD samples give an indication of laboratory analysis accuracy and precision within the sample matrix.

Blanks provide a measure of cross-contamination sources, decontamination efficiency, and other potential errors that can be introduced from sources other than the sample. Three types of blanks can be generated during sampling activities: trip blanks, field blanks, and equipment rinsate blanks.

One trip blank will be included in each cooler used for the daily shipment of Volatile Organic Analysis (VOA) samples. If more than one cooler is being sent on a given day, all of the VOA samples should be placed in one cooler, if possible, to minimize the number of trip blanks needed. The trip blanks will be prepared before each sampling event, shipped or transported to the field with the sampling bottles, and returned unopened for analysis. Trip blanks will indicate if there is any contamination during shipment to the field, from storage in the field, or from shipment from the field to the analytical laboratory.

One equipment blank per sample media will be obtained for every second day of sampling. Equipment blanks will give an indication of the efficiency of decontamination procedures.

One field blank will be collected for each week of sampling. Field blanks are used to determine the chemical quality of water used for such procedures as decontamination and blank collection.

Laboratory Analytical Quality Control Procedures

The analytical laboratory will use the quality control elements including matrix spikes, matrix spike duplicates, and laboratory blanks as specified in the *Navy Installation Restoration Laboratory Quality Assurance Guide, Interim Guidance Document*, February, 1996. Field quality control procedures are provided in Appendix A of the FSP.

Matrix Spike/Matrix Spike Duplicate

Matrix spike/matrix spike duplicates will be spiked by the laboratory in two separate aliquots of a sample selected by the sampler from each batch of 20 field samples. The MS/MSDs will be used to assess accuracy and precision. The MSD is identical to the MS; both are analyzed to determine the reproducibility of the results. The sampler will collect triple volume of one sample to provide the laboratory with enough material to analyze the sample, the spiked sample, and the spiked sample duplicate. MS/MSDs are not required for the low concentration method, and the laboratory performs other QC (lab control samples) with this method.

Section 11

Performance and Systems Audits

Both field and laboratory audits will be conducted.

Laboratory Performance and Systems Audits

The analytical laboratories will conduct internal quality control checks as indicated in each laboratory's LQAP. The laboratories are subject to external audits by the Navy and CH2M HILL.

Field Team Performance and Systems Audits

A performance audit will be conducted on an as-needed basis by the project manager during the sampling activities to verify that proper sampling and documentation procedures presented in the QAPP and the FSP are followed and that subsequent sample data are valid. The audit will focus on the details of the QA program. The audit checklist serves as the guide for performing audits for field procedures, is shown in Figure 11-1. The audit will evaluate the following:

- Project responsibilities
- Sample collection and preservation procedures
- Equipment decontamination procedures
- Field equipment calibration procedures
- Sample custody procedures
- Document control
- Sample identification system
- QC corrective action procedures

An audit report summarizing any results and corrections will be prepared and filed in the project files. Significant variances from established procedures will be reported to the project manager.

Figure 11-1
FIELD PERFORMANCE AUDIT CHECKLIST

Project Responsibilities

Project No.: _____ Date: _____

Project Location: _____ Signature: _____

Team Members: _____

Yes __ No __ 1) Was a SAP Prepared?
Comments _____

Yes __ No __ 2) Was a briefing held for project participants?
Comments _____

Yes __ No __ 3) Were additional instructions given to project participants?
Comments _____

Sample Collection

Yes __ No __ 1) Is there a written list of sampling locations and descriptions?
Comments _____

Yes __ No __ 2) Are samples collected as stated in the FSP?
Comments _____

Yes __ No __ 3) Are samples collected in the type of containers specified in the FSP?
Comments _____

Figure 11-1
FIELD PERFORMANCE AUDIT CHECKLIST
(Continued)

Yes __ No __ 4) Are samples preserved as specified in the FSP?
Comments _____

Yes __ No __ 5) Are the number, frequency, and type of samples collected as specified in the FSP?
Comments _____

Yes __ No __ 6) Are quality assurance checks performed as specified in the FSP?
Comments _____

Yes __ No __ 7) Are photographs taken and documented as specified in the FSP?
Comments _____

Document Control

Yes __ No __ 1) Have any accountable documents been lost?
Comments _____

Yes __ No __ 2) Have any accountable documents been voided?
Comments _____

Yes __ No __ 3) Have any accountable documents been disposed of?
Comments _____

Figure 11-1
FIELD PERFORMANCE AUDIT CHECKLIST
(Continued)

Yes __ No __ 4) Are the samples identified with sample tags?
Comments _____
_____
_____

Yes __ No __ 5) Are blank and duplicate samples properly identified?
Comments _____
_____
_____

Yes __ No __ 6) Are samples listed on a chain-of-custody record?
Comments _____
_____
_____

Yes __ No __ 7) Is chain-of-custody documented and maintained?
Comments _____
_____
_____

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Section 12

Preventive Maintenance

Routine maintenance procedures and schedules for sampling equipment are described in the manufacturer's instruction manuals. All records of inspection and maintenance will be dated and documented in the field notebook.

Maintenance procedures and schedules for all field and laboratory analytical instruments will follow the recommendations of the equipment manufacturers. Routine laboratory equipment maintenance will be performed by laboratory personnel as needed or as indicated in the LQAP. All records of inspection and maintenance will be dated and documented in laboratory record books.

Critical spare parts for the pH, OVM, conductivity meter, and explosimeter include batteries, electrodes, and membranes. They will be included in the sampling kits to minimize downtime. In addition, back-up meters will be available, if needed. Spare parts will be purchased from accepted vendors.

Section 13

Data Assessment Procedures

The precision and accuracy of data will be routinely assessed to ensure that they meet the requirements of the DQOs.

All data will be validated before interpretation by a subcontractor. The validation will be performed according to *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, February 1994, and the *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses*, January 1993.

Data validation will be performed by an independent contractor, as it would not be appropriate for CH2M HILL to validate data collected by CH2M HILL staff. Data that should be qualified will be flagged with the appropriate symbol. Results for field and equipment blanks will be reviewed, and the data will be qualified further, if necessary. Finally, the data set as a whole will be examined for consistency, anomalous results, and reasonableness.

Section 14

Corrective Actions

The project manager is responsible for initiating corrective actions. Corrective action steps will include problem identification, investigation responsibility assignment, action to eliminate the problem, increased monitoring of the effectiveness of the corrective action, and verification that the problem has been eliminated.

Examples of corrective actions include, but are not limited to, correcting CofC forms, analysis reruns (if holding time criteria permit), recalibration with fresh standards, replacement of sources of blank contamination, examination of calculation procedures, additional training in sample preparation and analysis, reassignment of analytical responsibilities using a different batch of containers, or recommending an audit of laboratory procedures. Additional approaches may include:

- Resampling and analyzing
- Evaluating and amending sampling and analytical procedures
- Accepting the data and acknowledging the level of uncertainty or inaccuracy by flagging the data and providing an explanation for the qualification.

Section 15

Quality Assurance Reports

A QA report will be completed at the end of the field activity to summarize the QA/QC status of the project and any problems. The report will be an assessment of the measured QA parameters (for example, precision and accuracy), results of performance audits, any reported non-conformance, and any significant QA problems and the recommended solutions. Any change in the QAPP will be summarized in a report or letter and sent to LANTDIV and distributed to the CH2M HILL project team.

WDCR1015/014.DOC

Final

Field Sampling Plan
Remedial Investigation and Feasibility Study
Pesticide Disposal Site (Site 5)
Preliminary Assessment/Site Investigation
Building W-316 PCB Waste Work Area (Site 21)

Norfolk Naval Base
Norfolk, Virginia

Contract Task Order 0003

August 15, 1996

Prepared for

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Naval Facilities Engineering Command

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Prepared by

CH2M HILL

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Herndon, Virginia

Section 2

Sampling Operations

All aspects of the sampling operations will conform to U.S. Navy specifications and guidelines. This includes the frequency of collecting and providing QC samples: duplicates; trip, field, and equipment blanks; and matrix spike and matrix spike duplicates.

Soil Sampling Techniques

The Site 5 RI/FS and Site 21 PA/SI will involve the collection of soil samples. Several different sampling techniques will be employed during the soil sampling phase of these investigations including split spoon and stainless-steel trowel sample collection. A brief explanation of each sampling technique is provided below. The Standard Operating Procedures (SOPs) for the collection of soil samples are included in Attachment A.

Split Spoon Sampling

Split spoon sampling techniques will used at locations where samples are being collected from several different depths, from beneath asphalt/concrete, or where compaction of the soil has made sample collection using manual sampling techniques impossible. A drill rig will be used to advance 6 1/4-inch hollow stem augers to the top of the desired sampling interval. A stainless-steel split spoon sampling device will be attached to the proper length of drilling rod and inserted through the hollow stem augers. A 150-pound hammer will be used to advance the split spoon sampling device an additional 2-feet required for sample collection. If necessary, several samples within a 1-foot diameter area will be collected at each location to acquire the volume of sample needed to fill all sample containers. The split spoon sampler will then be retrieved and the sample will be extruded.

The VOC sample containers will be filled first. The sample will be placed directly into the VOC sample container to minimize the volatilization of organic compounds. The remaining sample volumes will be placed into a stainless-steel bowl and mixed thoroughly. After mixing, all other sample containers will be filled.

Soil boring sampling holes will be backfilled with grout. Asphalt and concrete surfaces will be repaired with like material as necessary.

Stainless-Steel Trowel

A stainless-steel trowel will be used during the collection of sediment samples and shallow soil samples in areas where manual soil sampling techniques can be applied. The trowel will be used to transfer the soil or sediment from the sampling location into the sample containers. The volatile organic compound (VOC) sample containers will be filled first. The sample will be placed directly into the VOC sample container to minimize the volatilization of organic compounds. The remaining sample volume will be placed into a stainless-steel bowl and mixed thoroughly. After mixing, all other sample containers will be filled.

All samples will be placed in clean glass containers provided by the laboratory. Any sample that is split for duplicate analysis will be mixed thoroughly before being split (except for VOCs). Table 2-1 presents the required containers, preservatives, and holding times for soil and sediment samples. Table 2-2 presents a summary of soil samples to be submitted for analyses.

Groundwater and Surface Water Sampling Techniques

The Site 5 RI/FS and Site 21 PA/SI field activities involve the collection of groundwater samples. Groundwater samples will be collected from the two newly installed monitoring wells at each site using a Grundfos® Redi-Flo2 sampling pump. A brief explanation of the groundwater sampling techniques to be employed during the Site 5 RI/FS and Site 21 PA/SI are provided below. Detailed descriptions of monitoring well sampling techniques are included in Attachment A.

Monitoring Well Sampling

Before sampling, groundwater will be purged from each well. The volume of groundwater in the monitoring well will be calculated using values for the depth of the well, the depth to water, and the well diameter. Purging will be performed until a minimum of three well volumes of water have been removed and the temperature, specific conductance, and pH have stabilized within 10 percent for three consecutive readings. Sampling will commence when the parameter measurements have stabilized. Wells that are pumped dry during purging will be allowed to recover before sampling; the sample will be obtained as soon as a sufficient volume of groundwater to fill all sample containers has entered the well. The Investigation Derived Waste Management Plan (IDWMP) discusses treatment and disposal of purge water.

Samples will be placed in containers and pre-preserved by the laboratory according to the Navy's Level D protocol and analyzed within the proper holding time. For VOCs the bottles will be filled so as to minimize aeration of the samples. Sample vials will be filled completely and capped to prevent the entrapment of any air bubbles in the vial.

The bottle cap should be removed carefully from the laboratory cleaned sample bottle. The cap should not be laid down nor the inside touched. At no time should the inside of the bottle come into contact with anything other than the sample.

All appropriate preservatives will be added to the sample containers by the contracted laboratory before shipment to the CH2M HILL field team. Low concentration VOC samples will be preserved with hydrochloric acid (HCl), TAL metals samples will be preserved with nitric acid (HNO_3), and cyanide samples will be preserved with sodium hydroxide (NaOH). All samples will be kept cool at 4°C, using bagged ice.

Table 2-3 presents the required containers, preservatives, and holding times for groundwater samples. Table 2-4 presents a summary of groundwater samples to be submitted for analyses.

Table 2-1
REQUIRED CONTAINERS, PRESERVATIVES, AND HOLDING TIMES FOR SOIL SAMPLES

Analysis	Sample Container	Preservative	Holding Time	Volume of Sample Collected
TCL Volatiles	4-oz glass bottle with teflon-lined cap	Cool to 4°C	14 days	Fill completely
TCL Semivolatiles	Two 4-oz glass bottles with teflon-lined cap	Cool to 4°C	14 days	Fill completely
TCL Pest/PCB	Two 4-oz glass bottles with teflon-lined cap	Cool to 4°C	14 days	Fill completely
TAL Inorganics	4-oz glass bottle with teflon-lined cap	Cool to 4°C	6 months	Fill to shoulder

Note:

Refer to Table 2-3 for the required containers, preservatives, and holding times for the associated aqueous field quality control samples.

Table 2-2
SUMMARY OF SOIL SAMPLES TO BE SUBMITTED FOR ANALYSIS - SITE 5

Matrix	Laboratory Parameter	Samples	Field Duplicates[1]	Field Blanks[2]	Trip Blanks[3]	Matrix Spikes[4]	Equipment Blank[5]	Matrix Total
Soil	TCL Volatiles	10	1	1	5	1	2	20
	TCL Semivolatiles	10	1	1	0	1	2	15
	TCL Pesticides/PCBs	10	1	1	0	1	2	15
	TAL Metals and Cyanide	10	1	1	0	1	2	15
SUMMARY OF SOIL SAMPLES TO BE SUBMITTED FOR ANALYSIS - SITE 21								
Soil	TCL PCBs	14	2	1	0	1	1	19

Notes:
[1]Field duplicates are collected at a frequency of 1 per 10.
[2]Field blanks are collected at a frequency of 1 per source per event.
[3]Trip blanks are shipped with samples submitted for volatiles analysis. Trip blanks are used to monitor contamination that could be introduced during transportation. Trip blanks are collected at a frequency of 1 per cooler of volatiles samples.
[4]Matrix spike/matrix spike duplicates (MS/MSD) are collected at a frequency of 1 per 20. MS/MSDs represent samples for which extra volume must be collected for the laboratory to perform required QC analyses. Triple the normal volumes will be collected for all analyses.
[5]Equipment blanks are collected at a frequency of 1 every day.
Note: This table is based on Navy Level D QA/QC requirements.

Table 2-3
REQUIRED CONTAINERS, PRESERVATIVES, AND HOLDING TIMES FOR WATER SAMPLES

Analysis	Sample Container	Preservative	Holding Time	Volume of Sample Collected
Low Concentration Volatiles and TCL Volatiles	Three 40-ml glass vial w/teflon lined cap	HCl to pH <2; Cool to 4°C	14 days	Fill completely; no air bubbles
TCL Semivolatiles	2 1-liter amber bottle w/teflon lined cap	Cool to 4°C	7 days to extraction, 40 days to analysis	Fill to shoulder
TCL Pest/PCB	2 1-liter amber bottle w/teflon lined cap	Cool to 4°C	7 days to extraction, 40 days to analysis	Fill to shoulder
TAL Metals	1-liter polyethylene bottle for each analysis	HNO_3 to pH <2; Cool to 4°C	6 months	Fill to shoulder
TAL Cyanide	1-liter bottle	NaOH to pH > 12, Cool to 4°C	14 days	Fill to shoulder

Table 2-4
SUMMARY OF GROUNDWATER SAMPLES TO BE SUBMITTED FOR ANALYSIS - SITE 5

Matrix	Laboratory Parameter	Samples	Field Duplicates[1]	Field Blanks[2]	Trip Blanks[3]	Matrix Spikes[4]	Equipment Blanks[5]	Matrix Total
Groundwater	Low Concetration Volatiles	3	1	1	4	0	2	8
	TCL Semivolatiles	3	1	1	0	1	2	8
	TCL Pesticides/PCBs	3	1	1	0	1	2	8
	TAL Metals (filtered)	3	1	1	0	1	2	8
	TAL Metals (Unfiltered)	3	1	1	0	1	2	8
	TAL Cyanide	3	1	1	0	1	2	8
SUMMARY OF GROUNDWATER SAMPLES SUBMITTED FOR ANALYSIS - SITE 21								
Groundwater	TCL PCBs (filtered)	2	1	1	1	1	1	6
	TCL PCBs (unfiltered)	2	1	1	0	1	1	6

Notes:
[1]Field duplicates are collected at a frequency of 1 per 10.
[2]Field blanks are collected at a frequency of 1 per source per event.
[3]Trip blanks are shipped with water samples submitted for volatiles analysis. Trip blanks are used to monitor contamination that could be introduced during transportation. Trip blanks are collected at a frequency of 1 per cooler of volatiles samples.
[4]Matrix spike/matrix spike duplicates (MS/MSD) are collected at a frequency of 1 per 20. MS/MSDs represent samples for which extra volume must be collected for the laboratory to perform required QC analyses. Triple the normal volumes will be collected for all analyses. MS/MSD analysis not required when analyzing samples using the Low Concentration Volatile method.
[5]Equipment blanks are collected at a frequency of 1 every day.
Note: This table is based on Navy Level D QA/QC requirements.

Equipment Decontamination

All non-dedicated sampling equipment will be decontaminated prior to the beginning of sampling activities and after each use. Specific field decontamination procedures are presented in Attachment A.

Field Quality Control Procedures

Quality control duplicate samples and blanks are used to provide a measure of the internal consistency of the samples and to provide an estimate of the components of variance and the bias in the analytical process.

Blanks

Blanks provide a measure of cross-contamination sources, decontamination efficiency, and other potential errors that can be introduced from sources other than the sample. ASTM Type II water will be used for blanks. Three types of blanks will be generated during sampling activities: trip blanks, field blanks, and equipment blanks.

One trip blank will be included for each cooler containing samples for VOC analysis. The trip blanks will be prepared prior to each sampling event, shipped or transported to the field with the sampling bottles, and sent to the laboratory unopened for analysis. Trip blanks will not be prepared or handled in the field. Trip blanks will indicate if any contamination occurred during shipment to the field, field storage, or during shipment from the field to the analytical laboratory.

One field blank will be collected each week of sampling. The field blanks will indicate if any contaminants were introduced during the handling of the sample containers in the field or during sample analysis at the laboratory. The sample container will be filled with ASTM Type II water in the field at the time of sampling. The blanks will be capped, packed, and shipped with the samples.

One equipment blank will be collected and analyzed every other day during sampling activities. The equipment blanks will indicate the efficiency of equipment decontamination procedures.

Duplicates

Field duplicate samples will be collected at a frequency of 1 per 10 field samples per matrix. The location from which the duplicates are taken will be randomly selected. The duplicate sample will be submitted for analysis as two independent samples. These samples will be numbered non-sequentially.

Matrix Spike/Matrix Spike Duplicate (MS/MSD)

Matrix spike/matrix spike duplicate (MS/MSD) samples will be collected at a frequency of one per 20 field samples. Analytical results of these samples indicate the impact the matrix

(water or soil) has on extracting the analyte for analysis. Data validators will use these results to evaluate the accuracy of the analytical data.

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Sample Designation

Numbering Format for Field Samples

Each field sample will be designated by an alphanumeric code that will identify Norfolk Naval Base, the site number, the sample type, and the sample number. The following table is a general guide for sample identification:

First Segment of Sample Designation	Second Segment of Sample Designation	Third Segment of Sample Designation	
Base Code	Site Number	Sample Type	Sample Number
AA	AAA	AA	AAAAAA

Symbol Definition: A = Alphanumeric

Base Code - Consists of two alphanumeric characters

NB = Norfolk Naval Base

Site Number - Consists of three alphanumeric characters. The first character will distinguish a typical site from a SWMU. The last two characters will contain a number between 0 and 100, designating the site or SWMU number.

S = Site

U = SWMU

The site numbers for this CTO are as follows:

S05 = Site 5 - RI/FS Pesticide Disposal Site

S21 = Site 21 - PA/SI Building 316, PCB Waste Work Area

Sample Type - Consists of two alphanumeric characters. The possible combinations include the following:

SS = Surface soil sample

SB = Soil boring (subsurface) sample

SD	=	Sediment sample
SW	=	Surface water sample
GP	=	Geoprobe® groundwater sample
GW	=	Groundwater sample
DR	=	Drum sample
PZ	=	Piezometer sample
SG	=	Soil gas sample
TR	=	Trench sample
IS	=	Investigation-derived waste (IDW) soil sample
IW	=	Investigation-derived waste (IDW) water sample

Sample Number - Consists of up to six alphanumeric characters. The characters will include a sequential sample number obtained from the Field Sampling Plan and modifiers to designate the following:

P	=	Duplicate
F	=	Filtered
S	=	Shallow well
D	=	Deep well

Numbering Format for QA/QC Samples

Each QA/QC sample will be designated by an alphanumeric code that will identify the sample type and the date that the sample was collected. The following table is a general guide for sample identification:

First Segment of Sample Designation	Second Segment of Sample Designation
Sample Type	Sample Date
AA	AAAAAA

Symbol Definition: A = Alphanumeric

Sample type - Consists of two alphanumeric characters. The possible combinations include the following:

FB	=	Field blank
TB	=	Trip blank
EB	=	Equipment blank

Sample date - Consists of six alphanumeric characters that represent the date the sample was collected. The date will always be given in a DDMMYY format.

Examples of this numbering system for QA/QC samples are:

FB-100196	=	Field blank collected on October 1, 1996
TB-072997	=	Trip blank collected on July 29, 1997
EQ-080198	=	Equipment blank collected on August 1, 1998

Sample Shipping Procedures

Strict adherence to both personnel and equipment decontamination procedures will help ensure the safety of onsite workers as well as the acquisition of quality data.

All field sampling activities will be documented through the use of field logs and chain-of-custody procedures. Sample containers will be clean, first-quality containers provided by the contracted laboratory. A complete listing of the types of bottles and preservatives to be used is given in Tables 2-1 and 2-3 in Section 2 of this FSP. An identification label will be attached to each sample container indicating the sample number, station number, analysis to be performed, preservative used, date and time of sample collection, and the name of the responsible sampling team member.

After collection, samples will be packed in coolers with vermiculite (and ice) for shipment to the contracted laboratory via an overnight courier. Chain-of-custody forms will be taped to the inside of the lid of each cooler. Chain-of-custody forms contain general information about the location of the activity and the members of the sampling team, as well as specific information about the type of sample, sample location, number of sample containers from each station, and analyses to be performed. Each time the sample is relinquished or received, the party involved signs the form and indicates the time and date.

The coolers used to deliver the samples will be sealed with strapping tape. Evidence tape will be placed across the front and back of each lid to control tampering. The samples will be shipped to the laboratory at the end of each day of sampling to ensure that holding times are not exceeded.

Field Sampling Plan

Appendix A

List of Standard Operating Procedures for Sampling

Water Level Measurements

Groundwater Sampling from Monitoring Wells

Field Measurement of pH

Field Measurement of Specific Conductance and Temperature

Volatiles Monitoring with an OVM

Explosimeter Operations

VOC Sampling - Water

Shallow Soil Sampling

Homogenization of Soil and Sediment Samples

Soil Boring Sampling - Split Spoon

Logging of Soil Borings

Soil Boring Drilling and Abandonment

General Guidance for Monitoring Well Installation

Installation of Shallow Monitoring Wells

Decontamination of Personnel and Equipment

STANDARD OPERATING PROCEDURE

Water Level Measurements

STANDARD OPERATING PROCEDURE

Water-Level Measurements

I. Purpose and Scope

The purpose of this procedure is to provide a guideline for the measurement of the depth to groundwater in monitoring wells, where a second phase of floating liquid (e.g., gasoline) is not encountered. This SOP includes guidelines for discrete measurements of static water levels.

II. Equipment and Materials

A. Discrete Measurements of Static Water Level

- Electronic water level meter, Solinst or equivalent, with a minimum 100-foot tape; cable should have graduations in increments of 0.1 feet or less
- Engineering rule graduated in 0.01-foot increments

III. Procedures and Guidelines

A. Measurement of Static Water Level

Verify that the unit is turned on and functioning properly. Slowly lower the probe on its cable into the well until the probe just contacts the water surface; the unit will respond with a tone or light signal. Sight across the top of the locking well casing adjacent to the measuring point, recording the position of the cable when the probe is at the water surface. The measuring point will be a standardized surveyed location on the top of each well casing, adjacent to the lock hasp, indicated by a notch, paint mark, or similar method. Measure the distance from this point to the next lower interval marker on the cable, and record the water level reading in the log book.

Measure and record the three following additional readings: (1) the depth of the well; (2) the depth from the top of the casing to the top of the well riser; and (3) the distance to the surface of the concrete pad or to ground. Measurements are to be taken with respect to the measuring point on the top of the well casing. The depth of well may be measured using the water-level probe with the instrument turned off.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

A. Discrete Measurements of Static Water Level

Prior to each use, verify that the battery is charged by pressing the test button on the water-level meter. Verify that the unit is operating correctly by testing the probe in distilled or deionized water. Leave the unit turned off when not in use.

STANDARD OPERATING PROCEDURE

Groundwater Sampling from Monitoring Wells

STANDARD OPERATING PROCEDURE

Groundwater Sampling from Monitoring Wells

I. Purpose and Scope

This procedure presents guidelines for the collection of groundwater samples from monitoring wells.

II. Equipment and Materials

- Probe box; stainless steel box with inlet/outlet ports for purged groundwater and watertight ports for each probe
- pH meter; Orion Model SA250 or equivalent
- Temperature/conductivity meter; YSI Model 33 or equivalent
- In-line disposable 0.45µ filters; QED FF8100 or equivalent
- Bailer, teflon or stainless steel
- Peristaltic Pump with Tubing (capable of yielding 2 gpm)
- Submersible Pump

III. Procedures and Guidelines

A. Setup and Purging

1. For the well to be sampled, information is obtained on well location, diameter(s), depth, and screened interval(s), and the method for disposal of purged water.
2. A pump will be used for well purging. The expected mechanism is a submersible pump with dedicated purge pipe for each well.
3. Instruments are calibrated according to manufacturer's instructions.
4. The well number, site, date, and condition are recorded in the field logbook.
5. Plastic sheeting is placed on the ground, and the well is unlocked and opened.
6. Water level measurements are collected in accordance with SOP Water Level Measurements, and the total depth of the well is measured.

7. The volume in gallons of water in the well casing or sections of telescoping well casing is calculated as follows:

$0.052\ (\pi r^2 h) = 0.163\ (r^2 h) =$ gallons

where: $\pi = 3.14$

r = Radius of the well pipe in inches
h = height of water in well in feet

The volume of water in typical well casings may be calculated as follows:

2-inch diameter well:
0.163 gal/ft x ___ (linear feet of water) = gallons

4-inch diameter well:
0.653 gal/ft x ___ (linear feet of water) = gallons

6-inch diameter well:
1.469 gal/ft x ___ (linear feet of water) = gallons

The initial field parameters of pH, specific conductance, and temperature of water are measured and recorded in the field logbook. The measurement probes are inserted into the probe box. The purged groundwater is directed throughout the box, allowing measurements to be collected before the water contacts the atmosphere.

8. Sampling equipment is cleaned and decontaminated prior to sampling in accordance with SOP Decontamination of Personnel and Equipment.

9. If a bailer is being used, it is removed from either its protective covering or the well casing and attached to a cord compatible with constituents and long enough to reach the bottom of the well. If a bladder pump is being used, air, sample, and lifting lines are attached to the pump. The lifting lines should bear the weight of the pump; the air and sample lines are attached to the lifting lines at 10-foot intervals. If the well is purged using dedicated tubing, it is lowered into the well to the top of the screened zone.

10. The sampling device is lowered to the well interval from which the sample is to be collected. If a bailer is being used, it is allowed to fill with a minimum of surface disturbance to prevent sample water aeration. When the bailer is raised, the bailer cord must not touch the ground.

11. During purging, the field parameters are measured at least once during each well volume.

In productive wells, the well purging end point is determined using the field measurements. In nonproductive wells, the well is repeatedly bailed dry to obtain a minimum of three well volumes, and allowed to recover before sampling.

12. Three to five well volumes are purged (more may be purged if parameters do not stabilize). Purging is stopped when field parameters have stabilized over two consecutive well volumes. Field parameters are considered stabilized when pH measurements agree within 0.5 units, temperature measurements agree within 1°C, and specific conductance measurements agree within 10 percent (e.g., 100 units for readings of 1,000 µmhos/cm).

B. Sample Collection

Once purging has been completed, the well is ready to be sampled. The elapsed time between completion of purging and collection of the groundwater sample from the well should be minimized. Typically, the sample is collected immediately after the well has been purged, but this is also dependent on well recovery.

Samples will be placed in bottles that are appropriate to the respective analysis and that have been cleaned to laboratory standards. Each bottle typically will have been previously prepared with the appropriate preservative, if any.

The following information, at a minimum, will be recorded in the log book:

- Sample identification (site name, location, and project number; sample name/number and location; sample type and matrix; time and date; sampler's identity)
- Sample source and source description
- Field observations and measurements (appearance, volatile screening, field chemistry, sampling method), volume of water purged prior to sampling, number of well volumes purged, and field parameter measurements
- Sample disposition (preservatives added; laboratory sent to, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)
- Additional remarks

The steps to be followed for sample collection are as follows:

1. The cap is removed from the sample bottle, and the bottle is tilted slightly.
2. The sample is slowly poured from the bailer or discharged from the pump so that it runs down the inside of the sample bottle with a minimum of splashing. Samples may be field filtered before transfer to the sample bottle. Filtration must occur in the field immediately upon collection. Inorganics, including metals, are to be collected and preserved in the filtered form as well as the unfiltered form. The recommended method is through the use of a disposable in-line filtration module (0.45 micron filter) using the pressure provided by the

pumping device for its operation. When a bailer is used, filtration may be driven by a peristaltic pump.

3. Samples collected for VOC analysis will be collected using a bailer when the well is purged using dedicated tubing and a surface pump.

4. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to overflowing and capped.

5. The bottle is capped, then labeled clearly and carefully.

6. Samples are placed in appropriate containers and, if necessary, packed with ice in coolers as soon as practical.

7. If the sampler is dedicated, it is returned to the well and the well is capped and locked. Nondedicated samplers are cleaned and decontaminated in accordance with SOP Decontamination of Personnel and Equipment.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

Maintain field equipment in accordance with the manufacturer's recommendations; this will include, but is not limited to:

- Inspect sampling pump regularly and replace as warranted
- Inspect tubing regularly and replace as warranted
- Inspect air/sample line quick-connects regularly and replace as warranted
- Verify battery charge, calibration, and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

STANDARD OPERATING PROCEDURE

Field Measurement of pH

STANDARD OPERATING PROCEDURE

Field Measurement of pH

I. Purpose

To provide a general guideline for field measurement of pH.

II. Scope

Standard field pH determination techniques for use on groundwater samples.

III. Equipment and Materials

- pH buffer solution for pH 4, 7, and 10
- Deionized water in squirt bottle
- pH meter
- Combination electrodes
- Beakers
- Glassware that has been washed with soap and water, rinsed twice with hot water, and rinsed twice with deionized water

IV. Procedures and Guidelines

A. Calibration

Calibrate unit prior to initial daily use and at least once every 4 hours or every five samples, whichever is less. Calibrate with at least two solutions. Clean probe according to manufacturer's recommendations. Duplicate samples should be run once every 10 samples or every 4 hours.

1. Place electrode in pH 7 buffer solution.
2. Allow meter to stabilize and then turn calibration dial until a reading of 7.0 is obtained.
3. Rinse electrode with deionized water and place it in a pH 4 or pH 10 buffer solution.
4. Allow meter to stabilize again and then turn slope adjustment dial until a reading of 4.0 is obtained for the pH 4 buffer solution or 10.0 for the pH 10 buffer solution.

5. Rinse electrode with deionized water and place in pH 7 buffer. If meter reading is not 7.0, repeat sequence.

B. Procedure

1. Before going out into the field:

   a) Check batteries.
   b) Do a quick calibration at pH 7 and 4 to check electrode.
   c) Obtain fresh solutions.

2. Calibrate meter using calibration procedure.

3. Pour the sample into a clean beaker.

4. Rinse electrode with deionized water between samples.

5. Immerse electrode in solution. Make sure the white KCl junction on the side of the electrode is in the solution. The level of electrode solution should be one inch above sample to be measured.

6. Recheck calibration with pH 7 buffer solution after every five samples.

C. General

1. When calibrating the meter, use pH buffers 4 and 7 for samples with pH < 8, and buffers 7 and 10 for samples with pH > 8. If meter will not read pH 4 or 10, something may be wrong with the electrode.

2. Measurement of pH is temperature dependent. Therefore, buffers temperatures should be within about 2 degrees C of sample temperatures. For refrigerated or cool samples, use refrigerated buffers to calibrate the pH meter.

3. Weak organic and inorganic salts and oil and grease interfere with pH measurements. If oil and grease are visible, note it on the data sheet. Clean electrode with soap and water and rinse with distilled water. Then recalibrate meter.

4. Following field measurements:

   a) Report any problems.
   b) Compare with previous data.
   c) Clean all dirt off meter and inside case.
   d) Store electrode in pH 4 buffer.

5. Accuracy and precision are dependent on the instrument used; refer to manufacturer's manual. Expected accuracy and precision are +/- 0.1 pH unit.

V. Key Checks and Items

- Check batteries
- Calibrate

VI. Preventive Maintenance

- Refer to operation manual for recommended maintenance.
- Check batteries, have a replacement set on hand.

STANDARD OPERATING PROCEDURE

Field Measurement of Specific Conductance and Temperature

STANDARD OPERATING PROCEDURE

Field Measurement of Specific Conductance and Temperature

I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for field measurement of specific conductivity and temperature of groundwater samples.

II. Equipment and Materials

- Conductivity meter and electrode
- Distilled water in squirt bottle
- Standard potassium chloride (KCl) solution (0.01 N)

III. Procedures and Guidelines

A. **Technical:** Detection limit = 1 umho/cm @ 25°C; range = 0.1 to 100,000 umho/cm

B. **Calibration:** Calibrate prior to initial daily use with standard solution. The standards should have different orders of conductance. Clean probe according to manufacturer's recommendations. Duplicates should be run once every 10 samples. Calibration procedure:

1. With mode switch in OFF position, check meter zero. If not zeroed, set with zero adjust.
2. Plug probe into jack on side of meter.
3. Turn mode switch to red line and turn red line knob until needle aligns with red line on dial. If they cannot be aligned, change the batteries.
4. Immerse probe in 0.01 N standard KCl solution. Do not allow the probe to touch the sample container.
5. Set the mode control to TEMPERATURE. Record the temperature on the bottom scale of the meter in degrees C.
6. Turn the mode switch to appropriate conductivity scale (i.e., x100, x10, or x1). Use a scale that will give a midrange output on the meter.
7. Wait for the needle to stabilize. Multiply reading by scale setting and record the conductivity.

8. If the conductivity meter does not perform an automatic temperature adjustment, the conductivity may be adjusted to 25°C using the formula:

$$G_{25} = G_T / [1 + 0.02 (T - 25)]$$

Where:

G_{25} = conductivity at 25°C, umho/cm
T = temperature of sample, degrees C
G_T = conductivity of sample at temperature T, umho/cm

The table below lists the values of conductivity that the calibration solution would have if the distilled water were totally nonconductive; however, even water of high purity will possess a small amount of conductivity.

Temperature °C	Conductivity (umho/cm)
15	1,141.5
16	1,167.5
17	1,193.6
18	1,219.9
19	1,246.4
20	1,273.0
21	1,299.7
22	1,326.6
23	1,353.6
24	1,380.8
25	1,408.1
26	1,436.5
27	1,463.2
28	1,490.9
29	1,518.7
30	1,546.7

9. Rinse the probe with deionized water.

C. **Sample Measurement:** Pour the sample into a small beaker and place the probe in the sample. Note and record the reading. Rinse the probe with deionized water when done.

IV. Attachments

- Conductivity meter calibration sheet

V. Key Checks and Preventative Maintenance

- Check battery.
- Calibrate meter.
- Clean probe with deionized water when done.
- When reading results, note sensitivity settings.
- Refer to operations manual for recommended maintenance.
- Check batteries, and have a replacement set on hand.

CONDUCTIVITY METER CALIBRATION SHEET

			Instrument Readings		
Date	Time	Analyst Initials	Uncalibrated @ EC=225	Calibrated @ EC=225	Comments

STANDARD OPERATING PROCEDURE

Volatiles Monitoring by OVM

STANDARD OPERATING PROCEDURE

Volatiles Monitoring with an OVM

I. Purpose and Scope

The purpose of this procedure is to provide guidelines for the calibration and use of an OVM Organic Vapor Monitor.

II. Equipment and Materials

- Operations manual
- An OVM hand readout unit and side pack assembly
- 100 ppm isobutylene as calibration gas
- T-type feeder tube with 1.5 liter/min. regulator

III. Procedures and Guidelines

ONLY PROPERLY TRAINED PERSONNEL SHOULD USE THIS INSTRUMENT. FOR SPECIFIC INSTRUCTIONS, SEE OPERATIONS MANUAL.

OVM, Organic Vapor Monitor

1. Introduction

   The OVM Organic Vapor Monitor is designed to detect organic materials in air. It uses a photo-ionization detector (PID) as its detection principle. This detector allows the monitor to respond to a wide variety of organic compounds.

2. Operational Checks

   - See basic operating instructions in operations manual.

3. Calibration

   - See basic operating instructions in operations manual.

IV. Key Checks and Preventative Maintenance

- Check battery.
- Zero and calibrate.
- Verify sensor probe is working.
- Recharge unit after use.

A complete preventative maintenance program is beyond the scope of this document. For specific instructions, refer to the operations manual.

- A complete spare instrument should be available whenever field operations require volatiles monitoring.
- Spare parts should be on hand so minor repairs may be made in the field.
- Batteries should be charged daily.
- Occasionally allow the batteries to totally discharge before recharging to prevent battery memory from occurring.

STANDARD OPERATING PROCEDURE

Explosimeter Operations

STANDARD OPERATING PROCEDURE

Explosimeter Operations

I. Purpose and Scope

This SOP provides a guideline for field measurements of the levels of combustible gas and oxygen in air.

II. Equipment and Materials

- Industrial Scientific (MX251) Combustible Gas and Oxygen Indicator, or equivalent meter, which can be field calibrated
- Flow-control regulator and hose
- Calibration gas (50 percent LEL pentane—0.75 percent pentane and 15 percent oxygen in nitrogen)
- Equipment calibration data sheet

III. Procedures and Guidelines

A. **Calibration:** The explosimeter must be calibrated before initial daily use. Record calibration information on equipment calibration data sheet. Calibration will be performed according to the following procedure:

1. Turn instrument on
   - Unscrew knurled nut on bottom
   - Rotate metal cover 180°
   - Tighten knurled nut
2. Check battery
   - Check for no ``LoBatt'' display—do not use if LoBatt displayed
3. Calibrate instrument
   - Observe that instrument reads 0 percent LEL and 21 percent Oxygen (OX) (record readings)
   - Connect sampling pump onto top of instrument
   - Connect .75 percent Pentane/15 percent oxygen gas (with 1.5 LPM Regulator and direct tubing)
   - Turn pump ON

- Turn gas ON
- Record LEL and O_2 after stabilized; LEL must read 50 percent +/-5 percent; O_2 must read 15 percent +/- 5 percent
- Disconnect sample pump and return to charger

B. **Sample Measurement:** The instrument is then ready for air sampling. Note and record the readings for percent LEL and percent O_2.

IV. Attachments

- Equipment calibration data sheet

V. Key Checks and Preventative Maintenance

Check that the batteries be adequately charged. Certain materials such as silicone, silicates, and organic lead compounds tend to poison the catalyst in the instrument, thereby giving erroneously low readings; calibration checks should be made frequently if such materials are suspected to be present.

If the CGI does not cal-check within ±5 percent of 50 percent LEL, an internal calibration must be performed, or the instrument replaced.

STANDARD OPERATING PROCEDURE

VOC Sampling–Water

STANDARD OPERATING PROCEDURE

VOC Sampling—Water

I. Purpose and Scope

To provide general guidelines for sampling aqueous volatile organic compounds.

II. Scope

Standard techniques for collecting representative samples are summarized. Site specific details are discussed in the FSP.

III. Equipment and Materials

- Sample vials, clean latex or surgical gloves, pH meter
- Hydrochloric acid (HCl) for preservation
- pH meter or pH indicating paper
- Surgical or latex gloves

IV. Procedures and Guidelines

1. Sample VOCs before sampling other analyte groups.
2. When sampling for VOCs, especially residential wells, evaluate the area around the sampling point for possible sources of air contamination by VOCs. Products that may give off VOCs and possibly contaminate a sample include perfumes and cosmetics, skin applied pharmaceuticals, automotive products (gasoline, starting fluid, windshield deicers, carburetor cleaners, etc.) and household paint products (paint strippers, thinners, turpentine, etc.).
3. VOC sample vials will be pre-preserved with 0.5 ml HCl. To confirm that sufficient HCl has been added, the pH of a test sample will be checked. Sample pH must be less than 2. A small quantity of HCl will be available on site for the case where additional acid is required to preserve the sample.
4. Keep the caps off the sample vials for as short a time as possible.
5. Wear clean latex or surgical gloves.
6. Fill the sample vial immediately, allowing the water stream to strike the inner wall of the vial to minimize formation of air bubbles. DO NOT RINSE THE SAMPLE VIALS BEFORE FILLING.

7. Fill the sample vial with a minimum of turbulence, until the water forms a positive meniscus at the brim.

8. Replace the cap by gently stetting it on the water meniscus. Tighten firmly, but DO NOT OVERTIGHTEN.

9. Invert the vial and tap it lightly. If you see air bubbles in the sample, do not add more sample. Use another vial to collect another sample. Repeat if ` necessary until you obtain a proper sample.

V. Attachments

None.

VI. Key Checks and Items

- Check for possible sources of contamination.
- Check pH.
- Fill slowly, with as little turbulence as possible.
- Check for air bubbles.

STANDARD OPERATING PROCEDURE

Shallow Soil Sampling

STANDARD OPERATING PROCEDURE

Shallow Soil Sampling

I. Purpose

To provide general guidelines for the collection and handling of surface soil samples during field operations.

II. Scope

The method described for surface soil sampling is applicable for loosely packed earth and is used to collect representative samples.

III. Equipment and Materials

- Sample jars.
- A hand auger or other device that can be used to remove the soil from the ground. Only stainless steel, teflon, or glass materials should be used. The only exception is split spoons, which are most commonly available in carbon steel. These are acceptable for use only if they are not rusty.
- A stainless steel spatula should be used to remove material from the sampling device.
- Unpainted wooden stakes or pin flags
- Vermiculite
- Fiberglass measuring tape (at least 200 feet in length)

IV. Procedures and Guidelines

A. Wear protective gear, as specified in the Health and Safety Plan.

B. To locate samples, identify the correct location using the pin flags or stakes. Proceed to collect a sample from the undisturbed soil adjacent to the marker following steps C and D. If markers are not present, the following procedures will be used.

1. For samples on a grid:

   a. Use measuring tape to locate each sampling point on the first grid line as prescribed in the sampling plan. As each point is located, drive a numbered stake in the ground and record its location on the site map and in the logbook.

b. Proceed to sample the points on the grid line.

c. Measure to location where next grid line is to start and stake first sample. For subsequent samples on the line take two orthogonal measurements: one to the previous grid line, and one to the previous sample on the same grid line.

d. Proceed to sample the points on the grid line as described in IVC below.

e. Repeat 1c and 1d above until all samples are collected from the area.

2. For non-grid samples:

a. Use steel measuring tape to position sampling point at location described in the sampling plan by taking two measurements from fixed landmarks (e.g., corner of house and fence post).

b. Note measurements, landmarks, and sampling point on a sketch in the field notebook, and on a site location map.

c. Proceed to sample as described in IVC below.

d. Repeat 2a through 2c above until all samples are collected from the area.

C. To the extent possible, differentiate between fill and natural soil. If both are encountered at a boring location, sample both as prescribed in the field sampling plan. Do not locate samples in debris, tree roots, or standing water. In residential areas, do not sample in areas where residents' activities may impact the sample (e.g., barbecue areas, beneath eaves of rooves, driveways, garbage areas). If an obstacle prevents sampling at a measured grid point, move as close as possible, but up to a distance of one half the grid spacing in any direction to locate an appropriate sample. If an appropriate location cannot be found, consult with the Field Team Supervisor (FTS). If the FTS concurs, the sampling point will be deleted from the program. The FTS will contact the SM immediately. The SM and RPM will discuss whether the point should be deleted from the program. If it is deleted, the SM will follow-up with the RPM in writing.

D. To collect samples:

1. Use a decontaminated stainless steel scoop/trowel to scrape away surficial organic material (grass, leaves, etc.) adjacent to the stake.

2. If sampling:

a. Surface soil: Obtain soil sample by scooping soil using the augering scoop/trowel, starting from the surface and digging down to a depth of about 6 inches.

b. Subsurface soil. Obtain the subsurface soil sample using an auger down to the depths prescribed in the field sampling plan.

3. Take an OVM reading of the sampled soil and record the response in the field notebook. Also record lithologic description and any pertinent observations (such as discoloration) in the logbook.

4. Empty the contents of the scoop/trowel into a decontaminated stainless steel pan.

5. Repeat this procedure until sufficient soil is collected to meet volume requirements.

6. For TCL VOC and field GC aliquots, fill sample jars directly with the trowel/scoop and cap immediately upon filling. DO NOT HOMOGENIZE.

7. For TCL pesticides/PCBs and SVOCs, TAL metals, and field XRF aliquots, homogenize cuttings in the pan using a decontaminated stainless steel utensil in accordance with SOP Decon.

8. Transfer sample for analysis into appropriate containers with a decontaminated utensil.

9. Backfill the hole with vermiculite. To the extent possible, replace topsoil and grass and attempt to return appearance of sampling area to its pre-sampled condition. For samples in non-residential, unmowed areas, mark the sample number on the stake and leave stake in place. In mowed areas, remove stake.

V. Attachments

None.

VI. Key Checks and Items

- Phthalate-free latex or surgical gloves.
- Transfer volatiles first, avoid mixing.
- Decontaminate utensils before reuse.

STANDARD OPERATING PROCEDURE

Homogenization of Soil and Sediment Samples

STANDARD OPERATING PROCEDURE

Homogenization of Soil and Sediment Samples

I. Purpose

The homogenization of soil and sediment samples is performed to minimize any bias of sample representativeness introduced by the natural stratification of constituents within the sample.

II. Scope

Standard techniques for soil and sediment homogenization and equipment are provided in this SOP. These procedures do not apply to aliquots collected for TCL VOCs or field GC screening.

III. Equipment and Materials

Sample containers, stainless steel spoons or spatulas, and stainless steel pans.

IV. Procedures and Guidelines

Soil and sediment samples to be analyzed for semivolatiles, pesticides, PCBs, metals, cyanide, or field XRF screening should be homogenized in the field. After a sample is taken, a stainless steel spatula should be used to remove the sample from the split spoon or other sampling device. The sampler should not use fingers to do this, as gloves may introduce organic interferences into the sample.

Samples for VOCs should be taken immediately upon opening the spoon and should not be homogenized.

Prior to homogenizing the soil or sediment sample, any rocks, twigs, leaves, or other debris should be removed from the sample. The sample should be placed in a decontaminated stainless steel pan and thoroughly mixed using a stainless steel spoon. The soil or sediment material in the pan should be scraped from the sides, corners, and bottom, rolled into the middle of the pan, and initially mixed. The sample should then be quartered and moved to the four corners of the pan. Each quarter of the sample should be mixed individually, and then rolled to the center of the pan and mixed with the entire sample again.

All stainless steel spoons, spatulas, and pans must be decontaminated following procedures specified in SOP Decontamination of Personnel and Equipment prior to homogenizing the sample. A composite equipment rinse blank of homogenization equipment should be taken each day it is used.

STANDARD OPERATING PROCEDURE

Soil Boring Sampling–Split Spoon

STANDARD OPERATING PROCEDURE

Soil Boring Sampling–Split Spoon

I. Purpose

To provide a general procedure for sampling subsurface soil produced from a split spoon.

II. Scope

The scope of this procedure is to cover the sample team's responsibility beginning with the opening of the split spoon.

III. Equipment and Materials

- Latex or surgical gloves
- Stainless steel tray or pan
- Field notebook
- Stainless steel spoon or spatula
- Sampling jars
- Decontamination solutions and equipment

IV. Procedures and Guidelines

1. Field team personnel will wear latex or surgical inner gloves and nitrile or neoprene outer gloves to protect from potential dermal contact with hazardous substances.

2. After the split spoon is removed from the borehole and opened by the driller or driller's assistant, it will be turned over to field team personnel.

3. The sample description, depth, time, and date will be logged in the field notebook.

4. Samples for laboratory analysis will be separated and transferred from the split spoon half into the sample jars by a decontaminated stainless steel utensil. Samples for VOC analysis will be separated and transferred first, followed by semivolatile samples. For volatile samples, avoid mixing soil before or during transfer. Homogenize rest of samples according to SOP Homogenization of Soil and Sediment Samples.

5. Split spoon and media transfer tools will be decontaminated before being used again.

V. Attachments

None.

VI. Key Checks and Items

- Latex or surgical gloves.
- Decontaminate split spoon and transfer tools before next sample.
- Sample volatiles first, then semivolatiles. Avoid mixing.

STANDARD OPERATING PROCEDURE

Logging of Soil Borings

STANDARD OPERATING PROCEDURE

Logging of Soil Borings

I. Purpose and Scope

This SOP provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

II. Equipment and Materials

- Indelible pens
- Tape measure or ruler
- Field logbook
- Spatula
- HCl, 10 percent solution
- Squirt bottle with water
- Rock- or soil-color chart
- Grain-size chart
- Hand lens

III. Procedures and Guidelines

This section covers several aspects of the soil characterization: instructions for completing the CH2M HILL soil boring log Form D1586, field classification of soil, and standard penetration test procedures.

Instructions for Completing Soil Boring Logs

Soil boring logs will be completed in the field log books. Information collected will be consistent with that required for Form D1586, a standard CH2M HILL form.

The information collected in the field to perform the soil characterization is described below.

Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples also should be checked to see that information is correctly recorded on both jar lids and labels and on the log sheets.

Heading Information

Boring/Well Number. Enter the boring/well number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring.

Location. If stationing, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as "approximate" or "estimated" as appropriate.

Elevation. Elevation will be determined at the conclusion of field activities.

Drilling Contractor. Enter the name of the drilling company and the city and state where the company is based.

Drilling Method and Equipment. Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted.

Water Level and Date. Enter the depth below ground surface to the apparent water level in the borehole. The information should be recorded as a comment. If free water is not encountered during drilling or cannot be detected because of the drilling method, this information should be noted. Record date and time of day (for tides, river stage) of each water level measurement.

Date of Start and Finish. Enter the dates the boring was begun and completed. Time of day should be added if several borings are performed on the same day.

Logger. Enter the first initial and full last name.

Technical Data

Depth Below Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Note the depth at the top and bottom of the sample interval.

Sample Type and Number. Enter the sample type and number. For instance, S-1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.

Sample Recovery. Enter the length to the nearest 0.1 foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement.

Standard Penetration Test Results. In this column, enter the number of blows required for each 6 inches of sampler penetration and the "N" value, which is the sum of the blows in the middle two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, 4, and 5 is recorded as 2-3-4-5 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of less than 6 inches with a blow count of 50. A partial penetration of 50 blows for 4 inches is recorded as 50/4 inches.

Sample may be collected using a 300-pound hammer or 3-inch-diameter split-spoon samples at the site. Use of either of these sample collection devices invalidates standard penetration test results and should be noted in the comments section of the log. The 300-pound hammer should only be used for collection of 3-inch-diameter split-spoon samples. Blow counts should be recorded for collection

of samples using either a 3-inch split-spoon, or a 300-pound hammer. An "N" value need not be calculated.

Soil Description. The soil classification should follow the format described in the "Field Classification of Soil" subsection.

Comments. Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). In addition, note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Drilling interval through a boulder

Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488-93, Visual-Manual Procedure for Description and Identification of Soils.

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests (ASTM D 2487). It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488-93, attached). In addition, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D 2488-93 Group Name) with appropriate modifiers

2. Group symbol

3. Color

4. Moisture content

5. Relative density or consistency

6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488-93.

Soil Name

The basic name of a soil should be the ASTM D 2488-93 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).

- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488-93. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488-93.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as "Interlayered Sand and Silt," should be used. In addition, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488-93.

Group Symbol

The appropriate group symbol from ASTM D 2488-93 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488-93, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific

group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group. Grain size is estimated in accordance with ASTM D 2488-93 (Table 2).

Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed on Table 3.

Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586-84). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in Tables 4 and 5.

Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

Equipment and Calibration

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D 1586-84. The split-barrel sampler should measure 2-inch or 3-inch O.D., and should have a split tube at least 18 inches long. The minimum size sampler rod allowed is "A" rod (1-5/8-inch O.D.). A stiffer rod, such as an "N" rod (2-5/8-inch O.D.), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound or 300-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

IV. Attachments

ASTM D 2488-93: Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).

V. Key Checks and Preventive Maintenance

Check entries to the soil-boring log and field logbook in the field; because the samples will be disposed of at the end of fieldwork, confirmation and corrections cannot be made later. Check that sample numbers and intervals are properly specified. Check that drilling and sampling equipment is decontaminated using the procedures defined in SOP Decontamination of Drilling Rigs and Equipment.

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (See Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.5 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)[2]

3. Terminology

3.1 *Definitions:*

3.1.1 Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:

Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and

Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1.2 *clay*—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.1.3 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.1.4 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.1.5 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.1.6 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.1.7 *sand*—particles of rock that will pass a No. 4

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

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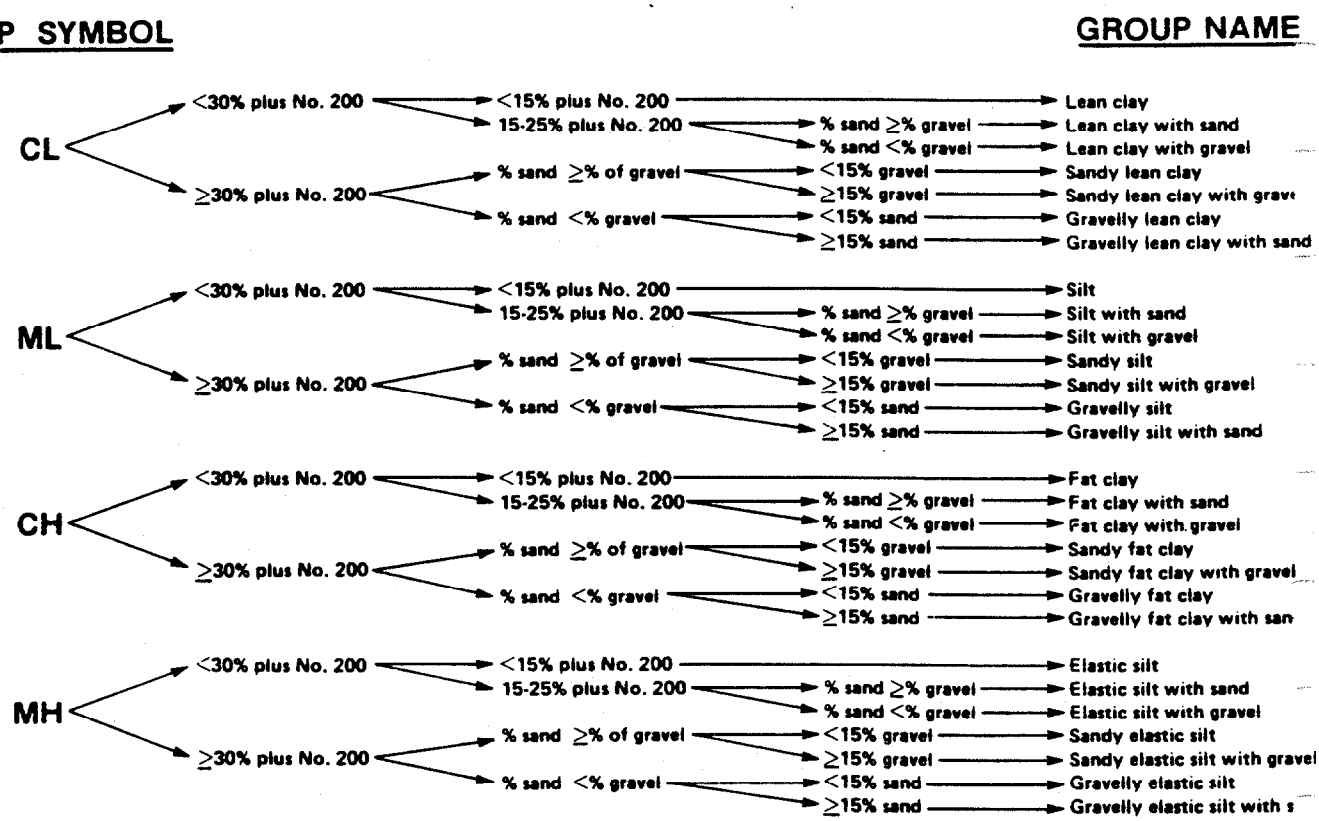
[2] *Annual Book of ASTM Standards*, Vol 04.08.



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)

(4.75-mm) sieve and be retained on a No. 200 (75-μm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-μm) sieve.

fine—passes a No. 40 (425-μm) sieve and is retained on a No. 200 (75-μm) sieve.

3.1.1.8 *silt*—soil passing a No. 200 (75-μm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

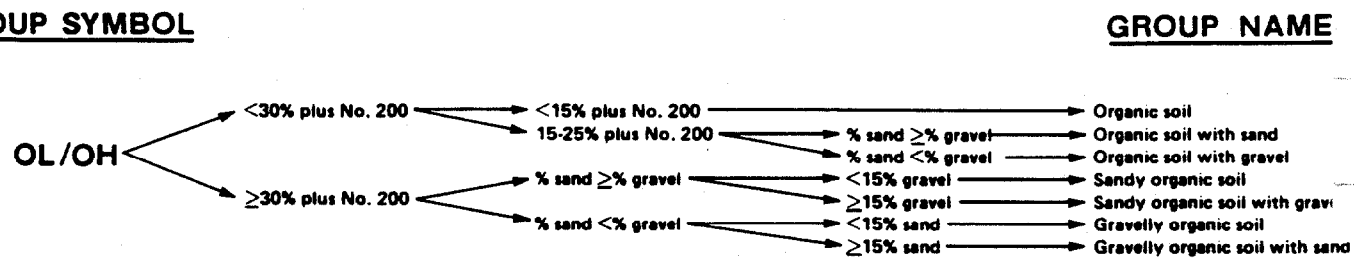
4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning group symbol(s) and name. The flow charts, Figs. 1a and 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and nam If the soil has properties which do not distinctly place it int a specific group, borderline symbols may be used, see Appendix X3.

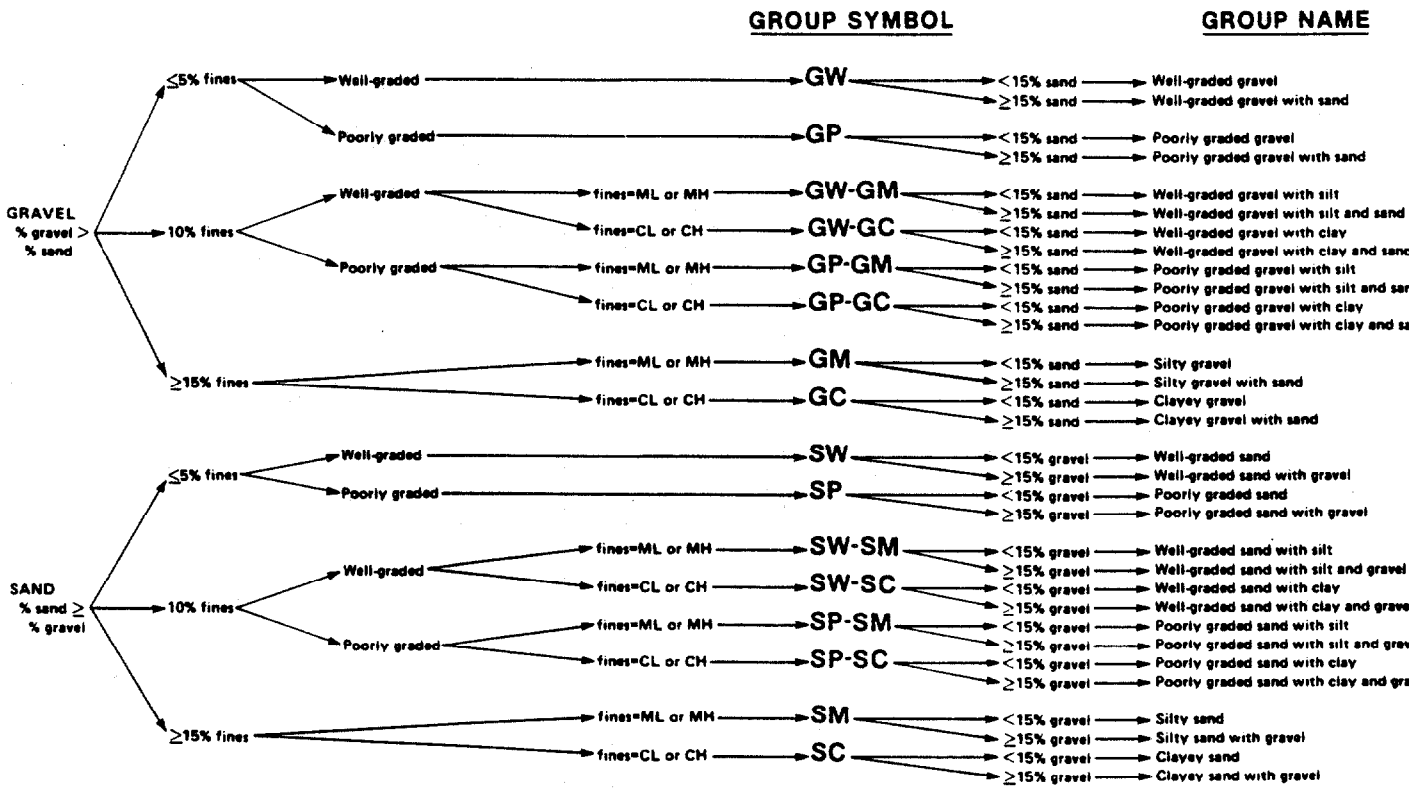
NOTE 3—It is suggested that a distinction be made between *du symbols* and *borderline symbols.*

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil h been identified as having the properties of a classification in accordan with Test Method D 2487 where two symbols are required. Tw symbols are required when the soil has between 5 and 12 % fines or



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manu characteristics.

5.6 When describing and identifying soil samples from given boring, test pit, or group of borings or pits, it is n necessary to follow all of the procedures in this practice f every sample. Soils which appear to be similar can b grouped together; one sample completely described an identified with the others referred to as similar based o performing only a few of the descriptive and identificatio procedures described in this practice.

5.7 This practice may be used in combination wi Practice D 4083 when working with frozen soils.

6. Apparatus

6.1 *Required Apparatus:*

6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus:*

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens.*

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, refe ences to water shall be understood to mean water from a ci water supply or natural source, including non-potable wat

7.2 *Hydrochloric Acid*—A small bottle of dilute hydr chloric acid, HCl, one part HCl (10 *N*) to three parts wat (This reagent is optional for use with this practice). S Section 8.

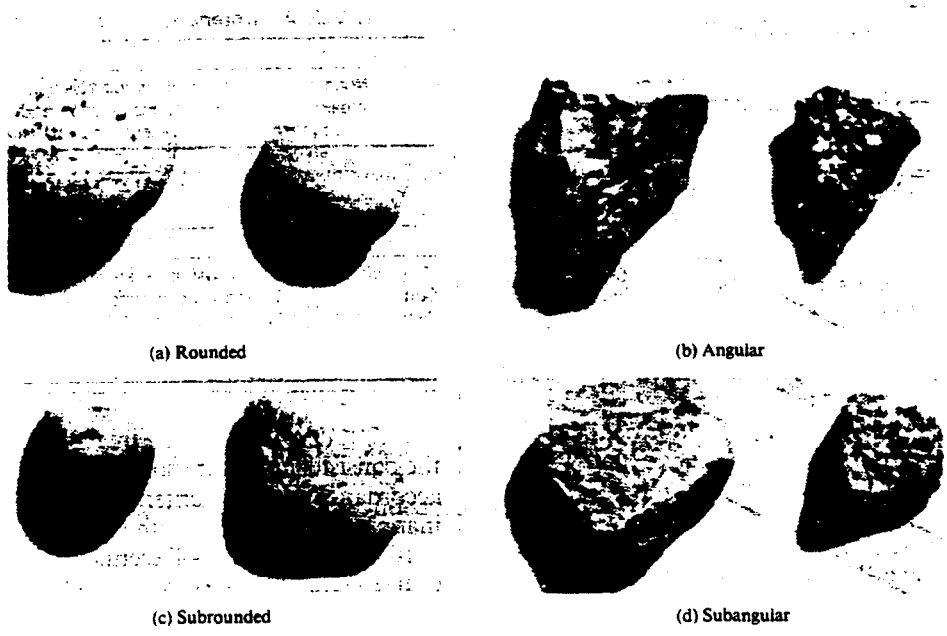


FIG. 3 Typical Angularity of Bulky Grains

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 5—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 6—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (3/8 in.)	200 g (0.5 lb)
19.0 mm (3/4 in.)	1.0 kg (2.2 lb)
38.1 mm (1 1/2 in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 7—If random isolated particles are encountered that a significantly larger than the particles in the soil matrix, the soil matr can be accurately described and identified in accordance with th preceeding schedule.

9.4 If the field sample or specimen being examined smaller than the minimum recommended amount, th report shall include an appropriate remark.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with t criteria in Table 1 and Fig. 3. A range of angularity may stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if th meet the criteria in Table 2 and Fig. 4. Otherwise, do n mention the shape. Indicate the fraction of the particles tha have the shape, such as: one-third of the gravel particles a flat.

10.3 *Color*—Describe the color. Color is an importa property in identifying organic soils, and within a give

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, an thickness refer to the greatest, intermediate, and least dimensions of a particl respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

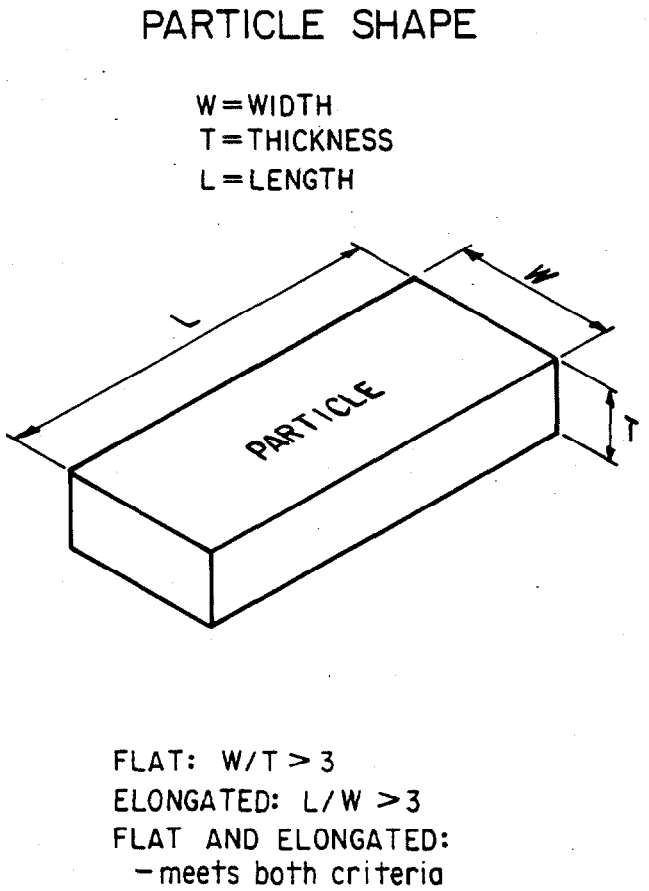


FIG. 4 Criteria for Particle Shape

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼ in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpre-

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

tation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 8—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 9—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength:*

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 10—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the result of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy:*

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness:*

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 *Identification of Inorganic Fine-Grained Soils:*

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 11—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 *Identification of Organic Fine-Grained Soils:*

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 12—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils (Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel estimated to be more than the percentage of sand.

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 13—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 14—Other examples of soil descriptions and identification are given in Appendixes X1 and X2.

NOTE 15—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %
Few—5 to 10 %
Little—15 to 25 %
Some—30 to 45 %
Mostly—50 to 100 %

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard subrounded to subangular gravel; about 15 % fine, hard subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the

percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix:	Suffix:
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

X6. RATIONALE

Changes in this version from the previous version, D 2488 – 90, include the addition of X5 on Abbreviated Soil Classification Symbols.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

STANDARD OPERATING PROCEDURE

Soil Boring Drilling and Abandonment

STANDARD OPERATING PROCEDURE

Soil Boring Drilling and Abandonment

I. Purpose and Scope

The purpose of this guideline is to describe methods to obtain samples of subsurface soil and then backfill boreholes to the surface.

II. Equipment and Materials

- Truck-mounted drilling rig, and a skid rig or barge-mounted tripod rig
- Hollow-stem augers (4¼-inch ID)
- Split-spoon samplers
- Downhole compacting tool (e.g., a pipe with a flat plate attached to the bottom)
- Cement
- Bentonite
- Hand augers, stainless steel

III. Procedures and Guidelines

Before sampling begins, equipment will be decontaminated according to the procedures identified in SOP: Decontamination of Personnel and Equipment. The location to be sampled is cleared of debris and trash, and the location is noted in the logbook.

Continuous-fight hollow-stem augers with an inside diameter of at least 4.25 inches are used. The use of water or other fluid to assist in hollow-stem drilling will be avoided.

The bit of the auger is placed on the ground at the location to be drilled and then turned with the drilling or soil-coring rig. For split-spoon sampling, the auger is advanced to a depth just above the top of the interval to be sampled.

While advancing the augers to the full borehole depth, the soils removed from the boring will be screened using a portable volatile organics detector. The borehole will be grouted to the surface with bentonite-cement grout. The soil cuttings are to be drummed and managed as described in SOP Disposal of Waste Fluids and Soils.

The cement-bentonite grout will be installed continuously in one operation from the bottom of the space to be grouted to the ground surface. When installing grout in soil borings, the grout will be installed through a tremie pipe that is placed inside the augers. The grouting will be completed before the augers are removed.

Samples will be collected from the soil borings at 2-foot intervals. The soil samples will be collected from the surface continuously to the water table. Because some of the

soil samples are being collected for chemical analysis, decontaminated stainless steel split-spoon samplers will be used for sample collection. The split-spoon samplers will be decontaminated according to the procedures outlined in SOP Decontamination of Personnel and Equipment. Sample collection will follow the general procedures outlined in SOP Soil Boring Sampling–Split Spoon.

A tripod drilling rig or skid rig will be required for boring installation in the lagoons. A tripod drilling rig is generally a tripod equipped to collect continuous samples using a hammer-driven sampler. The soil sample collection will be the same as that outlined above, except that hollow-stem augers are not used to advance the borehole. Borehole collapse due to soft sediments may occur when collecting samples using a tripod drilling rig.

Soil samples will be collected at 1-foot intervals. The soil samples will be placed in clean jars and a headspace measurement of the volatile organics in each of the samples determined. The headspace measurements will be used to identify the potentially most-contaminated samples which will be submitted for analysis through the CLP.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

Check that the drilling rig or soil-coring rig is in working order. Check that the borehole is grouted to the ground surface at the completion of drilling and sampling.

STANDARD OPERATING PROCEDURE

General Guidance for Monitoring Well Installation

STANDARD OPERATING PROCEDURE

General Guidance for Monitoring Well Installation

I. Purpose

To provide site personnel with a review of the well installation procedures that will be performed. These procedures are to be considered general guidelines only and are in no way intended to supplement or replace the contractual specifications in the driller's subcontract.

II. Scope

Bedrock well installations and shallow unconsolidated well installations are planned.

III. Equipment and Materials

IV. Procedures and Guidelines

1. Wells will be installed in accordance with standard EPA procedures. Note that USEPA Region III requires any well penetrating a confining layer to be double cased.
2. The threaded connections will be water-tight.
3. Shallow well screens will be constructed of 0.010 slot Schedule 40 PVC and will be 5 to 10 feet in length depending on saturated thickness of unconsolidated sediments. The exact length will be determined by the field team supervisor.
4. Wells will be surrounded by three concrete-filled, 4-inch diameter guard posts.
5. A record of the finished well construction will be compiled.
6. All soils and liquids generated during well installations will be drummed for proper disposal.

Shallow Unconsolidated Well Installation

- Monitoring wells in unconsolidated materials will be installed in at least 6-inch-diameter boreholes to accommodate well completion materials in designated locations.
- Unconsolidated monitoring wells will be constructed of 2-inch-diameter, factory manufactured, flush-jointed, schedule 40 PVC screen with threaded bottom plug and riser.
- Screens will be filter packed with a proper sized and graded, thoroughly washed, sound, durable, well-rounded basalt or siliceous sand.
- The filter pack will extend from 1 to 2 feet below the base to 2 feet above the top of the screen; filter pack will be allowed to settle before final measurement is taken.
- Annular well seals will consist of 2 feet of pelletized bentonite clay and placed above the filter pack.
- The top of the annular seal will be measured after the pellets have been allowed to settle and before the grout is applied.
- The annular space above the bentonite seal will be filled to grade with a bentonite-cement slurry grout mixture.
- The grout mixture consists of 94 lbs of cement (1 bag) per 6 gallons of water and 2 to 3 lbs of powdered bentonite per bag of cement to reduce shrinkage.
- The grout mix will be carefully applied to avoid disturbing the bentonite seal; the method of grout placement must force grout from the bottom of the space to be grouted to the surface.
- After allowing the grout to settle overnight, additional grout will be added to maintain grade.
- A protective steel casing equipped with keyed alike locking caps will be grouted in place for each new well; the casing will extend at least 2 feet above grade and painted a bright color.

Well Development

- New monitoring wells will be developed after the well has been completely installed and the grout has hardened (at least 24 hours)
- The well will be developed by surging and pumping.
- Equipment placed in the well will be decontaminated before use.
- Development will include surging the well by abruptly stopping flow and allowing water in the well column to fall back into the well.

- Pipes and pumps must not be fitted with foot valves or other devices that might inhibit the return flow of water to the well.
- Surging should continue throughout the development process.
- The air lift method will be used to pump materials out of the well. The air compressor will be fitted with filters to remove all oil and the air lift hose used will be made of inert materials.
- Well development will continue until the water produced is free of turbidity, sand, and silt.
- Development water will be considered hazardous and placed in sealed 55-gallon U.S. DOT approved steel drums supplied by CH2M HILL. CH2M HILL will label and date the drums, and transport the drums to an EPA designated site for storage.

V. Attachments

None.

VI. Key Check and Items

STANDARD OPERATING PROCEDURE

Installation of Shallow Monitoring Wells

STANDARD OPERATING PROCEDURE

Installation of Shallow Monitoring Wells

I. Purpose and Scope

The purpose of this guideline is to describe methods for drilling and installation of shallow monitoring wells and piezometers within the water table aquifer. Methods for drilling and installing bedrock monitoring wells are presented in SOP General Guidance for Monitoring Well Installation.

II. EQUIPMENT AND MATERIALS

Drilling

- Drilling or rig
- Hollow-stem augers

Well Riser/Screen

- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded riser
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted screen

Bottom Cap

- PVC, threaded to match the well screen
- Centering Guides (if used)
- Same material as the casing, except stainless steel may be used in lieu of PVC

Well Cap

- Above-grade well completion: PVC, threaded or push-on type, vented
- Flush-mount well completion: PVC, locking, leak-proof seal

Sand

- Clean silica sand, provided in factory-sealed bags, well-rounded, containing no organic material, anhydrite, gypsum, mica, or calcareous material; primary (coarse) filter pack, and secondary (fine) filter pack. Grain size determined based on sediments observed during drilling.

Bentonite

- Pure, additive-free bentonite pellets
- Pure, additive-free powdered bentonite
- Coated bentonite pellets; coating must biodegrade within 7 days

- Cement-Bentonite Grout
- Proportion of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 10 pounds of bentonite added per bag of cement to reduce shrinkage

Protective Casing

- Above-grade well completion: 6-inch minimum ID steel pipe with locking cover, diameter at least 2 inches greater than the well casing, painted with epoxy paint for rust protection; heavy duty lock; protective posts if appropriate
- Flush-mount well completion: Morrison 9-inch or 12-inch 519 manhole cover; rubber seal to prevent leakage; locking cover inside of road box

Well Development

- Double surge block with bottom solid, top open, separated by 2 feet of slotted pipe
- Pump, and associated equipment
- Calibrated meters to measure pH, temperature, and specific conductance
- Containerization for water produced from well.

III. Procedures and Guidelines

A. Drilling Method

Continuous-flight hollow-stem augers with a minimum 6-inch inside diameter (ID) will be used to drill shallow monitoring well boreholes. Split-spoon samples will be collected at selected intervals for chemical analysis and/or lithologic classification. Soil sampling procedures are detailed in SOP ShallowS.

The use of water to assist in hollow-stem auger drilling for monitoring well installation will be avoided.

Hollow-stem augers, rods, split-spoon samplers, and other downhole drilling tools will be properly decontaminated prior to the initiation of drilling activities and between each borehole location. Split-spoon samplers and other downhole soil sampling equipment will also be properly decontaminated before and after each use. SOP Decon details proper decontamination procedures.

Drill cuttings and decontamination fluids generated during well drilling activities will be contained according to the procedures detailed in FSP.

B. Monitoring Well Installation

Shallow monitoring wells will be constructed inside the hollow-stem augers, once the borehole has been advanced to the desired depth. If the borehole has been drilled to a depth greater than that at which the well is to be set, the

borehole will be backfilled with bentonite pellets or a bentonite-cement slurry to a depth approximately 1 foot below the intended well depth. Approximately 1 foot of clean sand will be placed on top of the bentonite to return the borehole to the proper depth for well installation.

The appropriate lengths of well screen, nominally 10 feet (with bottom cap), and casing will be joined watertight and lowered inside the augers to the bottom of the borehole.

Selection of the filter pack and well screen intervals for the shallow monitoring wells shall be made in the field. Based on lithologic samples previously obtained at the site, and comparison with samples to be obtained in the well borings, standard well screen slot of 0.010-inch and silica sand gradations conforming to Morie No. 1 are anticipated.

A primary sand pack (Morie No. 1) consisting of clean silica sand will be placed around the well screen. The sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack. The augers will be raised gradually during sand pack installation to avoid caving of the borehole wall; at no time will the augers be raised higher than the top of the sand pack during installation. During placement of the sand, the position of the top of the sand will be continuously sounded. The primary sand pack will be extended from the bottom of the borehole to a minimum height of 2 feet above the top of the well screen. A secondary, finer-grained, sand pack will be installed for a minimum of 1 foot above the coarse sand pack. Heights of the coarse and fine sand packs and bentonite seal may be modified in the field to account for the shallow water table and small saturated thickness of the surficial aquifer.

A bentonite pellet seal at least 2 feet thick will be placed above the sand pack. The pellets will be placed into the borehole in a manner that will prevent bridging. The position of the top of the bentonite seal will be verified using a weighted tape measure. If all or a portion of the bentonite seal is above the water table, clean water will be added to hydrate the bentonite. A hydration period of at least 30 minutes will be allowed following installation of the bentonite seal.

Above the bentonite seal, an annular seal of cement-bentonite grout will be placed. The cement-bentonite grout will be installed continuously in one operation from the bottom of the space to be grouted to the ground surface through a tremie pipe. The tremie pipe must be plugged at the bottom and have small openings along the sides of the bottom 1-foot length of pipe. This will allow the grout to diffuse laterally into the borehole and not disturb the bentonite pellet seal.

For monitoring wells that will be completed above-grade, a locking steel protective casing set in a concrete pad will be installed. The steel protective casing will extend at least 3 feet into the ground and 2 feet above ground. The concrete pad will be square, approximately 3 feet per side. The concrete will be sloped away from the protective casing.

Guard posts may be installed in high-traffic areas for additional protection. Four steel guard posts will be installed around the protective casing, within the edges of the concrete pad. Guard posts will be concrete-filled, at least 2 inches in diameter, and will extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, Morrison 9-inch or 12-inch 519 manhole cover with a rubber-sealed cover and drain will be installed. The top of the manhole cover will be positioned approximately 1 inch above grade. A square concrete pad, approximately 3 feet per side, will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic.

Concrete pads installed at all wells will be a minimum of 6 inches below grade and 6 inches above grade. The concrete pad will taper to 6-inch thickness at the edge. Protective casing, guard posts, and flush mounts will be installed into this concrete.

Each well will be properly labeled on the exterior of the locking cap or protective casing with a metal stamp indicating the permanent well number.

C. Well Development

Well development will be accomplished using a combination of surging throughout the well screen and pumping, until the physical and chemical parameters of the discharge water that are measured in the field have stabilized and the turbidity of the discharge water is substantially reduced. Fine-grained materials in the surficial aquifer at the site, may not allow low turbidity results to be achieved.

The surging apparatus will include two surge blocks separated by approximately 2 feet of coarsely slotted pipe. The lower surge block will be solid; the upper surge block will be open and attached to riser pipe leading to the ground surface. Water will be pumped continuously from the surge block screened interval throughout the surging process. The pumping will be accomplished by airlift induction methods or using a centrifugal pump or equivalent.

Well development will begin by surging the well screen, starting at the bottom of the screen and proceeding upwards, throughout the screened zone.

Following surging, the well will be pumped to remove the fine materials that have been drawn into the well. During pumping, measurements of pH, temperature, and specific conductance will be recorded.

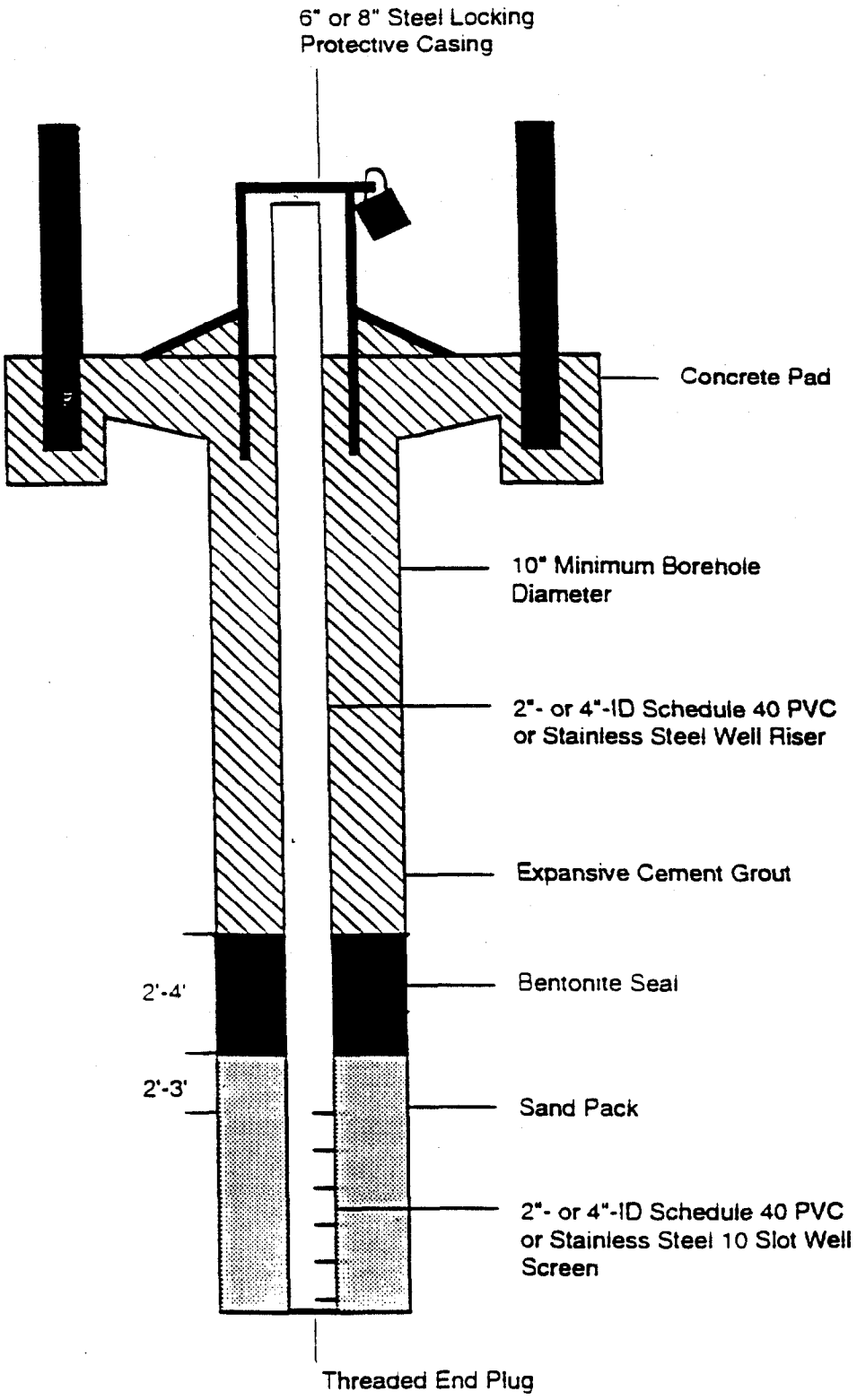
Development will continue by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is substantially reduced, and the pH, temperature, and specific conductance have stabilized

at regional background levels, based on historical data. Development will continue for a minimum of 30 minutes.

Well development equipment will be decontaminated prior to initial use and after the development of each well. Decontamination procedures are detailed in SOP Decontamination of Personnel and Equipment. Water generated during well development will be contained and managed as detailed in the FSP or IDWMP.

IV. Attachments

Schematic diagram of shallow monitoring well construction



TYPICAL SHALLOW MONITORING WELL CONSTRUCTION

STANDARD OPERATING PROCEDURE

Decontamination of Personnel and Equipment

STANDARD OPERATING PROCEDURE

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized ("DI") water (ASTM Type II water)
- Distilled water
- Potable water (must be from a municipal water supplier, otherwise a priority pollutant +40 analysis must be run)
- 2.5% (W/W) trisodium phosphate ("TSP") and water solution
- Concentrated (V/V) pesticide grade methanol or hexane (DO NOT USE ACETONE)
- 10% (V/V) nitric acid (HNO3) and water solution (only ultrapure grade HNO3 is to be used)
- Large plastic pails or tubs for TSP and water, scrub brushes, squirt bottles for TSP, methanol and water, plastic bags and sheets
- DOT approved 55-gallon drum for disposal of waste
- Phthalate-free gloves
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. PERSONNEL DECONTAMINATION

To be performed after completion of tasks whenever potential for contamination exists, and upon leaving the exclusion zone.

1. Wash boots in TSP solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with TSP solution, remove, and discard into DOT approved 55-gallon drum.

2. Wash outer gloves in TSP solution, rinse, remove, and discard into DOT approved 55-gallon drum.

3. Remove disposable coveralls ("Tyveks") and discard into approved 55-gallon drum.

4. Remove respirator (if worn).

5. Remove inner gloves and discard.

6. At the end of the work day, shower entire body, including hair, either at the work site or at home.

7. Sanitize respirator if worn.

B. SAMPLING EQUIPMENT DECONTAMINATION

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.

2. Prior to entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).

3. Rinse and scrub with potable water.

4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with TSP solution.

5. Rinse with potable water.

6. Rinse with 10% HNO3 solution when sampling for inorganics (carbon split spoons will be rinsed with a 1% solution).

7. Rinse with distilled or potable water and methanol or hexane solution (DO NOT USE ACETONE).

8. Air dry.

9. Rinse with deionized water.

10. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.

11. Collect all rinsate and dispose of in a DOT approved 55-gallon drum.

C. HEALTH AND SAFETY MONITORING EQUIPMENT DECONTAMINATION

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.

2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with TSP solution, then a towel wet with methanol solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT approved 55-gallon drum.

D. SAMPLE CONTAINER DECONTAMINATION

The outsides of sample bottles or containers filled in the field must be decontaminated before being packed for shipment or handled by personnel without hand protection.

1. Wipe container with a paper towel dampened with TSP solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN SEALED. Repeat the above steps using potable water.

2. Dispose of all used paper towels in a DOT approved 55-gallon drum.

E. HEAVY EQUIPMENT AND TOOLS

Heavy equipment such as drilling rigs, drilling rods/tools, and the backhoe will be decontaminated upon arrival at the site and between locations as follows:

1. Set up a decontamination pad in area designated by Navy

2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of TSP, methanol (or isopropanol) and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

Final

Health and Safety Plan
Remedial Investigation and Feasibility Study
Pesticide Disposal Site (Site 5)
Preliminary Assessment/Site Investigation
Building W-316 PCB Waste Work Area (Site 21)

Norfolk Naval Base
Norfolk, Virginia

Contract Task Order 0003

August 15, 1996

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by

CH2M HILL

Federal Group, Ltd.
Herndon, Virginia

Final

Health and Safety Plan
Remedial Investigation and Feasibility Study
Pesticide Disposal Site (Site 5)
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Attachment 1 Employee Signoff
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CH2M HILL HEALTH AND SAFETY PLAN

(Reference CH2M HILL SOP 19, *Health and Safety Plans*)

This health and safety plan will be kept on the site during field activities and will be reviewed and updated as necessary. The plan adopts, by reference, the standards of practice (SOP) in the CH2M HILL *Corporate Health and Safety Program, Program and Training Manual*, and CH2M HILL's *Site safety Notebook* as appropriate. The site safety coordinator (SSC) is to be familiar with these SOPs and the content of this plan. Site personnel must sign Attachment 1. In addition, this plan adopts procedures in the work plan for the project.

1 PROJECT INFORMATION AND DESCRIPTION

CLIENT OR OWNER: Department of the Navy
Atlantic Division

PROJECT NO: 134348

CH2M HILL PROJECT MANAGER: Jack Robinson, P.G.

OFFICE: WDC

SITE NAME: Norfolk Naval Base

SITE ADDRESS: 1510 Gilbert Street
Norfolk, Virginia 23511-2699

DATE HEALTH AND SAFETY PLAN PREPARED: March 19, 1996

DATE(S) OF INITIAL VISIT: 3/11/96

DATE(S) OF SITE WORK:

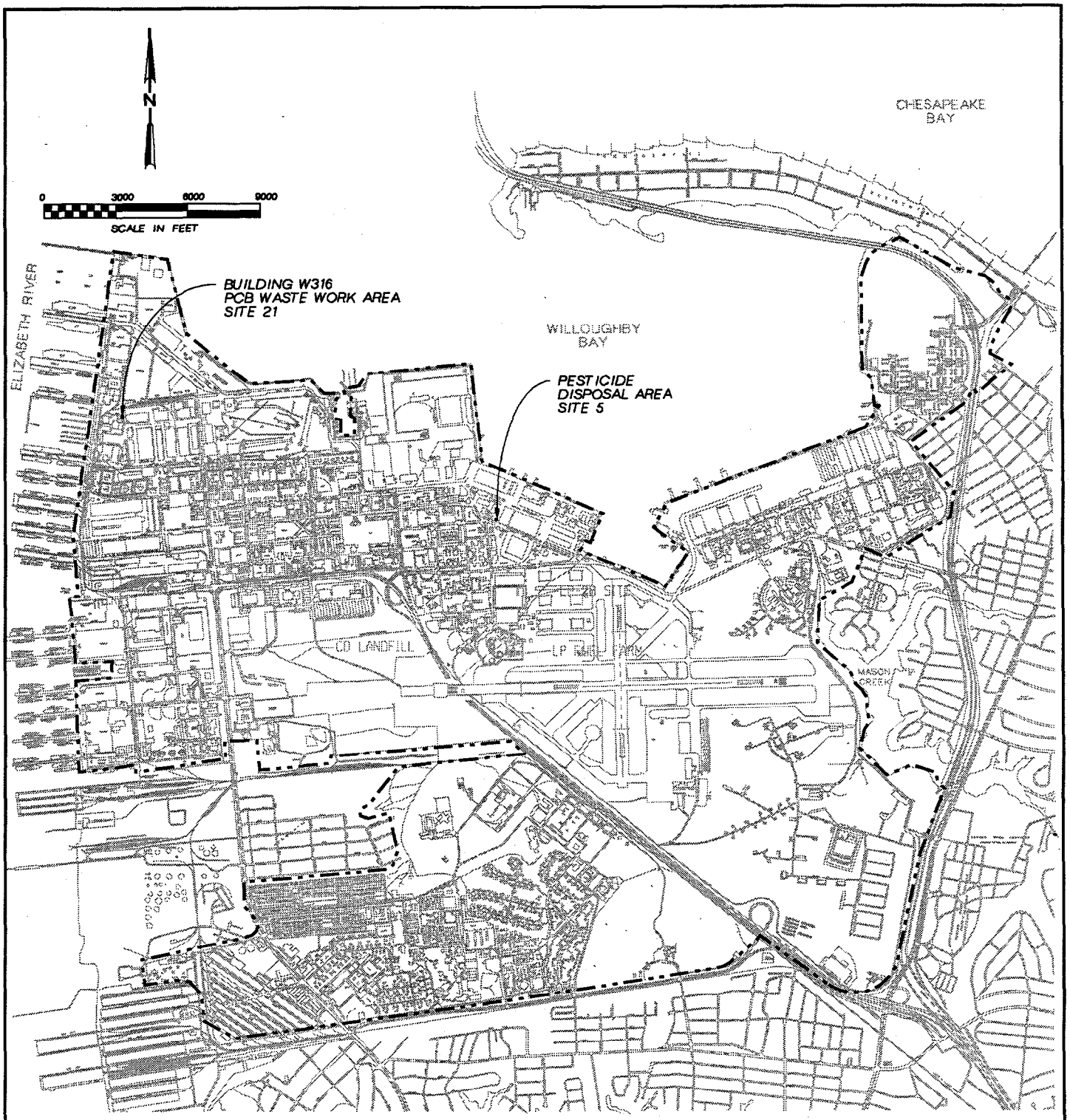
SITE ACCESS: All sites at the Naval Base, Norfolk are accessed through the Main Gate of the Base.

SITE SIZE: Naval Base, Norfolk is located on 4,631 acres of land directly northwest of the city of Norfolk, Virginia.

SITE TOPOGRAPHY: The facility is bounded on the north by Willoughby Bay, on the west by the junction of the Elizabeth River and the James River (forming the Hampton Roads), and on the south and east by the city of Norfolk. A portion of the east boundary of the facility is formed by Mason Creek (Figure 1-1). The Base includes approximately 4000 buildings and an airfield. The western portion of the Base is a developed waterfront area that contains piers and facilities for loading, unloading, and servicing naval vessels.

Land use surrounding Base is industrial and residential. The waterfront area south of the site provides shipping facilities for several large industries. Residential land use is located to the south and east of the Base. Willoughby Spit, a low-density residential area located northeast of Base, is also used for recreational activities.

PREVAILING WEATHER: The Norfolk region has a maritime climate which is characterized by long temperate summers and mild winters. The average annual temperature is 60.7 degrees Fahrenheit (F). July is the warmest month, with temperatures averaging 78.7 degrees F; while January is the coolest month, with temperatures averaging 43.1 degrees F. Freezing temperatures are infrequent in the region. Precipitation averages 43 inches annually and is evenly distributed throughout the year. A slight increase in precipitation occurs from June to August due to the prevalence of convective thunderstorms. The average annual snowfall is 8.8 inches. Winds are generally in the easterly direction and moderate, ranging from six to eleven knots.



LEGEND

— - - — INSTALLATION PROPERTY BOUNDARY

Figure 1-1
INSTALLATION LOCATION MAP
Naval Base, Norfolk

CH2M HILL

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SITE DESCRIPTION AND HISTORY: Naval Base, Norfolk, began operations in 1917 when the U.S. Navy acquired 474 acres of land to develop a naval base to support World War I activities. Bulkheads were built along the coast to extend available land. After dredge and fill operations, the total land under Navy control was 792 acres. An additional 143 acres of land were acquired in 1918 and officially commissioned for the Naval Air Station (NAS). From 1936 until 1940, improvements to the piers and expansion of supplies/materials handling facilities were completed. During World War II (between 1940 and 1945) major construction projects were completed including a hospital, power plant, numerous runways and hangers, a tank farm, and several barracks/housing complexes. During this time the area of the Base expanded to over 2,100 acres due to U.S. involvement in World War II. After World War II, the Base continued to acquire land through various types of land transfers and dredge and fill operations conducted in areas of Mason Creek and Bousch Creek Basins and Willoughby Bay. During its history the Base has expanded to become the worlds largest naval installation. In 1995, the Base had 15 piers handling 3,100 ship movements annually.

RI/FS Site 5

Site 5 consists of a french drain located southeast of Building V-95. The french drain, which consists of a 28-inch-diameter culvert placed vertically into a 26-foot-deep gravel-filled hole, was used for disposing of pesticide waste generated in the former pest control shop (Bldg. V-95). This shop was in operation from the late 1960s until 1973, and the french drain has not been used for pesticide disposal since 1973. Reportedly, 100 gallons per week of pesticide rinse water were disposed of in the french drain, along with intermittent discharges of overage concentrated pesticides. Pesticides used in this pest control shop reportedly included chlordane, malathion, DDT, DDD, and dieldrin. This area currently is fenced off and used for storage of other materials.

PA/SI Site 21

The Building W-316 PCB Waste Work Area is outdoors in the northwest part of the facility, directly south of the W-316 PCB Debris Storage Area (SWMU-8). This unit is used by the Navy Public Works Center to store various electrical components. The building and small storage yard adjacent to the building were used for storing out-of-service PCB transformers received from throughout the Base. The transformers were picked up by a contractor for offsite disposal. The unit began operation in 1982 or earlier and is still in operation. The unit is an approximately 0.25-acre fenced area underlain by soil, asphalt, and concrete. Transformers are stored on pallets in the area.

On April 25, 1990, PCB transformer #31419-1 stored in this unit was ruptured by a forklift during maintenance operations. Approximately 35 gallons of 108 parts per million (ppm) PCB oil was released to a 15x30-foot section of asphalt within the fenced area. The transformer was plugged, pumped out, and wiped down with kerosene. A total of 85 gallons of PCB oil was pumped. The spill was diked and contained with pig blankets, and absorbent was poured on the asphalt. Contaminated soil, sand, and absorbent material were shoveled into 55-gallon steel drums. The contaminated asphalt and underlying soil were excavated to a depth of 6 inches, and new asphalt was poured in the spill area.

2 PROJECT ORGANIZATION AND TASKS TO BE PERFORMED UNDER THIS PLAN

2.1 PROJECT ORGANIZATION

CLIENT: Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

CH2M HILL:
Project Manager: Jack Robinson
Field Team Leader: Brooke Bennett
Refer to Section 4 for field staff.

CONTRACTORS and SUBCONTRACTORS: Refer to Section 4.2.

2.2 DESCRIPTION OF TASKS (Reference Section 1, "Field Activity Start-up Form," of *Site Safety Notebook*

Refer to project documents (i.e., work plan) for detailed task information. A health and safety risk analysis has been performed for each task and is incorporated in this plan through task-specific hazard controls and requirements for monitoring and protection. Tasks in addition to those listed below require an approved amendment to this plan before additional work begins. Refer to Section 10.2 for procedures related to tasks that do not involve hazardous waste operations and emergency response (Hazwoper).

The RI/FS and PA/SI are being performed under the Department of Defense's Installation Restoration Program (IRP) that facilitates the investigation of past hazardous and toxic materials storage and disposal activities at military installations. United States Environmental Protection Agency (USEPA) guidance will be followed in planning and conducting the RI/FS and the PA/SI.

RI/FS Site 5

The aerial and vertical distribution and magnitude of site contamination will investigated during the RI through the installation and sampling of 2 soil borings and 2 monitoring wells and the collection of 4 surface soil samples. Results of the RI soil and groundwater sampling will be used to perform a baseline risk assessment (BLRA) and baseline ecological risk assessment (BERA) to assess the potential human health risks posed by the site and to identify and evaluate the potential effects of the contamination on biota in the area, respectively. Then the FS will be conducted to develop a range of distinct alternatives for waste management that, if implemented, would potentially remediate or control contaminated media (e.g., soil, groundwater) as deemed necessary in the RI to provide adequate protection of human health and the environment. Results of the site investigation, risk assessment, and feasibility study will be presented in the RI/FS report.

PA/SI Site 21

The PA of Site 21 will consist of gathering and reviewing information from various sources. Site management practices will be reviewed using available site documents, photographs, and interviews with base personnel to determine the existing potential for release. The aerial and vertical distribution and magnitude of site contamination will investigated during the SI through the installation and sampling of 10 soil borings and 2 monitoring wells. A PA/SI report will be prepared to document the results of the soil and groundwater characterizations. The PA/SI report will include brief summaries of the site history and background. Results of soil and groundwater sampling will be documented and a hazard assessment will be presented that documents the potential for contaminant transport via groundwater, surface water, soil, and air. Recommendations for further action will be presented.

2.2.1 HAZWOPER-REGULATED TASKS

- Test pit and excavation
- Drilling
- Geoprobe boring
- Groundwater monitoring
- Aquifer testing
- Surface water sampling
- Sediment sampling
- Surface soil sampling
- Hand augering
- Surveying
- Investigation-derived waste (drum) sampling and disposal
- Observation of loading of material for offsite disposal
- Oversight of remediation and construction

2.2.2 NON-HAZWOPER-REGULATED TASKS

Under specific circumstances, the training and medical monitoring requirements of federal or state Hazwoper regulations are not applicable. It must be demonstrated that the tasks can be performed without the possibility of exposure in order to use non-Hazwoper-trained personnel. **Prior approval from the HSM is required before these tasks are conducted on regulated hazardous waste sites.**

TASK	RESTRICTIVE CONDITIONS
• Electrical installation	
• Iron work (installing rebar)	
• Masonry work	
• General heavy equipment work (excavation, grading, etc.)	
• Mechanical installations (equipment, pumps, etc.)	
• Engineering testing/evaluation	
• Building construction	

3 HAZARD EVALUATION AND CONTROL

3.1 HEAT AND COLD STRESS (Reference CH2M HILL SOP HS-09, *Heat and Cold Stress*)

3.1.1 PREVENTING HEAT STRESS

- Drink 16 ounces of water before beginning work, such as in the morning or after lunch. Disposable (e.g., 4-ounce) cups and water maintained at 50° to 60°F should be available. Under severe conditions, drink 1 to 2 cups every 20 minutes, for a total of 1 to 2 gallons per day. Take regular breaks in a cool, preferably air-conditioned, area. Do not use alcohol in place of water or other nonalcoholic fluids. Decrease your intake of coffee and caffeinated soft drinks during working hours. Monitor for signs of heat stress.
- Acclimate to site work conditions by slowly increasing workloads; e.g., do not begin site work with extremely demanding activities.
- Use cooling devices, such as cooling vests, to aid natural body ventilation. The devices add weight, so their use should be balanced against efficiency.
- Use mobile showers or hose-down facilities to reduce body temperature and cool protective clothing.
- During hot weather, conduct field activities in the early morning or evening if possible.
- Provide adequate shelter to protect personnel against radiant heat (sun, flames, hot metal), which can decrease physical efficiency and increase the probability of heat stress.
- In hot weather, rotate shifts of workers.
- Maintain good hygiene standards by frequently changing clothing and by showering. Clothing should be permitted to dry during rest periods. Persons who notice skin problems should consult medical personnel.

3.1.2 SYMPTOMS AND TREATMENT OF HEAT STRESS

	Heat Syncope	Heat Rash (*miliaria rubra*, "prickly heat")	Heat Cramps	Heat Exhaustion	Heat Stroke
Signs and Symptoms	Sluggishness or fainting while standing erect or immobile in heat.	Profuse tiny raised red blister-like vesicles on affected areas, along with prickling sensations during heat exposure.	Painful spasms in muscles used during work (arms, legs, or abdomen); onset during or after work hours.	Fatigue, nausea, headache, giddiness; skin clammy and moist; complexion pale, muddy, or flushed; may faint on standing; rapid thready pulse and low blood pressure; oral temperature normal or low	Red, hot, dry skin; dizziness; confusion; rapid breathing and pulse; high oral temperature.
Treatment	Remove to cooler area. Rest lying down. Increase fluid intake. Recovery usually is prompt and complete.	Use mild drying lotions and powders, and keep skin clean for drying skin and preventing infection.	Remove to cooler area. Rest lying down. Increase fluid intake.	Remove to cooler area. Rest lying down, with head in low position. Administer fluids by mouth. Seek medical attention.	Cool rapidly by soaking in cool– but not cold– water. Call ambulance, and get medical attention immediately!

3.1.3 HEAT-STRESS MONITORING

For field activities part of ongoing site work activities in hot weather, the following procedures should be used to monitor the body's physiological response to heat and to estimate the work-cycle/rest-cycle when workers are performing moderate levels of work. These procedures should be considered when the ambient air temperature exceeds 70°F, the relative humidity is high(>50%), when workers are wearing semi-impermeable or impermeable clothing, or when the workers exhibit symptoms of heat stress.

The heart rate should be measured by the radial pulse for 30 seconds, as early as possible in the resting period. The HR at the beginning of the rest period should not exceed 110 beats/minute, or 20 beats/minute above resting pulse. If the HR is higher, the next work period should be shortened by 33 percent, while the length of the rest period stays the same. If the pulse rate still exceeds 110 beats/minute at the beginning of the next rest period, the following work cycle should be further shortened by 33 percent. The procedure is continued until the rate is maintained below 110 beats/minute, or 20 beats/minute above resting pulse. Additional methods of monitoring, such as taking oral temperature, or weighing individuals before and after their shift could also be included.

3.1.4 PREVENTING COLD STRESS

- Be aware of the symptoms of cold-related disorders, and ***wear proper clothing for the anticipated fieldwork.***
- Consider monitoring the work conditions and adjusting the work schedule, using guidelines developed by the U.S. Army (wind-chill index) and the National Safety Council (NSC).
- ***Wind-Chill Index.*** This measure relates the dry bulb temperature and the wind velocity. It is used only to estimate the combined effect of wind and low air temperatures on exposed skin. The wind-chill index sometimes is limited in its usefulness because the index does not take into account the body part that is exposed, the level of activity, or the amount or type of clothing worn. For those reasons, it is used only as a guideline to warn workers when they are in a situation that can cause cold-related illnesses. Used in conjunction with the NSC guidelines, the wind-chill index provides a starting point for adjusting work and warm-up schedules.
- ***NSC Guidelines for Work and Warm-Up Schedules.*** The cold-exposure limits recommended by the NSC can be used in conjunction with the wind-chill index to estimate work and warm-up schedules for fieldwork. The guidelines are not absolute; ***workers should be monitored for symptoms of cold-related illness.*** If symptoms are not observed, the work duration can be increased.
- The wind-chill index and the NSC guidelines are in the CH2M HILL *Corporate Health and Safety Program, Program and Training Manual,* SOP HS-09.

3.1.5 SYMPTOMS AND TREATMENT OF COLD STRESS

	Immersion (Trench) Foot	Frostbite	Hypothermia
Signs and Symptoms	Feet discolored and painful; infection and swelling present.	Blanched, white, waxy skin, but tissue resilient; tissue cold and pale.	Shivering, apathy, sleepiness; rapid drop in body temperature; glassy stare; slow pulse; slow respiration.
Treatment	Seek medical treatment immediately.	Remove victim to a warm place. Rewarm area quickly in warm–but **not** hot–water. Have victim drink warm fluids, but **not** coffee or alcohol. Do not break blisters. Elevate the injured area, and get medical attention.	Remove victim to a warm place. Have victim drink warm fluids, but **not** coffee or alcohol. Get medical attention.

3.2 PROCEDURES FOR LOCATING BURIED UTILITIES

Local Utility Mark-Out Service
Name: Mr. Bruce Davis–Public Works Department
Phone: (4) 4973 (on-base phone) or (804) 444-4973 (off-base phone)

- Where available, obtain utility diagrams for the facility.
- Review locations of sanitary and storm sewers, electrical conduits, water supply lines, natural-gas lines, and fuel tanks and lines.
- Review proposed locations of intrusive work with facility personnel knowledgeable of locations of utilities. Check locations against information from utility mark-out service.
- Where necessary, clear locations with a utility-locating instrument (e.g., metal detector).
- Where necessary (e.g., uncertainty about utility locations), excavation or drilling of the upper depth interval should be performed manually.
- Monitor for signs of utilities during advancement of intrusive work (e.g., sudden change in advancement of auger or split spoon).
- When the client or other onsite party is responsible for determining the presence and locations of buried utilities, the SSC should confirm that arrangement.

3.3 GENERAL PHYSICAL (SAFETY) HAZARDS AND CONTROLS

Engineering and administrative controls are to be implemented by the party in control of the site or the hazard (i.e., CH2M HILL, subcontractor, or contractor). CH2M HILL employees and subcontractors must, at a minimum, remain aware of hazards affecting them regardless of who is responsible for controlling the hazards. Specialty subcontractors are responsible for the safe operation of their equipment (e.g., drill rig, heavy equipment). CH2M HILL employees are not to operate, or assist in the operation of, any subcontractor or contractor equipment.

		Tasks									
Hazard (Refer to SOP, or HSP Section)	**Engineering Controls, Administrative Controls, and Work Practices**	**Test Pit and Excavation**	**Drilling, Geoprobe Installation, Well Installation and Abandonment**	**Groundwater Monitoring, Aquifer Testing, and Video Surveying of Wells**	**Surface Water and Sediment Sampling Using a Boat**	**Surface Water and Sediment Sampling from the Shore or Water**	**Hand Augering**	**Surveying**	**IDW Drum Sampling and Disposal[a]**	**Observation of Loading of Material for Offsite Disposal**	**Remediation and Construction Oversight**
Flying debris/objects (HS-07)	Provide shielding and PPE; maintain distance.	X	X		X	X	X		X	X	X
Noise > 85 dBA	Noise protection and monitoring required.	X	X		X					X	X
Gas cylinders (HS-21)	Instruct employees in the safe use of compressed gases. Make certain gas cylinders are properly anchored and chained. Keep cylinders away from ignition sources. Cap cylinders when not in use.	X	X								
Electrical	• Make certain third wire is properly grounded. Do not tamper with electrical wiring unless qualified to do so. Ground as appropriate. • Project field sites should have ground fault circuit interruptors (GFCIs) installed for all wiring, including extension cords. • Heavy equipment (e.g., drill rig) should remain at least 15 feet from overhead power line for power lines of 50 kV or less. For each 10 kV > 50, increase distance by ½ foot. • Operate and maintain equipment according to manufacturer's instructions. • Use only extension cords that are three-wire grounded. Cords passing through work areas must be covered or elevated to protect from damage. • Use only electrical tools and equipment that are either effectively grounded or double-insulated UL approved. • Properly label switches, fuses, and circuit breakers. • Remove cord from an outlet by grasping the plug, not pulling the cord. • Protect all electrical equipment, tools, switches, etc., from elements. • Avoid physical contact with power circuit. • Only qualified electricians are to install and work on electrical circuits and equipment.	X	X	X	X						X
Suspended loads	Work not permitted under suspended loads.	X	X		X					X	X
Buried utilities, drums, tanks, etc. (Section 3.3)	Locate buried utilities, drums, tanks, etc., before digging or drilling and mark location.	X	X				X				X
Slip, trip, fall hazards (e.g., wet/muddy surface, inadequate railing, unstable surface)	Provide slip-resistant surfaces, ropes, and/or other devices to be used. Brace and shore equipment	X	X	X	X	X	X	X	X	X	X
Back injury (HS-29)	Use proper lifting techniques, or provide mechanical lifting aids.	X	X	X	X	X	X		X		X
Confined space entry (Section 9.0)	Space must be evaluated by qualified person. Additional controls and monitoring, training, and an approved entry permit are generally required.	NOT APPROVED									
Trenches/excavations (HS-32)	Make certain trench meets OSHA standard before entering. All excavations > 4 feet deep must be sloped or shored, and have a ladder every 25 feet. Personnel and equipment must remain at least 2 feet from edge of trench at all times.	X									X
Protruding objects	Flag visible objects.	X	X	X	X	X	X	X	X	X	X
Visible lightning	Stop work.	X	X	X	X	X	X	X	X	X	X
Vehicle traffic (HS-24)	Provide temporary traffic controls, including trained flaggers and lookouts. Implement traffic control program when required.									X	X
Stairways, ladders, and scaffolds (HS-25)	Stairways and ladders are generally required when there is a break in elevation of 19 inches or more. Keep access ways clear. Equipment must meet OSHA specifications. Document employee training.		X								X
Elevated work area/falls (HS-31)	Provide guardrail, safety net, floor covers, body harness, and monitoring system, where applicable. Document employee training.	X				X					X
Fire prevention and control (HS-22)	• No spark sources are allowed within exclusion or decontamination zones. • Appropriate firefighting equipment must be available on the site. • Extinguishers are to be inspected visually every month and undergo an annual maintenance check. • Post "Exit" signs over exiting doors, and post "Fire Extinguisher" signs over extinguisher locations. Keep areas near exits and extinguishers clear. Open flames are prohibited in the vicinity of flammable materials. • Combustible materials stored outside should be at least 10 feet from the building. • Unnecessary combustible materials and flammable or combustible liquids must not be allowed to accumulate. • Flammable or combustible liquids must be kept in approved containers, and must be stored in an approved storage cabinet.	X	X			X			X		X

3.3 GENERAL PHYSICAL (SAFETY) HAZARDS AND CONTROLS

Engineering and administrative controls are to be implemented by the party in control of the site or the hazard (i.e., CH2M HILL, subcontractor, or contractor). CH2M HILL employees and subcontractors must, at a minimum, remain aware of hazards affecting them regardless of who is responsible for controlling the hazards. Specialty subcontractors are responsible for the safe operation of their equipment (e.g., drill rig, heavy equipment). CH2M HILL employees are not to operate, or assist in the operation of, any subcontractor or contractor equipment.

		Tasks									
Hazard (Refer to SOP, or HSP Section)	**Engineering Controls, Administrative Controls, and Work Practices**	**Test Pit and Excavation**	**Drilling, Geoprobe Installation, Well Installation and Abandonment**	**Groundwater Monitoring, Aquifer Testing, and Video Surveying of Wells**	**Surface Water and Sediment Sampling Using a Boat**	**Surface Water and Sediment Sampling from the Shore or Water**	**Hand Augering**	**Surveying**	**IDW Drum Sampling and Disposal***	**Observation of Loading of Material for Offsite Disposal**	**Remediation and Construction Oversight**
Inadequate illumination	Site work will be performed during daylight hours whenever possible. Work conducted during hours of darkness will require enough illumination intensity "to read a newspaper without difficulty."	X	X	X	X	X	X	X	X	X	X
Entanglement in rotating equipment	• Prohibit loose clothing and hair • Prohibit wearing jewelry		X				X				
Drilling	• The drill rig is not to be operated in inclement weather. • The driller is to verify that the rig is properly leveled and stabilized before raising the mast. • Personnel should be cleared from the sides and rear of the rig before the mast is raised. • The driller is not to drive the rig with the mast in the raised position. • The driller must check for overhead power lines before raising the mast. A minimum distance of 15 feet between mast and overhead lines (<50 kV) is recommended. Increased separation may be required for lines greater than 50 kV. • Personnel should stand clear before rig startup. • The driller is to verify that the rig is in neutral when the operator is not at the controls. • Become familiar with the hazards associated with the drilling method used (cable tool, air rotary, hollow-stem auger, etc.). • Do not wear loose-fitting clothing, watches, etc., that could get caught in moving parts. • Do not smoke or permit other spark-producing equipment around the drill rig. • The drill rig must be equipped with a kill wire or switch, and personnel are to be informed of its location. • Be aware and stand clear of heavy objects that are hoisted overhead. • The driller is to verify that the rig is properly maintained in accordance with the drilling company's maintenance program. • The driller is to verify that all machine guards are in place while the rig is in operation. • The driller is responsible for housekeeping (maintaining a clean work area). • The drill rig should be equipped with at least one fire extinguisher. • If the drill rig comes into contact with electrical wires and becomes electrically energized, do not touch any part of the rig or any person in contact with the rig, and stay as far away as possible. Notify emergency personnel immediately.		X								
Heavy equipment	• Become familiar with hazards specific to the equipment being used. • Always confirm that the operator is aware of your location, particularly when you approach or pass by equipment. • Backup alarm is required for heavy equipment. Do not count on backup alarms always functioning. Look around when alarm sounds. • Do not ride equipment not designed for passengers. • Do not climb on operating equipment. • Do not place yourself between fixed and moving parts or objects. • Do not stand adjacent to the equipment. • Stay clear of equipment on cross slopes and unstable terrain. • Stay clear of pile-driving operations. • Stay outside the turning radius of the equipment. • Operators using all-terrain vehicles (ATV) must be trained; other ATV requirements may apply. • Observer must remain in contact with operator and signal safe backup. • Personnel must remain outside the turning radius.	X	X		X					X	X
Working near water	• U.S. Coast Guard-approved personal flotation devices (PFDs–e.g., life jacket) provided for each employee will be worn. • PFDs will be inspected before and after each use. Defective equipment will not be used. • Sampling and other equipment will be used according to the manufacturer's instructions. • A minimum of one life-saving skiff will be provided for emergency rescue. • A minimum of one ring buoy with 90 feet of 3/8-inch solid-braid polypropylene (or equal) rope will be provided for emergency rescue. • Keep nonessential personnel 3 feet from edge of water					X					

3.3 GENERAL PHYSICAL (SAFETY) HAZARDS AND CONTROLS

Engineering and administrative controls are to be implemented by the party in control of the site or the hazard (i.e., CH2M HILL, subcontractor, or contractor). CH2M HILL employees and subcontractors must, at a minimum, remain aware of hazards affecting them regardless of who is responsible for controlling the hazards. Specialty subcontractors are responsible for the safe operation of their equipment (e.g., drill rig, heavy equipment). CH2M HILL employees are not to operate, or assist in the operation of, any subcontractor or contractor equipment.

Hazard (Refer to SOP, or HSP Section)	Engineering Controls, Administrative Controls, and Work Practices	Tasks									
		Test Pit and Excavation	Drilling, Geoprobe Installation, Well Installation and Abandonment	Groundwater Monitoring, Aquifer Testing, and Video Surveying of Wells	Surface Water and Sediment Sampling Using a Boat	Surface Water and Sediment Sampling from the Shore or Water	Hand Augering	Surveying	IDW Drum Sampling and Disposal*	Observation of Loading of Material for Offsite Disposal	Remediation and Construction Oversight
Working on water	• Safe means of boarding or leaving a boat or a platform will be provided to prevent slipping and falling. Boat/barge must be equipped with adequate railing. instructions/warnings (e.g., protect from pinch points, sharp objects, rope burns/entanglement). • Work requiring the use of a boat will take place only during daylight hours. • Work requiring the use of a boat will not take place during inclement weather. • The boat/barge must be operated according to U.S. Coast Guard regulations (speed, lightning, right-of-way, etc.). Shut off engine before refueling; do not smoke while refueling.				X						
IDW Drum sampling	Personnel are allowed to handle and/or sample drums containing investigation-derived waste (IDW) only; handling or sampling other drums requires a plan revision or amendment approved by the CH2M HILL HSM. The following control measures will be taken when sampling drums containing IDW: • Minimize transportation of drums. • Minimize number of people involved in the actual sampling. • Sample only labeled drums or drums known to contain IDW. • Use caution when sampling bulging or swollen drums. Relieve pressure slowly. • If drums contain, or potentially contain, flammable materials, use nonsparking tools to open. • Picks, chisels, and firearms may not be used to open drums. • Reseal bung holes or plugs whenever possible. • Avoid mixing incompatible drum contents. • Sample drums without leaning over the drum opening. • If there is evidence of contamination on the lid of the drum, cover the lid with plastic sheeting. • Transfer the content of drums using a method that minimizes contact with material. • Air monitoring and PPE requirements specified in sections 5 and 6 must address drum sampling. • Spill-containment procedures specified in Section 8 must be appropriate for the material to be handled.								X		

3.4 BIOLOGICAL HAZARDS AND CONTROLS

Hazard and Location	Control Measures
Snakes typically are found in underbrush and tall grassy areas.	If you encounter a snake, stay calm and look around; there may be other snakes. Turn around and walk away on the same path you used to approach the area. If a person is bitten by a snake, wash and immobilize the injured area, keeping it lower than the heart if possible. Seek medical attention immediately. **DO NOT** apply ice, cut the wound, or apply a tourniquet. Carry the victim or have him/her walk slowly if the victim must be moved. Try to identify the type of snake: note color, size, patterns, and markings.
Poison ivy, poison oak, and poison sumac typically are found in brush or wooded areas. They are more commonly found in moist areas or along the edges of wooded areas.	Become familiar with the identity of these plants. Wear protective clothing that covers exposed skin and clothes. Avoid contact with plants and the outside of protective clothing. If skin contacts a plant, wash the area with soap and water immediately. If the reaction is severe or worsens, seek medical attention.
Exposure to **bloodborne pathogens** may occur when rendering first aid or CPR, or when coming into contact with medical or other potentially infectious material, or when coming into contact with landfill waste or waste streams containing such infectious material.	Training is required before a task involving potential exposure is performed. Exposure controls and personal protective equipment (PPE) are required as specified in CH2M HILL SOP HS-36, *Bloodborne Pathogens*. Hepatitis B vaccination must be offered before the person participates in a task where exposure is a possibility.
Bees and other stinging insects may be encountered almost anywhere and may present a serious hazard, particularly to people who are allergic.	Watch for and avoid nests. Keep exposed skin to a minimum. Carry a kit if you have had allergic reactions in the past, and inform the SSC and/or the buddy. If a stinger is present, remove it carefully with tweezers. Wash and disinfect the wound, cover it, and apply ice. Watch for allergic reaction; seek medical attention if a reaction develops.

Other Potential Biological Hazards:

None known

3.5 TICK BITES (Reference CH2M HILL HS-03, *Tick Bites*)

Ticks typically are in wooded areas, bushes, tall grass, and brush. Ticks are black, black and red, or brown and can be up to one-quarter inch in size.

Prevention against tick bites includes avoiding tick areas; wearing tightly woven light-colored clothing with long sleeves and wearing pant legs tucked into boots or socks; spraying **only outside** of clothing with insect repellent containing permethrin or permanone, and spraying skin with DEET; and checking yourself frequently for ticks and showering as soon as possible. To prevent chemical repellents from interfering with sample analyses, exercise care while using repellents during the collection and handling of environmental samples.

If bitten by a tick, carefully remove the tick with tweezers, grasping the tick as close as possible to the point of attachment while being careful not to crush the tick. After removing the tick, wash your hands and disinfect and press the bite area. The removed tick should be saved. Report the bite to human resources personnel.

Look for symptoms of Lyme disease or Rocky Mountain spotted fever (RMSF). Lyme: a rash that looks like a bullseye with a small welt in the center. RMSF: a rash of red spots under the skin 3 to 10 days after the tick bite. In both cases, chills, fever, headache, fatigue, stiff neck, bone pain may develop. If symptoms appear, seek medical attention.

3.6 RADIOLOGICAL HAZARDS AND CONTROLS

Refer to CH2M HILL's *Corporate Health and Safety Program, Program and Training Manual*, and *Corporate Health and Safety Program, Radiation Protection Program Manual,* for standards of practice for operating in contaminated areas.

Hazards	Controls
None Known	None Required

3.7 HAZARDS POSED BY CHEMICALS BROUGHT ON THE SITE

3.7.1 HAZARD COMMUNICATION

(Reference CH2M HILL *Hazard Communication Manual* and Section 5 of the *Site Safety Notebook*)

CH2M HILL's *Hazard Communication Program Manual,* which is available from area or regional offices and from the Corporate Human Resources Department in Denver. The project manager is to request Material Safety Data Sheets (MSDSs) from the client or from the contractors and the subcontractors for chemicals to which CH2M HILL employees potentially are exposed. The SSC is to do the following:

- Give employees required site-specific HAZCOM training.
- Confirm that the inventory of chemicals brought on the site by subcontractors is available.
- Before or as the chemicals arrive on the site, obtain an MSDS for each hazardous chemical.
- Label chemical containers with the identity of the chemical and with hazard warnings, if any.

The chemical products listed below will be used on the site. Refer to Attachment 2 for MSDSs.

Chemical	Quantity	Location
Methane (calibration gas)	1 liter, compressed gas	Support Zone
Isobutylene (calibration gas)	1 liter, compressed gas	Support Zone
Pentane (calibration gas)	1 liter, compressed gas	Support Zone
Hydrochloric Acid (sample preservative)	< 500 ml	Support/Exclusion Zone
Nitric Acid (sample preservative)	< 500 ml	Support/Exclusion Zone
Sulfuric Acid (sample preservative)	< 500 ml	Support/Exclusion Zone
Sodium Hydroxide (sample preservative)	< 500 ml	Support/Exclusion Zone
Methanol (decontamination solvent)	< 1 gallon	Support/Decontamination Zone
Hexane (decontamination solvent)	< 1 gallon	Support/Decontamination Zone
Isopropanol (decontamination solvent)	< 1 gallon	Support/Decontamination Zone
pH Buffers (calibration standard)	< 500 ml	Support Zone
MSA Sanitizer (respirator cleaner)	< 1 liter, powder	Support/Decontamination Zone
Alconox/Liquinox (detergent)	< 1 liter, powder/liquid	Support/Decontamination Zone

3.7.2 SHIPPING AND TRANSPORTATION OF CHEMICAL PRODUCTS

(Reference CH2M HILL's *Procedures for Shipping and Transporting Dangerous Goods*)

Nearly all chemicals brought to the site are considered hazardous materials by the U.S. Department of Transportation (DOT). All staff who ship the materials or transport them by road must receive the CH2M HILL training in shipping dangerous goods. All hazardous materials that are shipped (e.g., via Federal Express) or are transported by road must be properly identified, labeled, packed, and documented by trained staff. Contact the HSM or the Equipment Coordinator for additional information.

3.8 CONTAMINANTS OF CONCERN (REFER TO PROJECT FILES FOR MORE-DETAILED CONTAMINANT INFORMATION)

Contaminant	Location and Highest[a] Concentration (ppm)	Exposure Limit[b]	IDLH[c]	Symptoms and Effects of Exposure	PIP[4] (eV)
Arsenic	GW: 0.64	0.01 mg/m^3	5 Ca	Ulceration of nasal septum, respiratory irritation; dermatitis; gastrointestinal disturbances; peripheral neuropathy, hyperpigmentation	NA
Cadmium	GW: 0.04 SS: 57 ppm SED: 8.2 ppm	0.005 mg/m^3	9 Ca	Pulmonary edema, coughing, chest tightness/pain, headache; chills, muscle aches, nausea, vomiting, diarrhea; difficulty breathing; loss of sense of smell; emphysema; mild anemia	NA
Chromium (as Cr(II) & Cr (III))	GW: 0.26 SS: 320 ppm SED:47 ppm	0.5 mg/m^3	25	Irritated eyes, sensitization dermatitis, histologic fibrosis of lungs	NA
DDT	SS: 120,000	0.5 mg/m^3	500 Ca	Paresthesia of tongue, lips, hand, and face; tremors; dizziness; confusion; headache; fatigue; convulsions; eye and skin irritation; vomiting	UK
Ethyl Benzene	SS:110,000	100 ppm	800	Eye, skin, and mucous membrane irritation; headache; dermatitis; narcotic; coma	8.76
Lead	GW: 0.72 SED: 250 ppm	0.05 mg/m^3	100	Weakness, lassitude; facial pallor; pal eye; weight loss, malnutrition; abdominal pain, constipation; anemia; gingival lead line; tremors; paralysis of wrist and ankles; encephalopathy; kidney disease; irritated eyes; hypotension	NA
Mercury	GW: 0.0004	0.05 mg/m^3	10	Skin and eye irritation, cough, chest pain, difficult breathing, bronchitis, pneumontitis, tremors, insomnia, irritability, indecision, headache, fatigue, weakness, GI disturbance	NA
Naphthalene	SS:7,200,000	10 ppm	250	Eye irritation, headache, confusion, excitement, nausea, vomiting, abdominal pain, bladder irritation, profuse sweating, dermatitis, corneal damage, optical neuritis	8.12
PCBs (AROCLOR 1260)	SS: 890	0.5 mg/m^3	5 Ca	Eye and skin irritation, acne-form dermatitis, liver damage, reproductive effects	UK

3.8 CONTAMINANTS OF CONCERN (REFER TO PROJECT FILES FOR MORE-DETAILED CONTAMINANT INFORMATION)					
Contaminant	**Location and Highest[a] Concentration (ppm)**	**Exposure Limit[b]**	**IDLH[c]**	**Symptoms and Effects of Exposure**	**PIP[4] (eV)**

Footnotes:

a: Specify sample-designation and media: SS (Surface Soil), SED (Sediment), SB (Soil Boring), A (Air), D (Drums), GW (Groundwater), L (Lagoon), TK (Tank), SL (Sludge), SW (Surface Water),
b: Appropriate value of PEL, REL, or TLV listed
c: IDLH = immediately dangerous to life and health (units are the same as specified "Exposure Limit" units for that contaminant); NL = No limit found in reference materials; CA = Potential occupational carcinogen
d: PIP = photoionization potential; NA = Not applicable; UK = Unknown Footnotes

3.9 POTENTIAL ROUTES OF EXPOSURE		
DERMAL: Contact with contaminated media. This route of exposure is minimized through proper use of PPE, as specified in Section 5.	**INHALATION:** Vapors and contaminated particulates. This route of exposure is minimized through proper respiratory protection and monitoring, as specified in sections 5 and 6, respectively.	**OTHER:** Inadvertent ingestion of contaminated media. This route should not present a concern if good hygiene practices are followed (e.g., wash hands and face before eating, drinking, or smoking).

4 PERSONNEL

4.1 CH2M HILL EMPLOYEE MEDICAL SURVEILLANCE AND TRAINING

(Reference CH2M HILL SOP HS-01, *Medical Surveillance*, and HS-02, *Health and Safety Training*)

The employees listed below are enrolled in the CH2M HILL Comprehensive Health and Safety Program and meet state and federal hazardous waste operations requirements for 40-hour initial training, 3-day on-the-job experience, and 8-hour annual refresher training. Employees designated "SSC" have received 8 hours of supervisor and instrument training and can serve as site safety coordinator (SSC) for the level of protection indicated. An SSC with a level designation (D, C, B) equal to or greater than the level of protection being used must be present during all tasks performed in exclusion or decontamination zones that involve the potential for exposure to health and safety hazards. Employees designated "FA-CPR" are currently certified by the American Red Cross, or equivalent, in first aid and CPR. At least one FA-CPR designated employee must be present during all tasks performed in exclusion or decontamination zones that involve the potential for exposure to health and safety hazards. The employees listed below are currently active in a medical surveillance program that meets state and federal regulatory requirements for hazardous waste operations. The CH2M HILL medical surveillance program is performed under the direct supervision of a licensed physician who is Board Certified in the practice of Occupational Medicine (see Section 13). Certain tasks (e.g., confined-space entry) and contaminants (e.g., lead) may require additional training and medical monitoring.

Pregnant employees are to be informed of and are to follow the procedures in CH2M HILL's SOP HS-04, *Reproduction Protection*, including
obtaining a physician's statement of the employee's ability to perform hazardous activities, before being assigned fieldwork.

Employee Name	Office	Responsibility	SSC/FA-CPR
Brooke Bennett	WDC	Field Team Leader	Level (D) SSC;FA-CPR
Don Martinson	WDC	Field Team Leader	Level (B) SSC; FA-CPR
Linnea Eng	WDC	Field Team Leader	Level (D) SSC;FA-CPR
Jack Robinson	WDC	Field Team Leader	Level (B) SSC; FA-CPR

4.2.1 CLIENT

Contact Name:	Mr. David Forsythe, NTR
Phone:	(804) 322-4783
Facility Contact Name:	Ms. Dianne Bailey, Program Manager
Phone:	(804) 322-2900
	Mr. William Whitmire, Hazardous Waste Dispatch
	(804) 444-7528
	Mr. Merrill Ashcraft, Navy On-Science Coordinator
	(804) 445-8851

4.2.2 CH2M HILL

Project Manager:	Jack Robinson (703) 471-1441
Health and Safety Manager:	John Longo (201) 316-9300
Field Team Leader:	Brooke Bennett (703) 471-1441
Site Safety Coordinator:	Brooke Bennett (703) 471-1441

The SSC is responsible for contacting the field team leader and the project manager. In general, the project manager either will contact or will identify the client contact. The Health and Safety Manager (HSM) should be contacted as appropriate. The SSC or the project manager must notify the client and the HSM when a serious injury or a death occurs or when health and safety inspections by OSHA or other agencies are conducted. Refer to sections 10 through 12 for emergency procedures and phone numbers.

4.2.3 SUBCONTRACTORS

(Reference Section 3, *Corporate Health and Safety Program Manual*)

When specified in the project documents (e.g., contract), this plan may cover CH2M HILL subcontractors. However, this plan does not address hazards associated with tasks and equipment that the subcontractor has expertise in (e.g., operation of drill rig). Specialty subcontractors are responsible for health and safety procedures and plans specific to their work. Specialty subcontractors are to submit plans to CH2M HILL for review and approval before the start of fieldwork. Subcontractors must comply with the established health and safety plan(s). CH2M HILL must monitor and enforce compliance with the established plan(s).

Subcontractor: Drilling subcontractor had not been selected at the time of the writing of this HASP.
Subcontractor Contact:
Telephone:

General health and safety communication with subcontractors contracted with CH2M HILL and covered by this plan is to be conducted as follows:

- Request that the subcontractor, if a specialty subcontractor, submit a safety or health plan applicable to their expertise (e.g., drill-rig safety plan or nuclear density gauge [NDG] health plan); attach the reviewed plan.
- Supply subcontractors with a copy of this plan, and brief them on its provisions.
- Direct health and safety communication to the subcontractor-designated safety representative.
- Notify the subcontractor-designated representative if a violation of the plan(s) is observed. Specialty subcontractors are responsible for mitigating hazards in which they have expertise.
- If a hazard condition persists, inform the subcontractor. If the hazard is not mitigated, stop affected work as a last resort and notify the project manager.
- When an apparent imminent danger exists, promptly remove all affected personnel. Notify the project manager.
- Make clear that consistent violations of the health and safety plan by a subcontractor may result in termination of the subcontract.

4.2.4 CONTRACTORS

(Reference Section 3, *Corporate Health and Safety Program Manual*)

This plan does not cover contractors that are contracted directly to the client or the owner. CH2M HILL is not responsible for directing contractor personnel and is not to assume responsibility through their actions. When the contractor is in control of the site, ask the contractor to conduct a briefing of their health and safety practices and to describe how they apply to CH2M HILL's activities. Request a copy of the contractor's health and safety plan.

Contractor: NA
Contact Name: NA
Telephone: NA

General health and safety communication with contractors *not* contracted with CH2M HILL is listed below. These procedures can also be applied to other third party communications (e.g., client personnel).

- Ask the contractor to brief CH2M HILL on the contractor's health and safety plan for how the plan affects CH2M HILL employees on the site.

- If acceptable to the client, communicate about health and safety directly with the contractor PM or other onsite contractor-designated representative. CH2M HILL employees are not to direct the details of the contractor's work or to advise on health and safety (e.g., how the contractor corrects unsafe conditions).

- If an observed hazard poses a risk to CH2M HILL personnel, notify the party controlling the work activity as soon as possible. Notify the project manager; the project manager will notify the client. Document oral notification in project records (i.e., the field logbook).

- If a hazardous condition endangering a CH2M HILL employee persists, inform the contractor and the project manager (the project manager will contact the client) that CH2M HILL cannot execute the assigned work until the hazard is mitigated.

- When an apparent imminent danger exists, orally warn the person(s) in danger and orally notify the contractor promptly. When an imminent danger involves a CH2M HILL employee, remove the employee and suspend CH2M HILL work immediately until the hazard has been mitigated. Inform the project manager and the contractor promptly.

- The SSC or the project manager must notify the client and CH2M HILL health and safety staff when (1) the contractor fails to remedy an unsafe condition affecting CH2M HILL personnel, (2) the contractor does not remedy the hazardous condition within a reasonable period of time, or (3) the contractor repeatedly creates the hazardous condition.

5 PERSONAL PROTECTIVE EQUIPMENT (PPE) (Reference CH2M HILL SOP HS-07, *Personal Protective Equipment*, HS-08, *Respiratory Protection*, Section 2 of the *Site Safety Notebook*)

5.1 PPE SPECIFICATIONS[a]

Task	Level	Body	Head	Respirator[b]
General work uniform when no chemical exposure is anticipated	D	Work clothes; steel-toe, steel-shank leather work boots; work gloves	Hardhat[c] Safety glasses Ear protection[d]	None required
Monitoring well installation and all sampling activities.	Modified D	**COVERALLS:** Polycoated Tyvek® **BOOTS:** Steel-toe, steel-shank chemical-resistant boots OR steel-toe, steel-shank leather work boots with outer rubber boot covers **GLOVES:** Inner surgical-style nitrile glove AND outer chemical-resistant nitrile glove.	Hardhat[c] Splash shield[c] Safety glasses Ear protection[d]	None required
Monitoring well installation and all sampling activities if criteria in Section 5.2 are met.	C	**COVERALLS:** Polycoated Tyvek® **BOOTS:** Steel-toe, steel-shank chemical-resistant boots OR steel-toe, steel-shank leather work boots with outer rubber boot covers **GLOVES:** Inner surgical-style nitrile glove AND outer chemical-resistant nitrile glove.	Hardhat[c] Splash shield[c] Ear protection[d] Spectacle inserts	APR, full face, MSA Ultratwin or equivalent; with GME-H[e] cartridges or equivalent
None anticipated	B	**COVERALLS:** Polycoated Tyvek® **BOOTS:** Steel toe, steel-shank chemical-resistant boots OR steel-toe, steel-shank leather work boots with outer rubber boot covers **GLOVES:** Inner surgical-style nitrile glove AND outer chemical-resistant nitrile glove.	Hardhat[c] Splash shield[c] Ear protection[d] Spectacle inserts	Positive-pressure demand self-contained breathing apparatus (SCBA): MSA Ultralite, or equivalent

[a] Modifications are as indicated. CH2M HILL will provide PPE to only CH2M HILL employees.
[b] No facial hair that would interfere with respirator fit is permitted.
[c] Hardhat and splash-shield areas are to determined by the SSC.
[d] Ear protection should be worn while working around drill rigs or other noise-producing equipment or when conversations cannot be held at distances of 3 feet or less without shouting. Refer to Section 6 for other requirements.
[e] The GME-H cartridge is the new standard-issue cartridge. Available stock of the previously standard GMC-H cartridges may NOT be used for tasks covered by this plan.

5.2 REASONS FOR UPGRADING OR DOWNGRADING LEVEL OF PROTECTION

Upgrade*	Downgrade
• Request from individual performing task. • Change in work task that will increase contact or potential contact with hazardous materials. • Occurrence or likely occurrence of gas or vapor emission. • Known or suspected presence of dermal hazards. • Instrument action levels (Section 6) exceeded.	• New information indicating that situation is less hazardous than originally thought. • Change in site conditions that decreases the hazard. • Change in work task that will reduce contact with hazardous materials.

*Performing a task that requires an upgrade to a higher level of protection (e.g., level D to level C) is permitted only when the PPE requirements have been specified in Section 5 and an SSC who meets the requirements specified in subsection 4.1 is present.

6 AIR MONITORING SPECIFICATIONS (Reference CH2M HILL SOP HS-06, *Air Monitoring*, and Section 2 of the *Site Safety Notebook*)

Instrument	Tasks	Action Levels[a]		Frequency[b]	Calibration
PID: OVM with 10.6eV lamp or equivalent	Monitoring well installation, soil, and groundwater sampling activities.	0 - 5 ppm 5 - 10 ppm > 10 ppm	Level D Level C Level B (not anticipated)	Initially and periodically during task	Daily; before and after each period of use
CGI: MSA model 260 or 261 or equivalent	Drilling	0-10%[c] LEL: 10-25%[c] LEL: >25%[c] LEL:	No explosion hazard Potential explosion hazard Explosion hazard; evacuate or vent	Continuous during advancement of boring or trench	Daily; before and after each period of use
O_2 Meter: MSA model 260 or 261 or equivalent	Drilling	>25.0%[c] O_2: 20.9%[c] O_2: <19.5%[c] O_2:	Explosion hazard; evacuate or vent Normal O_2 O_2 deficient; vent or use SCBA	Continuous during advancement of boring or trench	Daily; before and after each period of use
Dust Monitor: Miniram model PDM-3 or equivalent	Dust-generating activities (visible dust in the breathing zone)	0 - 1 mg/m^3 >1 - 5 mg/m^3 >5 mg/m^3	Level D Level C Stop work; implement dust suppression measures	Initially and periodically during task	Zero Daily; before and after each period of use
Noise-Level Monitor[e]:	None anticipated	< 85 dB(A) 85 - 120 dB(A) 120 dB(A)	No action required Hearing protection required[e] Stop; re-evaluate	Initially and periodically during task	Daily; before and after each period of use

Note a: Action levels apply to sustained breathing-zone measurements above background.

Note b: The exact frequency of monitoring depends on field conditions and is to be determined by the SSC; generally, every 5 to 15 minutes is acceptable; more frequently may be appropriate. Monitoring results should be recorded. Documentation should include instrument and calibration information, time and measurement result, personnel monitored, and place/location where measurement is taken (e.g., "Breathing Zone/MW-3," "at surface/SB-2," etc.).

Note c: If the measured percent of O_2 is less than 10, an accurate LEL reading will not be obtained. Percent LEL and percent O_2 action levels apply to only ambient working atmospheres, and do not apply to confined-space entry. More-stringent percent LEL and O_2 action levels are required for confined-space entry; refer to Section 9.

Note d: Refer to SOP HS-10 for instructions and documentation on radiation monitoring and screening.

Note e: Contact HSM. Noise monitoring, training, and audiometric testing also are required.

6.1 CALIBRATION SPECIFICATIONS

(Refer to the respective manufacturer's instructions for proper instrument-maintenance procedures)

Instrument	Gas	Span	Reading	Method
PID: HNU, 10.2 eV probe	100 ppm isobutylene	9.8 ± 2.0	55 ppm	1.5 lpm reg T-tubing OR 0.25 lpm reg direct tubing
HNU, 11.7 eV probe		5.0 ± 2.0	68 ppm	
PID: OVM, 10.0 or 10.6 eV bulb	100 ppm isobutylene	RF = 0.55	55 ppm	1.5 lpm reg T-tubing
OVM, 11.8 eV bulb		RF = 0.68	68 ppm	
PID: MiniRAE, 10.6 eV bulb	100 ppm isobutylene	CF=53	53 ppm ±5 ppm	1.5 lpm REG T-Tubing
PID: TVA 1000	100 ppm isobutylene	CF=0.55	55 ppm ± 5 ppm	1.5 lpm REG T-Tubing
FID: OVA-128	100 ppm methane	3.0 ± 1.5	100 ppm	1.5 lpm reg T-tubing
FID: TVA 1000	100 ppm methane	CF=1.00	100 ppm ± 10	1.5 lpm reg T-tubing
Dust Monitor: Miniram-PDM3	Dust-free air	Not applicable	0.00 mg/m^3 in "Measure" mode	Dust-free area OR Z-bag with HEPA filter
CGI: MSA 260, 261, 360, or 361	0.75% pentane	N/A	50% LEL ± 5 % LEL	1.5 lpm reg direct tubing

6.2 AIR SAMPLING

Sampling may be required by other OSHA regulations where there may be exposure to certain contaminants. Air sampling typically is required when site contaminants include lead, cadmium, arsenic, asbestos, and certain volatile organic compounds. Contact the HSM immediately if these contaminants are encountered.

Method Description: Not applicable

Personnel and Areas

Results must be sent immediately to the HSM. Regulations may require reporting to monitored personnel. Results reported to:

HSM: John Longo/NJO
Other:

7 DECONTAMINATION (REFERENCE CH2M HILL SOP HS-13, *DECONTAMINATION*)

The SSC must monitor the effectiveness of the decontamination procedures. Decontamination procedures found to be ineffective will be modified by the SSC.

7.1 DECONTAMINATION SPECIFICATIONS

Personnel

- Boot wash/rinse
- Glove wash/rinse
- Outer-glove removal
- Body-suit removal
- Inner-glove removal
- Respirator removal
- Hand wash/rinse
- Face wash/rinse
- Shower ASAP
- **PPE-disposal method:**
  **
- **Water-disposal method:**
  **

**Refer to Investigation-Derived Waste Management Plan for disposal methods.

Sample Equipment

- Wash/rinse equipment
- Solvent-rinse equipment
- **Solvent-disposal method:**
  **

Heavy Equipment

- Power wash
- Steam clean
- **Water-disposal method:**
  **

7.2 DIAGRAM OF PERSONNEL-DECONTAMINATION LINE

No eating, drinking, or smoking is permitted in contaminated areas and in exclusion or decontamination zones. The SSC should establish areas for eating, drinking, and smoking. Contact lenses are not permitted in exclusion or decontamination zones.

Figure 7-1 illustrates a typical establishment of work zones, including the decontamination line. Work zones are to be modified by the SSC to accommodate task-specific requirements.

8 SPILL-CONTAINMENT PROCEDURES

Sorbent material will be maintained in the support zone. Incidental spills will be contained with sorbent and will be disposed of properly.

9 CONFINED-SPACE ENTRY

(Reference CH2M HILL SOP HS-17, *Confined Space Entry*)

No confined-space entry will be permitted. Confined-space entry requires additional health and safety procedures, training, and a permit. If conditions change such that confined-space entry is necessary, contact the HSM to develop the required entry permit.

When planned activities will not include confined-space entry, permit-required confined spaces accessible to CH2M HILL personnel are to be identified before the task begins. The SSC is to confirm that permit spaces are properly posted or that employees are informed of their locations and informed of their hazards.

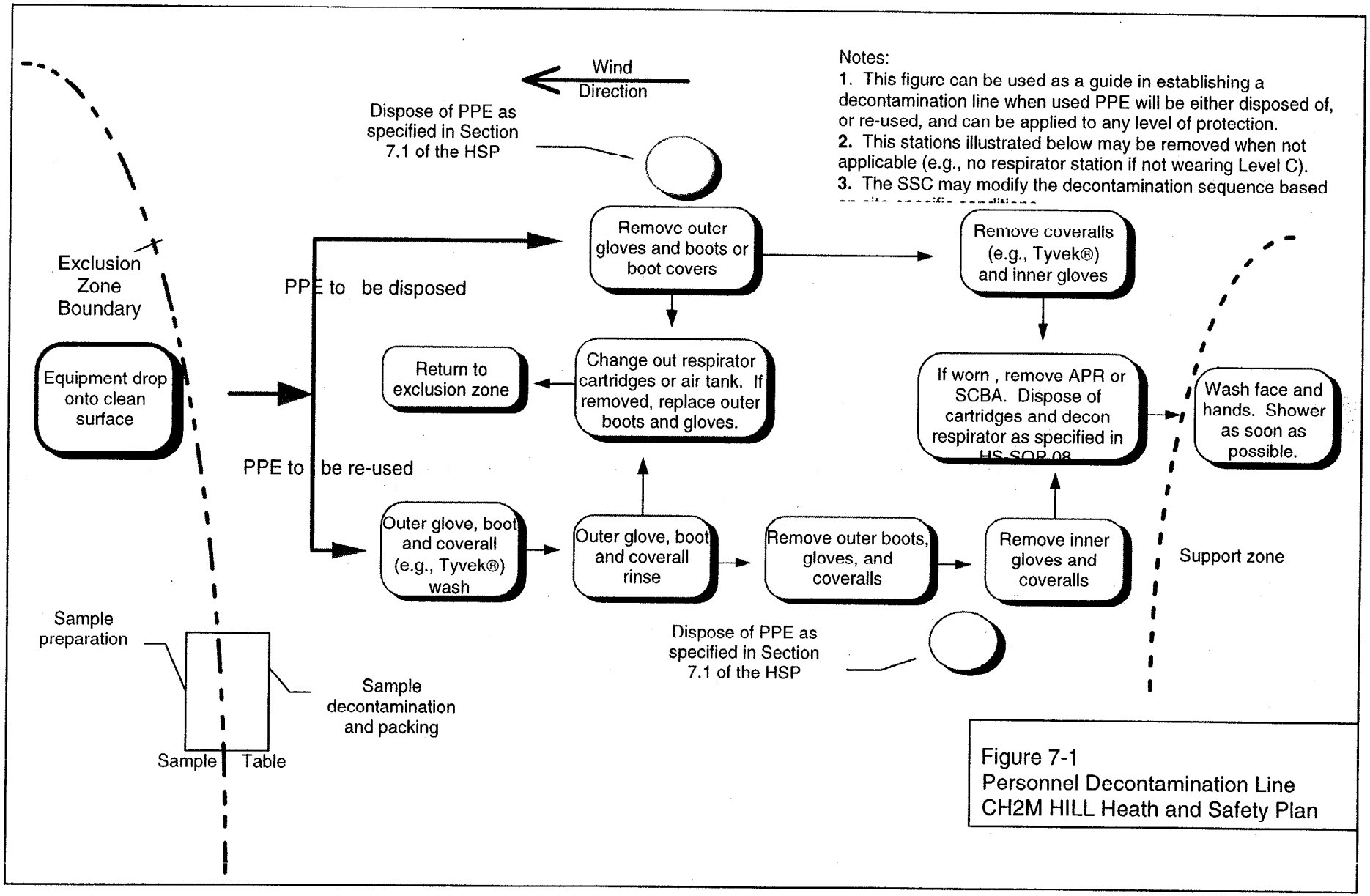


Figure 7-1
Personnel Decontamination Line
CH2M HILL Heath and Safety Plan

10 SITE-CONTROL PLAN

10.1 SITE-CONTROL PROCEDURES

- The site safety coordinator (SSC) will conduct a site safety briefing (see below) before starting field activities or as tasks and site conditions change.
- Topics for briefing on site safety: general discussion of health and safety plan, site-specific hazards, locations of work zones, PPE requirements, equipment, special procedures, emergencies. Refer to Section 8 of *Site Safety Notebook.*
- The SSC records attendance at safety briefings in a logbook and documents the topics discussed.
- The SSC will ensure that a daily log-in and log-out book is maintained for all personnel entering the site.
- Post the OSHA job-site poster in a central and conspicuous location at sites where project field offices, trailers, or equipment storage boxes are established. Posters can be obtained by calling either 800/548-4776 or 800/999-9111.
- Field Trailers: Post "Exit" signs above exit doors, and post "Fire Extinguisher" signs above locations of extinguishers. Keep areas near exits and extinguishers clear.
- Determine wind direction.
- Establish work zones: support, decontamination, and exclusion zones. Delineate work zones with flags or cones as appropriate. Support zone should be upwind of the site.
- Establish decontamination procedures, including respirator-decontamination procedures, and test the procedures.
- Use access control at the entry and exit from each work zone.
- Store chemicals in appropriate containers.
- Make MSDSs available for onsite chemicals to which employees are exposed.
- Establish onsite communication consisting of the following:
  - Line-of-sight and hand signals
  - Air horn
  - Two-way radio or cellular telephone if available
- Establish offsite communication.
- Establish and maintain the "buddy system."
- Establish procedures for disposing of material generated on the site.
- Initial air monitoring is conducted by the SSC in appropriate level of protection.
- The SSC is to conduct periodic inspections of work practices to determine the effectiveness of this plan -- refer to CH2M HILL SOP 18, *Health and Safety* Checklist, or Section 4 of *Site Safety Notebook.* Deficiencies are to be noted, reported to the HSM, and corrected.

10.2 HAZWOPER COMPLIANCE PLAN (Reference CH2M HILL SOP HS-17, *Health and Safety Plans*)

This section outlines procedures to be followed when certain activities do not require 24- or 40-hour training. ***Note, prior approval from the HSM is required before these tasks are conducted on regulated hazardous waste sites.***

- Certain parts of the site work may be covered by state or federal Hazwoper standards and therefore require training and medical monitoring. Anticipated tasks must be included in subsection 2.2.1.
- Air sampling must confirm that there is no exposure to gases or vapors before non-Hazwoper-trained personnel are allowed on the site. Other data (e.g., soil) also must document that there is no potential for exposure. The HSM must approve the interpretation of these data. Refer to subsections 3.8 and 6.2 for contaminant data and air sampling requirements, respectively.
- Non-Hazwoper-trained personnel must be informed of the nature of the existing contamination and its locations, the limits of their access, and the emergency action plan for the site. Non-Hazwoper-trained personnel also must be trained in accordance with all other state and federal OSHA requirements, including 29 CFR 1910.1200 (HAZCOM). Refer to subsection 3.7.1 for hazard communication requirements.
- Air monitoring with direct-reading instruments conducted during regulated tasks also should be used to ensure that non-Hazwoper-trained personnel (e.g., in an adjacent area) are not exposed to volatile contaminants. Non-Hazwoper-trained personnel should be monitored whenever the belief is that there may be a possibility of exposure (e.g., change in site conditions), or at some reasonable frequency to confirm that there is no exposure. Refer to Section 6.1 for air monitoring requirements.
- Treatment system start-ups: Once a treatment system begins to pump and treat contaminated media, the site is, for the purposes of applying the Hazwoper standard, considered a treatment, storage, and disposal facility (TSDF). Therefore, once the system begins operation, only Hazwoper-trained personnel (minimum of 24 hours of training) will be permitted to enter the site. All non-Hazwoper-trained personnel must leave the site.

If Hazwoper-regulated tasks are conducted concurrently with nonregulated tasks, non-Hazwoper-trained subcontractors must be removed from areas of exposure. If non-Hazwoper-trained personnel remain on the site while a Hazwoper-regulated task is conducted, the contaminant/exposure area (exclusion zone) must be posted, non-Hazwoper-trained personnel must be reminded of the locations of restricted areas and the limits of their access, and real-time monitoring must be conducted. Non-Hazwoper-trained personnel at risk of exposure must be removed from the site until it can be demonstrated that there is no longer a potential for exposure to health and safety hazards.

11 EMERGENCY RESPONSE PLAN (REFERENCE CH2M HILL SOP HS-12, *EMERGENCY RESPONSE*)

11.1 PRE-EMERGENCY PLANNING

The SSC performs the applicable pre-emergency planning tasks before starting field activities and coordinates emergency response with the facility and local emergency-service providers as appropriate.

- Review the facility emergency and contingency plans where applicable.
- Locate the nearest telephone; determine what onsite communication equipment is available (e.g., two-way radio, air horn).
- Identify and communicate chemical, safety, radiological, and biological hazards.
- Confirm and post emergency telephone numbers, evacuation routes, assembly areas, and route to hospital; communicate the information to onsite personnel.
- Post site map marked with locations of emergency equipment and supplies, and post OSHA job-site poster. The OSHA job-site poster is required at sites where project field offices, trailers, or equipment-storage boxes are established. Posters can be obtained by calling either 800/548-4776 or 800/999-9111.
- Field Trailers: Post "Exit" signs above exit doors, and post "Fire Extinguisher" signs above locations of extinguishers. Keep areas near exits and extinguishers clear.
- Review changed site conditions, onsite operations, and personnel availability in relation to emergency response procedures.
- Evaluate capabilities of local response teams where applicable.
- Where appropriate and acceptable to the client, inform emergency room and ambulance and emergency response teams of anticipated types of site emergencies.
- Designate one vehicle as the emergency vehicle; place hospital directions and map inside; keep keys in ignition during field activities.
- Inventory and check site emergency equipment, supplies, and potable water.
- Communicate emergency procedures for personnel injury, exposures, fires, explosions, chemical and vapor releases.
- Review notification procedures for contacting CH2M HILL's medical consultant and team member's occupational physician.
- Rehearse the emergency response plan once before site activities begin, including driving the route to the hospital.
- The emergency response plan will be periodically exercised and critiqued.
- Brief new workers on the emergency response plan.
- The SSC will evaluate emergency response actions and initiate appropriate follow-up actions.

11.2 EMERGENCY EQUIPMENT AND SUPPLIES

The SSC should mark the locations of emergency equipment on the site map and should post the map.

Emergency Equipment and Supplies	Location
20 lb (or two 10-lb) fire extinguisher (A, B, and C classes)	CH2M HILL Field Vehicle
First aid kit	CH2M HILL Field Vehicle
Eye wash*	CH2M HILL Field Vehicle
Potable water	CH2M HILL Field Vehicle
Bloodborne-pathogen kit	CH2M HILL Field Vehicle
Additional equipment (specify)	None anticipated

*The emergency eye wash unit must meet the American National Standards Institute (ANSI) criteria and be capable of delivering 1.5 liters (0.4 gallons) per minute of potable water to the eyes for fifteen minutes.

11.3 EMERGENCY MEDICAL TREATMENT

- Notify appropriate emergency response authorities listed in sections 12 and 13 (e.g., 911).
- During a time of no emergency, contact CH2M HILL's medical consultant for advice and guidance on medical treatment.
- The SSC will assume charge during a medical emergency until the ambulance arrives or until the injured person is admitted to the emergency room.
- Prevent further injury.
- Initiate first aid and CPR where feasible.
- Get medical attention immediately.
- Perform decontamination where feasible, and to the extent possible; lifesaving and first aid or medical treatment take priority. Decontamination procedures may need to be postponed, but should be implemented as soon as possible after the victim is stabilized.
- Notify the field team leader and the project manager of the injury.
- Make certain that the injured person is accompanied to the emergency room.
- Notify the health and safety manager.
- Notify the injured person's human resources department within 24 hours.
- Prepare an incident report -- refer to CH2M HILL SOP 12, *Emergency Response and First Aid*, and Section 6 of *Site Safety Notebook*. Submit the report to the corporate director of health and safety and the corporate human resources department (COR) within 48 hours.
- When contacting the medical consultant, state that you are calling about a CH2M HILL matter, and give your name, your telephone number, the name of the injured person, the extent of the injury or exposure, and the name and location of the medical facility where the injured person was taken.

11.4 NONEMERGENCY PROCEDURES

The procedures listed above may be applied to nonemergency incidents. Injuries and illnesses (including overexposure to contaminants) must be reported to Human Resources. If there is doubt about whether medical treatment is necessary, or if the injured person is reluctant to accept medical treatment, contact the CH2M HILL medical consultant.

- When contacting the medical consultant, state that the situation is a CH2M HILL matter, and give your name, your telephone number, the name of the injured person, the extent of the injury or exposure, and the name and location of the medical facility where the injured person was taken.
- Follow these procedures as appropriate.

11.5 INCIDENT RESPONSE

In fires, explosions, or chemical releases, actions to be taken include the following:

- Shut down CH2M HILL operations and evacuate the immediate work area.
- Account for personnel at the designated assembly area(s).
- Notify appropriate response personnel.
- Assess the need for site evacuation, and evacuate the site as warranted.

Instead of implementing a work-area evacuation, note that small fires or spills posing minimal safety or health hazards may be controlled.

11.6 EVACUATION

- Evacuation routes will be designated by the SSC before work begins.
- Onsite and offsite assembly points will be designated before work begins.
- Personnel will leave the exclusion zone and assemble at the onsite assembly point upon hearing the emergency signal for evacuation.
- Personnel will assemble at the offsite point upon hearing the emergency signal for a site evacuation.
- The SSC and a "buddy" will remain on the site after the site has been evacuated (if possible) to assist local responders and advise them of the nature and location of the incident.
- The SSC accounts for all personnel in the onsite assembly zone.
- A person designated by the SSC before work begins will account for personnel at the offsite assembly area.
- The SSC will write up the incident as soon as possible after it occurs and will submit a report to the corporate director of health and safety.

11.7 EVACUATION ROUTES AND ASSEMBLY POINTS

Refer to the site map in Section 1. Evacuation routes and assembly areas (and alternative routes and assembly areas) are specified on the site map.

11.8 EVACUATION SIGNALS

Signal	Meaning
Grasping throat with hand	Emergency–help me.
Thumbs up	OK; understood.
Grasping buddy's wrist	Leave area now.
Continuous sounding of horn	Emergency; leave site now.
Client/Facility: No site-specific signals applicable	

12 EMERGENCY RESPONSE

12.1 EMERGENCY RESPONSE TELEPHONE NUMBERS

SITE ADDRESS: Norfolk Naval Base Norfolk, Virginia	**Phone:** **Cellular Phone:**
Security (NAVBASE): Response Operator	**Phone:** (4) 2324 or (804) 444-2324 (4) 2737 or (804) 444-2737
Fire: Security (HAS): Mr. Frank King	**Phone:** (4) 3333 or (804) 444-3333
Ambulance: (Sewell Point) (Public)	**Phone:** (4) 2674 or (804) 444-2674 (9) 911 or 911
Public Works Department (Utility Clearances): Mr. Bruce Davis	**Phone:** (4) 4973 or (804) 444-4973
Emergency: (one call)	**Phone:** (4) 0716 or 0720, or 911
Hazardous Waste Dispatcher: Mr. William Whitmire	**Phone:** (4) 7528 or (804) 444-7528
COMNAVBASE Duty Desk**	**Phone:** (804) 322-2866/67
Navy On-Scene Coordinator (NOSC)	**Phone:**
Navy On-Scene Commander (NOSCR)	**Phone:**
Local Emergency Planning Committee (LEPC)	**Phone:**

*When using a cellular phone outside the telephone's normal calling area, exercise caution in relying on the cellular phone to activate 911. When the caller is outside the normal calling area, the cellular service carrier should connect the caller with emergency services in the area where the call originated, but this may not occur. Telephone numbers of backup emergency services should be provided if a cellular phone is relied on to activate 911.

** All spills must be reported to the COMNAVBASE Duty Desk

Hospital: DePaul Medical Center **Address:** 150 Kingsley Lane, Norfolk, VA	**Phone:** (9) 889-5111 or (804) 889-5111 (emergency room)

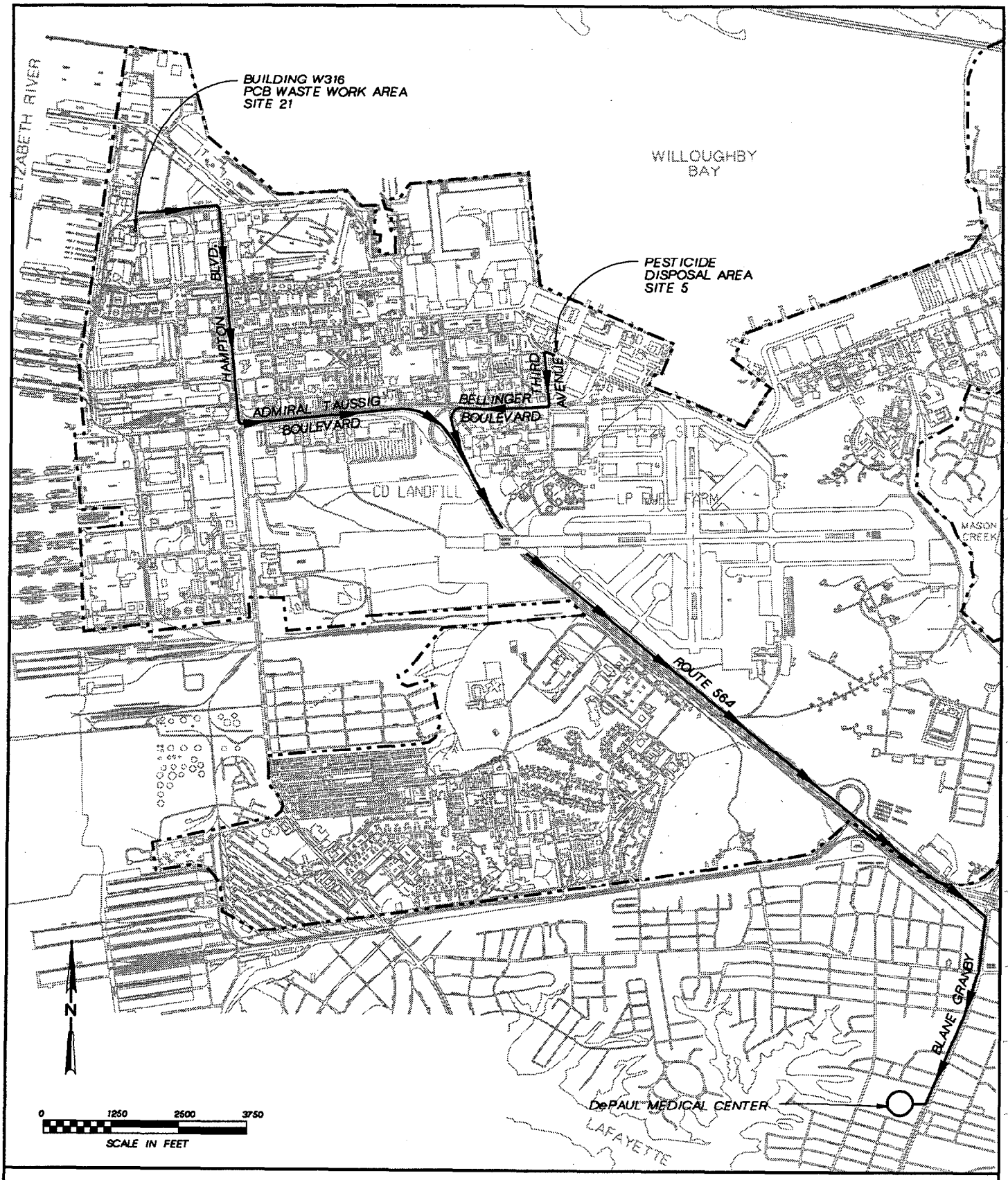
Route to Hospital: (Refer to Figure 12-1) - Depends on location within base area

12.2 GOVERNMENT AGENCIES INVOLVED IN PROJECT

Federal Agency and Contact Name: **Phone:**	Department of the Navy, Atlantic Division Mr. David Forsythe, NTR (804) 322-4783
State Agency and Contact Name: **Phone:**	Not assigned
Local Agency and contact Name: **Phone:**	Not assigned

Contact the project manager. Generally, the project manager will contact relevant government agencies.

WDCR1015/013.DOC



LEGEND

— · · — INSTALLATION PROPERTY BOUNDARY

——— ROUTE TO HOSPITAL

Figure 12-1
ROUTE TO HOSPITAL
Naval Base, Norfolk

CH2M HILL

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13 EMERGENCY CONTACTS

If an injury occurs, notify the injured person's personnel office as soon as possible after obtaining medical attention for the injured person. Notification MUST be made within 24 hours of the injury.

CH2M HILL Medical Consultant

Dr. Elayne F. Theriault
Environmental Medical Resources, Inc.
Atlanta, Georgia
800/229-3674 OR 770/455-0818
(After-hours calls will be returned within 20 minutes.)

Occupational Physician (Regional or Local)

Dr. Laura Staton
46440 Benedict Drive, Suite 108
Sterling, Virginia 22170
(703) 444-5656

Corporate Director Health and Safety

Name: Mollie Netherland/SEA
Phone: 206/453-5005

Site Safety Coordinator (SSC)

Name: Jack Robinson/WDC
Phone: (703) 471-1441

Medical and Training Administrator

Name: Susan Rineholt/COR
Phone: 303/771-0900

Regional Manager

Name: Dick Bedard
Phone: (617) 723-9036

Health and Safety Manager (HSM)

Name: John Longo
Phone: (201) 316-9300

Project Manager

Name: Mike Tilchin
Phone: (703) 471-1441

Radiation Health Manager (RHM)

Name: Frank Petelka/ORO
Phone: 615/483-9032 (H)615/482-8667

Regional Human Resources Department

Name: Michelle Riley-Jones
Phone: (703) 471-1441

Client

Name: David Forsythe, NTR
Phone: (804) 322-4783

Corporate Human Resources Department

Name: Julie Zimmerman/COR
Phone: 303/771-0900

Federal Express Dangerous Goods Shipping

Phone: 800/238-5355

CH2M HILL Emergency Number for Shipping Dangerous Goods

Phone: 800/255-3924

Worker's Compensation and Auto Claims

GAB Business Services, Inc.
Phone: 800/747-7222 After hours 800/621-5410

Report fatalities AND report vehicular accidents involving pedestrians, motorcycles, or more than two cars.

14 APPROVAL

This site-specific health and safety plan has been written for use by CH2M HILL only. CH2M HILL claims no responsibility for its use by others unless that use has been specified and defined in project or contract documents. The plan is written for the specific site conditions, purposes, dates, and personnel specified and must be amended if those conditions change.

14.1 ORIGINAL PLAN

WRITTEN BY: Don Martinson **DATE:** 4-1-96

APPROVED BY: **DATE:** 8/14/96

14.2 REVISIONS

REVISIONS MADE BY: **DATE:**

REVISIONS TO PLAN:

REVISIONS APPROVED BY: **DATE:**

15 DISTRIBUTION

Name	Office	Responsibility	Number of Copies
Jerri McCauslin	COR	Senior Program Assistant	1
John Longo	NJO	Health and Safety Manager/Approver	1
Mike Tilchin	WDC	Project Manager	1
Jack Robinson	WDC	Field Team Leader/Field Team	
Jack Robinson	WDC	Site Safety Coordinator	1
Client	NA	Client Project manager	

16 ATTACHMENTS

Attachment 1: Employee Signoff
Attachment 2: Applicable Material Safety Data Sheets

Attachment 1
Employee Signoff

EMPLOYEE SIGNOFF

The employees listed below have been given a copy of this health and safety plan, have read and understood it, and agree to abide by its provisions.

EMPLOYEE NAME	EMPLOYEE SIGNATURE AND DATE

Attachment 2
Material Safety Data Sheets

APPENDIX B
MATERIAL SAFETY DATA SHEET
TABLE OF CONTENTS

Aluminum Metal/Powder
Antimony Metal/Powder
Arsenic & Compounds
Barium & Compounds
Benzene Hexachloride
Beryllium Metal/Powder
Cadmium
Calcium Metal
Carbon Disulfide
Chlorodane
Chlorobenzene
Chromic Acid & Chromates
Coal Tar Creosote
Copper
DDT
p-Dichlorobenzene
1,1-Dichloroethane
1,2-Dichloroethylene
Dieldrin
2,4-Dinitrotoluene
Iron
Lead (inorganic)
Magnesium (Metal)
Manganese Metal/Powder
Mercury
Methyl Chloroform
Methyl Ethyl Ketone
Methylene Chloride
Nickel Metal
Nitrobenzene
Perchloroethylene
Phenol
PCBs
Picric Acid
Silver
Sodium Metal
Styrene *monomer*
Toluene
Trichloroethylene
Vinylidene Chloride

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Material Safety Data Sheets Collection:

Sheet No. 100
Aluminum Metal/Powder

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

Section 1. Material Identification

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

R	1
I	2
S	2
K	1

NFPA

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

Section 2. Ingredients and Occupational Exposure Limits

Aluminum metal/powder, ca 100%*

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

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

NIOSH REL, 1987
None established

Toxicity Data†
None reported

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

Section 3. Physical Data

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

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

Section 4. Fire and Explosion Data

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

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

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

Section 5. Reactivity Data

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

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Section 6. Health Hazard Data

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

Section 7. Spill, Leak, and Disposal Procedures

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

Section 8. Special Protection Data

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

Section 9. Special Precautions and Comments

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

Transportation Data (49 CFR 172.101)

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

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

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Material Safety Data Sheets Collection:

Sheet No. 70
Antimony Metal/Powder

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

Section 1. Material Identification 30

Antimony Metal/Powder Description: A naturally occurring ore found in sulfides, oxides, complex lead, silver, copper, and mercury sulfides. Prepared in the laboratory by reducing Sb_2O_3 with KCN. Used in manufacturing bullets, bearing metal, hard lead, blackening iron, coating metals, white metal, thermoelectric piles, storage batteries, cable sheaths, type metal, and alloys (Britannia or Babbitt metal). Pure antimony compounds are used as catalysts in organic synthesis, abrasives, plasticizers, pigment, and flameproofing compounds; also used in manufacturing paints, enamels, matches, glass, pharmaceuticals, explosives, and tartar emetic.
Other Designations: Stibium; antimony regulus; Sb; CAS No. 7440-36-0.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide* (Genium ref. 73) for a suppliers list.

R 1
I 3
S 3
K 1

Genium

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

Section 2. Ingredients and Occupational Exposure Limits

Antimony, ca 99%

OSHA PEL	ACGIH TLV, 1989-90	NIOSH REL, 1987*	Toxicity Data†
8-hr TWA: 0.5 mg/m³ (as Sb)	TLV-TWA: 0.5 mg/m³ (as Sb)	10-hr TWA: 0.5 mg/m³	Rat, intraperitoneal, LD_{50}: 100 mg/kg Rat, oral, LD_{50}: 100 mg/kg

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

Section 3. Physical Data

Boiling Point: 2975 °F (1635 °C)
Melting Point: 1166.9 °F (630.5 °C)
Vapor Pressure: 1 mm Hg at 1627 °F (886 °C)
Molecular Weight: 121.76 g/mol
Specific Gravity (H_2O = 1 at 39 °F (4 °C)): 6.68 at 77 °F (25 °C)
Water Solubility: Insoluble
Mohs Hardness: 3.0 to 3.5

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

Section 4. Fire and Explosion Data

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

Extinguishing Media: Dry chemical powder.
Unusual Fire or Explosion Hazards: Antimony bulk metal is combustible in air at *high temperature*. When ignited it burns with a brilliant flame, giving off dense, white antimony trioxide (Sb_2O_3) fumes. When exposed to heat or ignition sources, powdered antimony is a moderate fire and explosion hazard. Particle size and dispersion in air determine reactivity.
Special Fire-fighting Procedures: Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Personal protective clothing and eye protection are essential.

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

Section 5. Reactivity Data

Stability/Polymerization: Antimony metal (bulk) is stable in dry air at room temperature in closed containers. It slowly tarnishes in moist air. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Antimony is not very reactive with cold, dilute acids, but it reacts readily with aqua regia and hot, concentrated sulfuric acid. Powdered antimony* also reacts with hot, concentrated hydrochloric acid (HCl). On contact with acid, it emits toxic antimony trihydride (SbH_3) fumes; electrolysis of acid sulfides and stirred antimony halide yields explosive antimony. Antimony can react vigorously or violently with oxidizing agents such as nitrate salts, halogens, nitric acid, perchloric acids, chlorine trifluoride (ClF_3), potassium permanganate ($KMnO_4$), ammonium nitrate (NH_4NO_3), bromine trinitride (BrN_3), bromine trifluoride (BrF_3), chlorine monoxide (ClO), chlorine trifluoride (ClF_3), potassium nitrate (KNO_3), sodium nitrate ($NaNO_3$), and potassium oxide (K_2O_2).
Conditions to Avoid: Nascent hydrogen can react with Sb, or its alloys with Mg or Zn, to form antimony trihydride, a colorless, highly toxic gas (causing headache, nausea, vomiting, abdominal pain, hemolysis (separation of hemoglobin from red blood corpuscles), hematuria (blood in the urine), and death) with a disagreeable odor (0.1-ppm TLV).
Hazardous Products of Decomposition: Thermal oxidative decomposition of antimony can produce toxic SbH_3 fumes.

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

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Section 6. Health Hazard Data

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

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

Section 8. Special Protection Data

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

Section 9. Special Precautions and Comments

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

Transportation Data (49 CFR 172.102)

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

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

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Material Safety Data Sheets Collection:

Sheet No. 296
Arsenic and Compounds

Issued: 4/90

Section 1. Material Identification

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Arsenic Description: Obtained from flue dust of copper and lead smelters as white arsenic (arsenic trioxide). Reduction with charcoal and sublimation in an N_2 current yields pure arsenic. Metallic arsenic is used for hardening copper, lead, and alloys; as a doping agent in germanium and silicon solid-state products, special solders, and medicine; and to make gallium arsenide for dipoles and other electronic devices. Arsenic compounds are used in manufacturing certain types of glass; in textile printing, tanning, taxidermy, pharmaceuticals, insecticides and fungicides, pigment production, and antifouling paints; and to control sludge formation in lubricating oils. Arsenic trioxide is the source for 97% of all arsenic products.

Other Designations: CAS No. 7440-38-2; arsen; arsenic black; As; gray arsenic; metallic arsenic.

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

R	1
I	4
S	2
K	0

Genium

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

Section 2. Ingredients and Occupational Exposure Limits

Arsenic and soluble compounds, as As

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

ACGIH TLV, 1989-90
TLV-TWA: 0.2 mg/m³

NIOSH REL, 1987
Ceiling: 0.002 mg/m³

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

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

Section 3. Physical Data*

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

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

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

Section 4. Fire and Explosion Data

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

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

Section 5. Reactivity Data

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

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Section 6. Health Hazard Data

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

Section 7. Spill, Leak, and Disposal Procedures

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

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

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

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

Section 8. Special Protection Data

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

Section 9. Special Precautions and Comments

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

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Arsenic, solid	IMO Shipping Name: Arsenic, metallic
DOT Hazard Class: Poison B	IMO Hazard Class: 6.1
ID No.: UN1558	IMO Label: Poison
DOT Label: Poison	IMDG Packaging Group: II
DOT Packaging Requirements: 173.366	ID No.: UN1558
DOT Packaging Exceptions: 173.364	

MSDS Collection References: 7, 26, 38, 53, 73, 85, 87, 88, 89, 100, 103, 109, 123, 124, 126, 127, 130, 136, 138
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Material Safety Data Sheets Collection:

Sheet No. 297
Barium and Compounds

Issued: 4/90

Section 1. Material Identification

31

Barium and Compounds Description: Produced by reducing barium oxide with aluminum or silicon in a vacuum at high temperature. The minerals barite ($BaSO_4$) and witherite ($BaCO_3$) are the primary sources of barium. Used as lubricant for anode rotors in X-ray tubes; a deoxidizer for copper; an extender in paints; a loader for paper, soap, rubber, and linoleum; a carrier for radium; a fire extinguisher for uranium or plutonium fires; a rodenticide; a stabilizer and mold lubricant in the rubber and plastics industries; a flux for magnesium alloys; getter alloys in vacuum tubes; and in spark-plug alloys and Frary's metal. Important barium compounds include carbonate (ceramics, rodenticide), sulfate (pigment and filler), hydroxide (water treatment, ceramics), nitrate (pyrotechnics), chloride (chemicals), chromate (pigments), oxide (lubricants), and peroxide (bleach).

Other Designations: CAS No. 7440-39-3; Ba.

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

R 2
I 3
S 2
K 4

Genium

HMIS
H 2
F 2
R 4
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Barium, ca 100%

OSHA PEL
8-hr TWA: 0.5 mg/m³ (Barium, soluble compounds, as Ba)

NIOSH REL, 1987
None established

Toxicity Data*
None listed

ACGIH TLV, 1989-90
TLV-TWA: 0.5 mg/m³ (Barium, soluble compounds, as Ba)

* Monitor *RTECS* (CQ8370000), for additional future data.

Section 3. Physical Data*

Boiling Point: 2984 °F/1640 °C
Melting Point: 1337 °F/725 °C
Vapor Pressure: 10 mm Hg at 1920 °F/1049 °C
Molecular Weight: 137.33 g/mol
Specific Gravity (H_2O = 1 at 39 °F/4 °C): 3.51 at 68 °F/20 °C
Water Solubility: Insoluble

Appearance and Odor: A silver white metal that is slightly lustrous and somewhat malleable.
Comment: Barium has a distinctive property of absorbing gases.

* Physcial data are for barium only.

Section 4. Fire and Explosion Data

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

Extinguishing Media: *Do not* use water or foam. For small fires, use dry chemical, soda ash, lime, or sand. For large fires, withdraw from area and let fire burn.

Unusual Fire or Explosion Hazards: In the powder form, barium is flammable at room temperature. It is also explosive in the form of dust when exposed to heat, flame, or by chemical reaction. The chlorate, peroxide, and nitrate compounds are reactive and may present fire hazards in storage and use.

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

Section 5. Reactivity Data

Stability/Polymerization: Barium is stable at room temperature under special storage and handling conditions (Sec. 9). If the free metal is exposed to air, an explosion hazard exists because hydrogen is liberated. Barium compounds are more stable than elemental barium. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Barium reacts violently with water, carbon tetrachloride, trichloroethylene, fluorotrichloromethane, and tetrachloroethylene. This material is incompatible with acids, trichloroethylene and water, trichlorotrifluoroethane, 1,1,2-trichloro trifluoro ethane, and flurotrichloroethane. Barium is extremely reactive and reacts readily with halogens and ammonia. Barium compounds are not as reactive as elemental barium. See MSDSs 40, 119, 132, 173, 181, and 251 for specific chemical incompatibilities.

Conditions to Avoid: Avoid heating barium in hydrogen to about 392 °F/200 °C since it reacts violently and forms barium hydride (BaH_2). An explosion hazard exists if the free metal is exposed to moist air or cold water because hydrogen is liberated.

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Section 6. Health Hazard Data

Carcinogenicity: Although the NTP, IARC, and OSHA do not list barium as a carcinogen, the IARC lists barium chromate (VI) as a carcinogen.
Summary of Risks: Barium presents mainly an explosion hazard. However, soluble compounds of barium by the oral route are highly toxic and the fatal dose of the chloride has been stated to be 0.8 to 0.9 g. Death may occur from a few hours to a few days. The soluble barium compounds exert a profound effect on skeletal, arterial, intestinal, bronchial, and particularly cardiac muscle. Effects on the hematopoietic system (responsible for the formation of blood or blood cells in the living body) and the cerebral cortex are also noted. Poisoning may also occur if the dust of soluble compounds is inhaled. Certain compounds of barium are irritants of the skin, eyes, and mucous membranes. Barium oxide and barium hydroxide, strongly alkaline in aqueous solution, cause severe skin irritation and burns of the eye. Inhalation of insoluble barium produces a benign pneumoconiosis (baritosis). The half-life of barium in bone has been estimated at 50 days.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Skin, eyes, mucous membranes, lung, heart.
Primary Entry Routes: Inhalation of dust or fume, ingestion, skin or eye contact.
Acute Effects: Systemic absorption from ingestion causes gastroenteritis (inflammation of the stomach lining and the intestines), slow pulse rate (heart may stop while contracting), muscle spasm, and hypokalemia (potassium deficiency in the blood). Inhalation causes coughing, bronchial irritation, and pneumoconiosis. Contact with soluble salts causes dermatitis, irritation of the eyes and mucous membranes, and burns. During radiological examination, intraperitoneal (in the abdomen) or intrathoracic (in the chest) barium sulfate contamination resulting from a complication rupture may cause a significant inflammatory response.
Chronic Effects: Although baritosis (caused by inhaling barium sulfate) produces nodular opacities on chest X-rays, there is no evidence of clinical illness or bodily dysfunction.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have a *conscious* person drink 1 to 2 glasses of water, then induce vomiting.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Consider using calcium gluconate for muscular spasms. Consider gastic lavage followed by saline catharsis if soluble barium compounds are ingested. Institute cardiac monitoring for all significant ingestions of soluble barium salts.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel of spill. Immediately shut off all heat and ignition sources and evacuate hazard area. Cleanup personnel should protect against dust inhalation and contact with skin, eyes, and mucous membranes. For small dry spills, use a clean shovel to place material into a clean, dry container with a cover. For a large dry spill, cover with a plastic sheet to minimize spreading. For liquid spills, cover with sand or other noncombustible material and place in disposal containers. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations*
RCRA Hazardous Waste (40 CFR 261.33): Not listed
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

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

*Designations for barium only.

Section 8. Special Protection Data

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

Section 9. Special Precautions and Comments

Storage Requirements: Store under inert gas, petroleum, or oxygen-free liquid in a cool, dry, well-ventilated area away from all incompatibles (Sec. 5).
Engineering Controls: Barium metal itself presents mainly an explosion hazard. All engineering systems should be of maximum explosion-proof design and electrically grounded and bonded. Use nonsparking tools. Proper storage is essential. Avoid dust inhalation and skin, eye, and mucous membrane contact. All processes should be enclosed and/or exhaust ventilation installed to keep the dust concentrations below the recommended levels. Practice good personal hygiene and housekeeping procedures. Preemployment and periodic medical examinations should be given to workers exposed to barite dust. Prevent exposing individuals with respiratory disorders.

Transportation Data (49 CFR 172.102)
IMO Shipping Name: Barium alloys, pyrophoric
IMO Hazard Class: 4.2
IMO Label: Spontaneously combustible
IMDG Packaging Group: II
ID No.: UN1854

MSDS Collection References: 7, 26, 38, 73, 85, 87, 89, 100, 103, 109, 123, 124, 126, 127, 133, 136, 138, 139
Prepared by: MJ Allison, BS; Industrial Hygiene Review: DJ Wilson, CIH; Medical Review: W Silverman, MD

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BENZENE HEXACHLORIDE

BHC

Common Synonyms
1, 2, 3, 4, 5, 6-Hexachlorocyclohexane
Lindane
BHC
Gammexane
Tri-6

Solid crystals or powder, or solution — Solid is light to dark brown — Musty odor

Solid sinks in water. Solution generally floats on water.

Avoid contact with liquid and solid. Keep people away
Wear goggles and self-contained breathing apparatus
Stop discharge if possible
Call fire department
Stay upwind and use water spray to "knock down" vapor
Isolate and remove discharges material
Notify local health and pollution control agencies.

Fire

Solid not flammable, but usually dissolved in combustible liquid.
POISONOUS GASES ARE PRODUCED WHEN SOLID IS HEATED OR WHEN SOLUTION BURNS.
Wear goggles and self-contained breathing apparatus.
Extinguish with foam, dry chemical, or carbon dioxide

Exposure

CALL FOR MEDICAL AID.

SOLID OR SOLUTION
POISONOUS IF SWALLOWED.
Irritating to skin and eyes.
Remove contaminated clothing and shoes
Flush affected areas with plenty of water
IF IN EYES, hold eyelids open and flush with plenty of water
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk

Water Pollution

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

Notify local health and pollution control officials.
Notify operators of nearby water intakes

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)
Issue warning-water contaminant, poison
Should be removed
Chemical and physical treatment

2. LABEL

2.1 Category: None
2.2 Class: Not pertinent

3. CHEMICAL DESIGNATIONS

3.1 CG Compatibility Class: Not listed
3.2 Formula: $C_6H_6Cl_6$
3.3 IMO/UN Designation: 6.1/2761
3.4 DOT ID No.: 2761
3.5 CAS Registry No.: 58-89-9

4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (as shipped): Solid
4.2 Color: Light tan to dark brown
4.3 Odor: Characteristic

5. HEALTH HAZARDS

5.1 Personal Protective Equipment: Data not available
5.2 Symptoms Following Exposure: Hyperirritability and central nervous excitation: notably vomiting, restlessness, muscle spasms, ataxia, and clonic and tonic convulsions. Subsequent central nervous depression leading to respiratory failure. Occasional dermatitis and urticaria.
5.3 Treatment of Exposure: Gastric lavage and saline catharics (not oil laxatives because they promote absorption). Sedatives: pentobarbital or phenobarbital in amounts adequate to control convulsions. Calcium gluconate intravenously may be used in conjunction with sedatives to control convulsions. Rest and quiet. Do NOT use epinephrine because ventricular fibrillation may result.
5.4 Threshold Limit Value: 0.5 mg/m³
5.5 Short Term Inhalation Limits: 1 mg/m³ for 30 min.
5.6 Toxicity by Ingestion: Gamma isomer (Lindane): Grade 3: LD_{50} 50 to 500 mg/kg (rat) Technical mixture: Grade 2: LD_{50} 0.5 to 5 g/kg
5.7 Late Toxicity: Mutagen to human lymphocytes.
5.8 Vapor (Gas) Irritant Characteristics: Moderately irritating. Personnel will not usually tolerate moderate or high concentrations.
5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.
5.10 Odor Threshold: Data not available
5.11 IDLH Value: 1,000 mg/m³

6. FIRE HAZARDS

6.1 Flash Point: Not flammable
6.2 Flammable Limits in Air: Not flammable
6.3 Fire Extinguishing Agents: Not pertinent
6.4 Fire Extinguishing Agents Not to be Used: Not pertinent
6.5 Special Hazards of Combustion Products: Toxic gases are generated when solid is heated or when solution burns.
6.6 Behavior in Fire: Not pertinent
6.7 Ignition Temperature: Not flammable
6.8 Electrical Hazard: Not pertinent
6.9 Burning Rate: Not flammable
6.10 Adiabatic Flame Temperature: Data not available
6.11 Stoichiometric Air to Fuel Ratio: Data not available
6.12 Flame Temperature: Data not available

7. CHEMICAL REACTIVITY

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

8. WATER POLLUTION

8.1 Aquatic Toxicity:
0.77 ppm/96 hr/bluegill/TL$_m$/fresh water
0.136 ppm/96 hr/guppy/TL$_m$/fresh water
0.034 ppm/10 hr/coho fry/100% lethal/salt water
8.2 Waterfowl Toxicity: 2000 mg/kg
8.3 Biological Oxygen Demand (BOD): Data not available
8.4 Food Chain Concentration Potential: High

9. SHIPPING INFORMATION

9.1 Grades of Purity: Technical grade: 40-45% gamma isomer Lindane: pure gamma isomer
9.2 Storage Temperature: Data not available
9.3 Inert Atmosphere: Data not available
9.4 Venting: Data not available

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)
II

11. HAZARD CLASSIFICATIONS

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

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 Physical State at 15°C and 1 atm: Solid
12.2 Molecular Weight: 290.83
12.3 Boiling Point at 1 atm: Not pertinent
12.4 Freezing Point: Not pertinent
12.5 Critical Temperature: Not pertinent
12.6 Critical Pressure: Not pertinent
12.7 Specific Gravity: 1.891 at 15°C (solid)
12.8 Liquid Surface Tension: Not pertinent
12.9 Liquid Water Interfacial Tension: Not pertinent
12.10 Vapor (Gas) Specific Gravity: Not pertinent
12.11 Ratio of Specific Heats of Vapor (Gas): Not pertinent
12.12 Latent Heat of Vaporization: Not pertinent
12.13 Heat of Combustion: Not pertinent
12.14 Heat of Decomposition: Not pertinent
12.15 Heat of Solution: Not pertinent
12.16 Heat of Polymerization: Not pertinent
12.25 Heat of Fusion: Data not available
12.26 Limiting Value: Data not available
12.27 Reid Vapor Pressure: Data not available

NOTES

BHC	BENZENE HEXACHLORIDE

12.17 SATURATED LIQUID DENSITY		12.18 LIQUID HEAT CAPACITY		12.19 LIQUID THERMAL CONDUCTIVITY		12.20 LIQUID VISCOSITY	
Temperature (degrees F)	Pounds per cubic foot	Temperature (degrees F)	British thermal unit per pound-F	Temperature (degrees F)	British thermal unit-inch per hour-square foot-F	Temperature (degrees F)	Centipoise
	NOT PERTINENT		NOT PERTINENT		NOT PERTINENT		NOT PERTINENT

12.21 SOLUBILITY IN WATER		12.22 SATURATED VAPOR PRESSURE		12.23 SATURATED VAPOR DENSITY		12.24 IDEAL GAS HEAT CAPACITY	
Temperature (degrees F)	Pounds per 100 pounds of water	Temperature (degrees F)	Pounds per square inch	Temperature (degrees F)	Pounds per cubic foot	Temperature (degrees F)	British thermal unit per pound-F
68.02	.001		NOT PERTINENT		NOT PERTINENT		NOT PERTINENT

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Material Safety Data Sheets Collection:

Sheet No. 59
Beryllium Metal/Powder

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

Section 1. Material Identification 30

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

R 1
I 4
S 2
K 1

Genium

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

Section 2. Ingredients and Occupational Exposure Limits

Beryllium and compounds, ca 100%

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

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

Section 3. Physical Data

Boiling Point: 5378 °F (2970 °C)
Melting Point: 2332 °F (1278 °C)
Vapor Pressure: 7.6 mm Hg at 3470 °F (1910 °C)
Atomic Weight: 9.01 g/mol
Specific Gravity (H_2O = 1 at 39 °F (4 °C)): 1.848 at 68 °F (20 °C)
Water Solubility, hot water: Slight
cold water: Insoluble

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

Section 4. Fire and Explosion Data

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

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

Section 5. Reactivity Data

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

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

Section 6. Health Hazard Data

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

Continue on next page

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Section 6. Health Hazard Data, continued

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

FIRST AID

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

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

Section 7. Spill, Leak, and Disposal Procedures

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

OSHA Designations

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

EPA Designations

RCRA Hazardous Waste (40 CFR 261.33): Not listed

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

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

SARA Toxic Chemical (40 CFR 372.65): Not listed

Section 8. Special Protection Data

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

Section 9. Special Precautions and Comments

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

Transportation Data (49 CFR 172.101, .102)

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

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

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

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

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Material Safety Data Sheet

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GENIUM PUBLISHING CORP.

No. 23

CADMIUM
(Revision C)
Issued: September 1977
Revised: November 1988

SECTION 1. MATERIAL IDENTIFICATION

27

Material Name: CADMIUM

Description (Origin/Uses): Used in electroplating other metals; in dentistry; in alloys; in nickel-cadmium batteries; and in reactor control rods.

Other Designations: Cd; CAS No. 7440-43-9

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

Genium

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

SECTION 2. INGREDIENTS AND HAZARDS, EXPOSURE LIMITS

Cadmium, CAS No. 7440-43-9, ca 100%

OSHA PEL
8-Hr TWA: 0.1 mg/m³ (Cd Fume)
Ceiling: 0.3 mg/m³ (Cd Fume)
8-Hr TWA: 0.2 mg/m³ (Cd Dust)
Ceiling: 0.6 mg/m³ (Cd Dust)

ACGIH NIC,* 1988-89
TLV-TWA: 0.01 mg/m³ (Cadmium and Compounds, as Cd)
ACGIH A2, Suspected Human Carcinogen

ACGIH TLVs, 1988-89
TLV-TWA: 0.05 mg/m³ (Cadmium Dusts and Salts, as Cd)
TLV-Ceiling: 0.05 mg/m³ (Cadmium Oxide Fume, as Cd)
TLV-TWA: 0.05 mg/m³ (Cadmium Oxide Production)

Toxicity Data**
Human, Inhalation, LC_{Lo}: 39 mg/m³ (20 Minutes)

*Notice of Intended Changes, Genium reference 116, p. 39.
**See NIOSH, *RTECS* (EU9800000), for additional data referring to reproductive, tumorigenic, and mutagenic effects.

SECTION 3. PHYSICAL DATA

Boiling Point: 1413°F (767°C)
Melting Point: 610°F (321°C)
Vapor Pressure: 0.095 Torr at 610°F (321°C)
Molecular Weight: 112 Grams/Mole
Solubility in Water (%): Insoluble
Specific Gravity (H_2O = 1): 8.642

Appearance and Odor: A soft, blue white, malleable, lustrous metal that can be cut easily with a knife; odorless.
Comments: Cadmium has a significant vapor pressure of 0.000021 torr (corresponding to 0.12 mg/m³) at 315°F (157°C). Heating this metal without using correct engineering controls and/or personal protective equipment can result in overexposure.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method*	Autoignition Temperature*	LEL*	UEL*

Extinguishing Media: *Cadmium metal burns readily in air if it is heated. As with most metals, the reactivity/dust-cloud-explosion hazard increases as the cadmium metal becomes more finely divided. In fact, finely divided, powdered cadmium metal can be pyrophoric (it burns spontaneously in air without any source of ignition). Carbon dioxide, dry chemical, or sand are recommended extinguishing agents for cadmium fires. **Unusual Fire or Explosion Hazards:** Cadmium dust can explode during a fire. Massive cadmium metal does not present this potential explosion hazard; however, certain work operations such as grinding, welding, or cutting, can produce dust made of finely divided cadmium particles. **Warning:** Do not create a dust cloud of cadmium particles, especially during cutting, grinding, or welding operations. **Special Fire-fighting Procedures:** Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode.

SECTION 5. REACTIVITY DATA

Stability/Polymerization: Cadmium is stable in closed containers during routine operations. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Cadmium reacts dangerously with ammonium nitrate, hydrazoic acid, tellurium, and zinc (Genium ref. 84). **Conditions to Avoid:** Avoid all exposure to sources of ignition and to incompatible chemicals. **Hazardous Products of Decomposition:** When heated, which is likely during fires and work operations such as welding and machining, cadmium metal can decompose into cadmium metal fume and cadmium oxide fume.

SECTION 6. HEALTH HAZARD INFORMATION

Carcinogenicity: The ACGIH classifies cadmium and its compounds as suspected human carcinogens (group A2); the IARC lists them as probable human carcinogens (group 2B); and the NTP classifies them as anticipated human carcinogens (group b). **Summary of Risks:** Heating cadmium metal produces intensely irritating cadmium metal fume. The acute effects of its excessive inhalation, which include severe tracheobronchitis, pneumonitis, and pulmonary edema, are life threatening and are usually delayed for several hours; their mortality rate is about 20%. Nonfatal pneumonitis has resulted from exposure to 0.5 to 2.5 mg/m³; a fatality has been reported for five hours' exposure at 9 mg/m³ and for 1 hour's exposure at 40 to 50 mg/m³. There is no warning discomfort or immediate irritation from exposure to cadmium fume. Acute gastroenteritis and symptoms of metal fume fever are associated with even lower acute exposure. Symptoms of acute overexposure include excessive salivation, a dry, burning throat; headache; aching muscles; coughing; chest tightness and pain; nausea; chills, and fever chills; and fever. **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Skin, eyes, respiratory system, kidneys, and blood. **Primary Entry:** Inhalation, skin contact. **Acute Effects:** See Summary of Risks, above. **Chronic Effects:** Long-term, chronic inhalation of cadmium dust, salts, or fume causes chronic cadmium poisoning characterized by a distinctive, nonhypertrophic emphysema with or without renal tubular injury, accompanied by the urinary excretion of a protein with a molecular weight

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SECTION 6. HEALTH HAZARD INFORMATION, cont.

of 20,000 to 30,000. This protein is itself a sign of early but reversible chronic poisoning. (Possible chromosomal aberrations and decreased birth weight among babies of women exposed to cadmium have been noted.) **Danger:** Continued overexposure from inhalation causes irreversible renal tubular damage. Cancer, anemia, eosinophilia, anosmia, chronic rhinitis, yellowed teeth, and bone changes have been reported. Bone pain in the ribs, backbone, and femur is common; disorders of calcium metabolism develop; and kidney stones and pulmonary fibrosis have been described. **FIRST AID: Eyes.** Immediately flush eyes, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 minutes. **Skin.** Rinse the affected area with flooding amounts of water, then wash it with soap and water. **Inhalation.** Remove the exposed person to fresh air; restore and/or support his or her breathing as needed. Have qualified medical personnel administer oxygen as required. **Ingestion.** If a physician is not readily available, give the exposed person 2 to 3 glasses of water to drink and induce vomiting. A physician may administer a gastric lavage followed by saline catharsis. **Comments:** A comprehensive medical program is advised for those who work with cadmium or its compounds. This should include chest X rays and forced-vital-capacity tests. Get medical help (in plant, paramedic, community) for all exposures. Seek prompt medical assistance for further treatment, observation, and support after first aid. **Note to Physician:** Chelation therapy may be useful in treatment; calcium disodium edetate and pencillamine are recommended. Dimercaprol (BAL) is not recommended because of reported renal toxicity of the cadmium-BAL complex.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, evacuate unnecessary personnel, eliminate all sources of ignition immediately, and provide adequate ventilation. Cleanup procedures must not create dusty conditions. Pick up the spilled material using vacuuming, mopping, or wet-sweeping techniques. Cleanup personnel need protection against inhalation of dust and fume (see sect. 8). **Waste Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations. Concentrated solutions of cadmium waste can be precipitated with lime and collected by filtration. Effluent should be treated as needed to reduce the concentration of the cadmium to a level that is within regulatory compliance limits.

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000 Subpart Z).
EPA Designations (40 CFR 302.4)
RCRA Hazardous Waste, No. D006 (40 CFR 261.24 [Characteristic of EP toxicity])
CERCLA Hazardous Substance, Reportable Quantity: 1 lb (0.454 kg), per the Clean Water Act (CWA), § 307 (a).

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing of a cadmium solution is possible, wear a full face shield. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Use a NIOSH-approved respirator per Genium reference 88 for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (spills or cleaning reactor vessels and storage tanks), wear an SCBA. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, and gauntlets, to prevent prolonged or repeated skin contact with this material. **Ventilation:** Install and operate general and local maximum explosion-proof ventilation systems powerful enough to maintain airborne levels of cadmium below the OSHA PEL cited in section 2. Local exhaust ventilation is preferred because it prevents dispersion of the contaminant into the general work area by eliminating it at its source. Consult the latest edition of Genium reference 103 for detailed recommnedations. **Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work areas. **Contaminated Equipment:** Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Do *not* wear contact lenses in any work area. Remove contaminated clothing and launder it before wearing it again; clean this material from your shoes and equipment. Do not wear work clothes home. **Comments:** Practice good personal hygiene; always wash thoroughly after using this material and before eating, drinking, smoking, using the toilet, or applying cosmetics. Keep it off your clothing and equipment. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do *not* eat, drink, or smoke in any work area. Do not inhale cadmium fume. Do not expose individuals with lung, liver, kidney, and blood ailments to cadmium until such exposure is approved by a physician.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store cadmium in closed containers in a cool, dry, well-ventilated area away from sources of ignition and strong oxidizers. Protect containers from physical damage. Avoid storage situations where corrosion can occur. Keep powdered cadmium in closed containers; prevent the airborne dispersion of powdered cadmium. **Engineering Controls:** Make sure all engineering systems (production, transportation) are of maximum explosion-proof design. Ground and bond all containers, pipelines, etc., used in shipping, transferring, reacting, producing, and sampling operations to prevent static sparks. **Other Precautions:** The toxic effects of cadmium are influenced by the presence or absence of other elements such as zinc and selenium. If these materials are present in the workplace, careful evaluation of any exposure to cadmium is required to understand any contributing factors.

Hazardous Materials Table (49 CFR 172.101): Not Listed
Optional Hazardous Materials Table (49 CFR 172.102)

ID No. UN2570

IMO Shipping Name: Cadmium Compounds
IMO Hazard Class: 6.1
IMO Labels: Poison or Saint Andrew's Cross (X)*

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

References: 1, 26, 38, 84-94, 100, 116, 117, 120, 122.

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Material Safety Data Sheet

From Genium's Reference Collection
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GENIUM PUBLISHING CORP.

No. 221

CALCIUM METAL

Issued: November 1987

SECTION 1. MATERIAL IDENTIFICATION

Material Name: CALCIUM METAL

Description (Origin/Uses): Produced by electrolysis of calcium chloride. Used in alloys of aluminum, copper, and lead.

Other Designations: Calcicat; Calcium; Ca; NIOSH *RTECS* No. EV8040000; CAS No. 7440-70-2

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

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

SECTION 2. INGREDIENTS AND HAZARDS

SECTION 2. INGREDIENTS AND HAZARDS	%	EXPOSURE LIMITS
Calcium Metal, CAS No. 7440-70-2 Calcium plus water yields calcium hydroxide, $Ca(OH)_2$, having the CAS No. 1305-62-0 and the NIOSH *RTECS* No. EW2800000 with the following data: ACGIH TLV, 1987-88 TLV-TWA: 5 mg/m³	100	Element Calcium: No Exposure Limits Established Artificial Isotopes: ^{45}Ca and ^{47}Ca pose a radiation hazard; they emit gamma radiation.

SECTION 3. PHYSICAL DATA

Boiling Point: 2703°F (1484°C)
Water Solubility: Reacts Violently with Water*
Specific Gravity (H_2O = 1): 1.5
Melting Point: 1542°F (839°C)
Molecular Weight: 40.08 Grams/Mole
pH: Water Solution Alkaline (pH >7)

*Soluble in water forming the hydroxide; soluble in acids forming salts.

Appearance and Odor: Silver-white, crystalline, lustrous metal; tarnishes to blue-gray-white on exposure to air. Odorless.

Comments: Calcium metal is soluble in alcohol, ammonia, and dilute acids.

SECTION 4. FIRE AND EXPLOSION DATA

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

Extinguishing Media: Do *not* use water, foam, or halogenated hydrocarbons such as Halon® or carbon tetrachloride to extinguish fires involving calcium metal. Carbon dioxide and dry chemical are ineffective. Use only graphite powder, soda ash, powdered sodium chloride, or an appropriate metal-fire-extinguishing dry powder such as Met-L-X®. For large fires, withdraw from the area and let the fire burn (see Genium ref. 85). **Unusual Fire/Explosion Hazards:** Calcium metal is a flammable solid. It is extremely dangerous when wet; keep it dry. This material forms calcium hydroxide and hydrogen gas (explosion hazard) when wet. It may form toxic fumes of calcium oxide. This substance can also develop explosive pressures in closed containers. It reacts with wet extinguishing agents (water, alcohol, halogens, and possibly carbon dioxide). Its contact with alkali hydroxides or carbonates may result in detonation. **Special Fire-fighting Procedures:** Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Fire fighters should move containers from the fire area if this can be done without risk. Do not use water or foam! Use dry powders only. Fire fighters should wear full protective gear. This kind of fire may produce irritating or poisonous gases. **Comments:** Finely divided calcium metal particles may ignite spontaneously in air or oxygen at room temperature. Fires may reignite after they have been extinguished. Runoff of waste material into a sewer or drain may create an additional fire or explosion hazard.

SECTION 5. REACTIVITY DATA

Calcium metal is not stable. Hazardous polymerization is not known to occur.

Chemical Incompatibilities: Hazardous reactions involving this material occur with air, moist air, water, acids, strong oxidizing agents, alcohols, and halogens. Contact with alkali hydroxides or carbonates may cause detonation.

Conditions to Avoid: This material may ignite spontaneously if exposed to air or kept in the presence of moisture. Store in airtight containers or under oil (see sect. 9). Calcium metal can develop explosive pressures in containers; keep them dry at all times.

Hazardous Products of Decomposition: Toxic calcium oxide fumes, which can react with water to produce heat, calcium hydroxide (corrosive), and flammable hydrogen gas (explosion hazard).

Comments: Calcium metal reacts with water considerably less than sodium metal does.

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SECTION 6. HEALTH HAZARD INFORMATION

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

Summary of Risks: This material is harmful or fatal if swallowed; inhaled as a mist (calcium hydroxide), dust, or fume; or absorbed through the skin or mucous membranes. Solid calcium metal will cause skin and eye burns because it reacts with moisture to form corrosive calcium hydroxide. Fumes from burning calcium metal (calcium oxide) are highly irritating to skin, eyes, and mucous membranes, including the upper respiratory tract. **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Eyes, skin, mucous membranes (upper respiratory tract). **Primary Entry:** Inhalation, ingestion, skin and eye contact. **Acute Effects:** Corrosive and irritating to body tissue. May cause skin burns and corneal damage. Inhalation of dust or fume may cause respiratory irritation, cough, difficulty in breathing (dyspnea), and chemical pneumonitis. **Chronic Effects:** Prolonged inhalation of dust or fume may cause severe mucous membrane irritation, chemical pneumonitis.

FIRST AID: Eye Contact. Flush eyes, including under the eyelids, promptly and gently with plenty of running water for 15 minutes. If burns are present seek medical help immediately. **Skin Contact.** Remove calcium metal-contaminated material immediately with a dry cloth. Wash with large amounts of water until all of the chemical is removed. In case of chemical burn, treat as indicated. **Inhalation.** Remove victim to fresh air; restore and/or support his breathing as needed. Keep him warm and at rest. **Ingestion.** If swallowed, and victim is conscious, give him large amounts of water to dilute the alkali. Do not induce vomiting. A gastric lavage can be used by trained staff. Never give anything by mouth to someone who is unconscious.

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Do not touch spilled calcium metal. Wear protective apparel. Do not smoke or place flame or ignition sources near a spill area. Do not allow water to touch spilled material or to get inside containers. Use a cover (plastic sheet) to prevent water or rain from dissolving spilled material or to prevent its spreading. Isolate hazard area and keep nonessential personnel away from spill or leak site. Shovel small dry spills into a dry container and cover it tightly. Move containers away from spill to a safe area. Take up small spills with sand or an absorbent material and contain it as described above. Dike the flow of large calcium metal and water spills with soil, sandbags, or concrete. Keep the waste from entering drains or open sewers. Wear fully protective gear.

Waste Disposal: You may dilute residual spilled material with water jets. Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations
Air Contaminant (20 CFR 1910.1000 Subpart Z): Not Listed
EPA Designations (40 CFR 302.4)
RCRA Hazardous Waste, No. D003 (Reactivity)
CERCLA Hazardous Substance: Not Listed

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Follow the eye- and face-protection guidelines of 29 CFR 1910.133. Wear chemical splash-proof and dust-resistant safety goggles and/or a faceshield (8" minimum) with approved safety glasses to prevent eye and face contact with calcium metal.

Gloves: Wear appropriate, heavy-duty, chemical-resistant gloves. **Respirator:** Where uncomfortable or nuisance levels of calcium metal dust exist, a dust/mist respirator can be used. Where high levels of calcium metal dust or fume or calcium hydroxide, calcium oxide, or hydrogen may exist (as in a fire situation or spill), use only an SCBA with a full facepiece operated in the pressure-demand or positive-pressure mode.

Special Considerations: Wear protective clothing; a rubber apron may be appropriate for the particular work situation.

Ventilation: Work with this material only under a chemical fume hood with localized ventilation or where general dilution ventilation is adequate.

Safety Stations: Make eyewash stations, washing facilities, and safety showers available in areas of use and handling because calcium metal is corrosive to eyes and body tissue.

Contaminated Equipment: Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Particles may cling to contact lens surfaces, causing corneal injury.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage Segregation: Store calcium metal away from sources of heat, ignition (sparks and open flame), water, combustible material, acids, halogens, alcohols, and other liquid chemicals. Store it away from oxidizers.

Special Handling/Storage: Protect containers against physical damage. Store this material in airtight containers under an inert atmosphere such as nitrogen or argon or under liquid hydrocarbons (naphtha, kerosene, or coal oil). *Never store it under halogenated hydrocarbons* such as Freon®. Avoid high temperatures. An isolated, well-ventilated, fire-resistant building is recommended for large-quantity storage. Do not store material near automatic water sprinklers or where water or steam is present. Provide enough heat in the storage area to keep material sufficiently dry. **Comments:** Calcium metal is air sensitive. Keep it in tightly closed containers at all times when not in use. Remove only the amount of calcium metal from its storage container that is immediately necessary. Use a metal container with a tightly fitting lid or well-stoppered glass bottles for storage and transport. Scrupulously avoid water contamination of storage tanks, reactor vessels, testing areas, etc.

Transportation Data (49 CFR 172.101-2)

DOT Hazard Class: Flammable Solid	DOT Shipping Name: Calcium Metal	DOT ID No. UN1401
DOT Label: Flammable Solid; Dangerous When Wet	IMO Label: Dangerous When Wet	IMO Class: 4.3

Additional DOT Requirements: Keep Cold and Dry. Segregation is the same as for flammable solids labeled Dangerous When Wet.

References: 1-11, 12, 18, 24, 37, 39, 44, 73, 82, 84, 87-94. OW/PJI

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Indust. Hygiene/Safety
Medical Review

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Material Safety Data Sheets Collection:

Sheet No. 350
Carbon Disulfide

Issued 11/77 Revision: D, 3/92

Section 1. Material Identification

37

Carbon Disulfide (CS_2) Description: Prepared industrially by heating charcoal with vaporized sulfur or by reaction of natural petroleum fractions with sulfur. Used in manufacturing soil disinfectants, electronic vacuum tubes, viscose rayon, cellophane, flotation agents, ammonium salts and carbon tetrachloride; in insecticides, chemical analysis, electroplating, fumigation, oil extraction, dry cleaning and degreasing; and as a solvent for lipids, sulfur, rubber, oils, resin and waxes.
Other Designations: CAS No. 75-15-0, carbon bisulfide, dithiocarbonic anhydride, sulphocarbonic anhydride, Weeviltox.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.
Cautions: Carbon disulfide is a highly flammable, dangerous explosion hazard. It is irritating to eyes, skin, and mucous membranes, and toxic to the central nervous (CNS), peripheral nervous (PNS), and cardiovascular (CVS) systems.

‡ The NFPA health rating of "2" is misleading due to the severity of this material's toxicity to the CNS, CVS, and PNS and its chronic effects. A "3" is more appropriate.

HMIS
H 3*
F 4
R 0
PPG†
* Sec. 6, Chronic Effects
† Sec. 8

NFPA‡
4 / 2 / 0 / —
R 1
I 4
S 3§
K 4
§Skin absorption

Section 2. Ingredients and Occupational Exposure Limits

Carbon disulfide, ca 99% (major impurities are sulfur compounds)

1990 OSHA PELs (Skin)
8-hr TWA: 4 ppm (12 mg/m³)
15-min STEL: 12 ppm (36 mg/m³)

1990 NIOSH RELs
TWA: 1 ppm (10 mg/m³)
STEL: 10 ppm (30 mg/m³)

1990 IDLH Level
500 ppm

1991-92 ACGIH TLV (Skin)
TWA: 10 ppm (31 mg/m³)

1990 DFG (Germany) MAKs
TWA: 10 ppm (30 mg/m³)
Peak Exposure Limit: 20 ppm/30 min /4 x/shift, momentary value
Half-life: <2 hr

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 40 mg/m³/91 weeks produced paternal effects (spermatogenesis)
Human, inhalation, LC_{Lo}: 2000 ppm/5 min; no toxic effects noted
Human, oral, LD_{Lo}: 14 mg/kg; toxic effects not yet reviewed
Rat, oral, LD_{50}: 3188 mg/kg

* See NIOSH, *RTECS* (FF6650000), for additional mutation, reproductive and toxicity data.

Section 3. Physical Data

Boiling Point: 115 °F (46.5 °C)
Freezing Point: -168 °F (-110.8 °C)
Vapor Pressure: 300 mm Hg at 68 °F (20 °C)
Vapor Density (air = 1): 2.64
Coefficient of Viscosity: 0.363 at 68 °F (20 °C)
Molecular Weight: 76.13
Specific Gravity: 1.2632 at 68 °F (20 °C)
Water Solubility: Slightly, 220 mg/100 cc water at 71.6 °F (22 °C)
Other Solubilities: Soluble in alcohol, benzene and ether
Refraction Index: 1.66232 at 77 °F (25 °C)

Appearance and Odor: Clear, colorless to slightly yellow liquid with a sweet, chloroform-like odor when pure and a foul, rotten egg smell as the commercial product. The odor threshold is 0.1 to 0.2 ppm.
Comments: From both health effect and fire/explosion perspectives, this liquid's very high vapor pressure at room temperature indicates that airborne concentrations can build quickly to dangerous levels. Take precautions to ensure safety (Sec. 8).

Section 4. Fire and Explosion Data

Flash Point: -22 °F (-30 °C), CC	Autoignition Temperature: 194 °F (90 °C)	LEL: 1.5% v/v	UEL: 50% v/v

Extinguishing Media: Foams are more effective in carbon disulfide fires than previously believed, when water and dry chemical were the preferred extinguishing agents. Four foams tested are listed in order of increasing effectiveness: high-expansion, aqueous film-forming, fluoroprotein, and protein. If foam is unavailable, rely on carbon dioxide (CO_2) or water spray. Do not scatter material with more water than necessary to put out fire.
Unusual Fire or Explosion Hazards: Carbon disulfide's burning rate is 2.7 mm/min. Vapor may travel to an ignition source and flash back. Container may explode in heat of fire. CS_2 poses a vapor explosion hazard indoors, outdoors, and in sewers. Carbon disulfide can be ignited by friction, rusted or hot steam pipes, and may accumulate static electricity. Heat from an ordinary light bulb is enough to cause ignition.
Special Fire-fighting Procedures: Since fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing is ineffective for fires involving carbon disulfide. Apply cooling water to sides of tanks until long after fire is extinguished. Stay away from ends of tanks. Immediately withdraw from area if you hear a rising sound from venting safety device or notice any tank discoloration due to fire. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Carbon disulfide is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Carbon disulfide will decompose to its elements in contact with mercury fulminate. It is incompatible with alkali metals, chlorine and other halogens, nitrogen oxide, metal azides, oxidants, aluminum, ethylene diamine and zinc. Carbon disulfide reacts exothermically with phenyl copper-triphenylphosphine complexes.
Conditions to Avoid: Exposure to ignition sources and contact with incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of carbon disulfide can produce carbon monoxide (CO), carbon dioxide (CO_2), and toxic sulfur oxides (SO_x)

Section 6. Health Hazard Data

Carcinogenicity: The IARC,[164] NTP,[142] and OSHA[164] do not list carbon disulfide as a carcinogen. **Summary of Risks:** CS_2 enters the body primarily via the lungs (inhalation) but can be absorbed via skin. It is irritating to skin, eyes, and mucous membranes and can cause serious damage to CVS, CNS, and PNS. CS_2 is cardiotoxic (toxic to heart), thrombotoxic (adversely affecting blood-clotting ability), and arrythmagenic (causing irregular heartbeat). A Parkinsonian-like effect is sometimesobserved. Exposure to 60 to 100 ppm for a short time can result in severe intoxication and death. Exposure to 5000 ppm is rapidly fatal. 70 to 90% of CS_2 is metabolized, with lungs and kidney excreting the rest. **Medical Conditions Aggravated by Long-Term Exposure:** Coronary heart disease and CNS disorders. **Target Organs:** Skin, CNS, PNS, CVS, eyes, liver, kidney.

Continue on next page

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Section 6. Health Hazard Data, *continued*

Primary Entry Routes: Inhalation and skin contact/absorption. **Acute Effects:** CS_2 is irritating and corrosive to the eyes, skin, and mucous membranes. Introduction into eyes causes burning pain, red and swelling lids, and conjunctivitis. Skin contact with liquid may lead to burning and second- or third-degree burns. CS_2 defats tissue and skin sensitization may occur. Skin absorption can result in peripheral nerve damage. Other symptoms from inhalation or skin absorption include headache, dizziness, euphoria, convulsions, nausea, vomiting, muscle weakness, and in severe cases may lead to death by respiratory failure. **Chronic Effects:** Chronic exposure to carbon disulfide may increase the risk of arteriosclerosis as well as cause delirium, psychosis, bad dreams leading to insomnia, CNS damage, peripheral neuropathies (abnormal and usually degenerative state of the nerves causing pain and unstimulated sensations), appetite loss, tremors, gastric disturbances, liver dysfunction, optical neuritis, and retinal hemorrhages. In women, chronic exposure to carbon disulfide can cause menstrual disorders. Spontaneous abortions and premature births are reported.

FIRST AID

Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. *Do not* allow victim to rub or keep eyes tightly shut. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting with 1 to 2 tablespoons of Ipecac (adult dose). After patient vomits, give 2 tablespoons activated charcoal in 8 oz. of water to drink.

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

Note to Physicians: Since effects may be delayed, keep victim under observation. The iodine-azide test is useful in detecting degree of exposure and hypersusceptibility of exposed workers. I.V. urea 0.5 to 1.5 g/kg is recommended to inactivate free carbon disulfide in the blood. Vitamin B6 in large doses is recommended. Obtain CBC, EKG, urinalysis, and electrolyte balance.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Plan and design appropriate emergency-response procedures prior to carbon disulfide spills or leaks.* Immediately notify safety personnel, isolate area, deny entry and stay upwind. Shut off all ignition sources. Cleanup personnel should wear fully encapsulating, vapor-protective clothing to protect against contamination. If possible, detoxify material before cleanup. For small spills, take up with earth, sand, vermiculite or other absorbent, noncombustible material and place in clean, dry containers with a secure lid for later disposal. For large spills, flush liquid to a special retention basin where it can collect under a layer of water (to prevent ignition or explosion) for disposal or reclamation. Perform all cleanup operations with nonsparking tools. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** If released to water, carbon disulfide should volatilize with a half-life of 2.6 hr (according to model river plan) and should not bioconcentrate significantly in aquatic organisms. In the atmosphere, CS_2 reacts with atomic oxygen and photochemically produced hydroxyl radicals with a half-life of 9 days. **Environmental Toxicity Values:** Sunfish, LC_{100}, 100 µg/L/hr; trout, LC_{100}, 500 µg/L/0.1 hr. **Soil Absorption/Mobility:** Carbon disulfide is highly mobile and volatilizes or leaches into soil. **Disposal:** Large amounts of CS_2 may be distilled for reclamation and packaged for reuse. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. P022

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Reportable Quantity (RQ), 100 lb (45.4 kg) [* per RCRA, Sec. 3001 and CWA 311(b)(4)]

Listed as a SARA Extremely Hazardous Substance (40 CFR 355)

Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

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

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For 10 ppm, use any chemical cartridge respirator with organic vapor cartridges. For 50 ppm, air-purifying respirator with organic vapor cartridges and a full facepiece. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent all skin contact. Suggested materials for protective clothing include polyvinyl alcohol (PVA) and polyethylene with breakthrough times of 8 and 4 hr, respectively. **Ventilation:** Provide general and local explosion-proof exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local explosion-proof exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Protect containers from physical damage. Store in iron, glass, porcelain or steel containers. Keep small quantities in cool, dry, well-ventilated area away from incompatibles (Sec. 5). Store large quantities in tanks; add water or inert gas (such as nitrogen) to fill emptying tanks. Submerge tanks in water or locate them above concrete basins large enough to hold the tanks' contents. Equip storage facilities with automatic sprinklers and test regularly. Outside or detached storage is preferred.

Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. To prevent static sparks, electrically ground all system parts including piping, valves, and moveable containers. Prohibit electrical installations and heating facilities in or near storage areas. Never transfer carbon disulfide by means of air pressure; use pump, water, or inert gas. Use wooden sticks (no spark potential) to measure the contents of CS_2 tanks and containers.

Administrative Controls: Consider preplacement and periodic medical exams of exposed workers that emphasize eyes, skin, CNS, PNS, CVS, and reproductive system, and perform electrocardiograms.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Carbon bisulfide or Carbon disulfide
DOT Hazard Class: Flammable liquid
ID No.: UN1131
DOT Label: Flammable liquid
DOT Packaging Exceptions: None
DOT Packaging Requirements: 173.121

IMO Shipping Name: Carbon disulphide
IMO Hazard Class: 3.1
ID No.: UN1131
IMO Label: Flammable liquid, Poison
IMDG Packaging Group: I

MSDS Collection References: 26, 38, 73, 89, 100, 101, 103, 124, 126, 127, 132, 136, 140, 149, 153, 159, 162, 163, 164

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CHLORDANE

CDN

Common Synonyms

Chlordan
1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene
Teachlor; Octa-klor
Velsicol 1068

Brown

Sharp odor

Insoluble in water.

AVOID CONTACT WITH LIQUID. KEEP PEOPLE AWAY.
Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves).
Stop discharge if possible.
Call fire department.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

Not flammable but solution may be combustible.
POISONOUS GASES MAY BE PRODUCED IN FIRE.
Extinguish with dry chemicals, foam or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

CALL FOR MEDICAL AID.

LIQUID OR SOLUTION
POISONOUS IF SWALLOWED OR IF SKIN IS EXPOSED.
Irritating to skin and eyes.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
DO NOT RUB AFFECTED AREAS.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk and have victim induce vomiting.
IF SWALLOWED and victim is UNCONSCIOUS OR HAVING CONVULSIONS, do nothing except keep victim warm.

Water Pollution

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

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

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)

Issue warning-poison
Restrict access
Should be removed
Chemical and physical treatment

2. LABEL

2.1 Category: None
2.2 Class: Not pertinent

3. CHEMICAL DESIGNATIONS

3.1 CG Compatibility Class: Not listed
3.2 Formula: $C_{10}H_6Cl_8$
3.3 IMO/UN Designation: 6.1/2762
3.4 DOT ID No.: 2762
3.5 CAS Registry No.: 57-74-9

4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (as shipped): Liquid
4.2 Color: Brown
4.3 Odor: Penetrating; aromatic; slightly pungent, like chlorine

5. HEALTH HAZARDS

5.1 Personal Protective Equipment: Respirator for sprays, fogs, or dust; goggles; rubber gloves.
5.2 Symptoms Following Exposure: Moderately irritating to eyes and skin. Ingestion, absorption through skin, or inhalation of mist or dust may cause excitability, convulsions, nausea, vomiting, diarrhea, and some local irritation of the gastrointestinal tract.
5.3 Treatment of Exposure: INHALATION: administer oxygen and give fluid therapy; do not give epinephrine, since it may induce ventricular fibrillation; enforce complete rest. EYES: flush with water for at least 15 min. SKIN: wash off skin with adequate quantities of soap and water; do NOT scrub. INGESTION: induce vomiting and follow with gastric lavage and administration of saline cathartics; ether and barbiturates may be used to control convulsions; oxygen and fluid therapy are also recommended; do NOT give epinephrine. Since no specific antidotes are known, symptomatic therapy must be accompanied by complete rest.
5.4 Threshold Limit Value: 0.5 mg/m³
5.5 Short Term Inhalation Limits: 2 mg/m³ for 30 min.
5.6 Toxicity by Ingestion: Grade 3; oral LD_{50} = 283 mg/kg (rat)
5.7 Late Toxicity: Possible liver damage; loss of appetite and weight.
5.8 Vapor (Gas) Irritant Characteristics: Data not available
5.9 Liquid or Solid Irritant Characteristics: Data not available
5.10 Odor Threshold: Data not available
5.11 IDLH Value: 500 mg/m³

6. FIRE HAZARDS

6.1 Flash Point: Solution: 225°F O.C.; 132°F C.C. Solid is not flammable.
6.2 Flammable Limits in Air: 0.7%-6% (kerosene solution)
6.3 Fire Extinguishing Agents: Dry chemical, foam, carbon dioxide
6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective on solution fire.
6.5 Special Hazards of Combustion Products: Irritating and toxic hydrogen chloride and phosgene gases may be formed when kerosene solution or compound burns.
6.6 Behavior in Fire: Not pertinent
6.7 Ignition Temperature: 410°F (kerosene solvent)
6.8 Electrical Hazard: Data not available
6.9 Burning Rate: Not pertinent

(Continued)

7. CHEMICAL REACTIVITY

7.1 Reactivity With Water: No reaction
7.2 Reactivity with Common Materials: No reaction
7.3 Stability During Transport: Stable to 180°F
7.4 Neutralizing Agents for Acids and Caustics: Not pertinent
7.5 Polymerization: Not pertinent
7.6 Inhibitor of Polymerization: Not pertinent
7.7 Molar Ratio (Reactant to Product): Data not available
7.8 Reactivity Group: Data not available

8. WATER POLLUTION

8.1 Aquatic Toxicity: 0.5 ppm/96 hr/goldfish/TL_m/fresh water
8.2 Waterfowl Toxicity: LD_{50} = 1,200 mg/kg
8.3 Biological Oxygen Demand (BOD): Data not available
8.4 Food Chain Concentration Potential: High

9. SHIPPING INFORMATION

9.1 Grades of Purity: Technical. A variety of dusts, powders, and solutions in kerosene containing 2-80% chlordane are shipped.
9.2 Storage Temperature: Ambient
9.3 Inert Atmosphere: No requirement
9.4 Venting: Open (flame arrester)

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

A-X-Y

11. HAZARD CLASSIFICATIONS

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

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 Physical State at 15°C and 1 atm: Liquid
12.2 Molecular Weight: 409.8
12.3 Boiling Point at 1 atm: Decomposes
12.4 Freezing Point: Not pertinent
12.5 Critical Temperature: Not pertinent
12.6 Critical Pressure: Not pertinent
12.7 Specific Gravity: 1.6 at 25°C (liquid)
12.8 Liquid Surface Tension: (est.) 25 dynes/cm = 0.025 N/m at 20°C
12.9 Liquid Water Interfacial Tension: (est.) 50 dynes/cm = 0.05 N/m at 20°C
12.10 Vapor (Gas) Specific Gravity: Not pertinent
12.11 Ratio of Specific Heats of Vapor (Gas): Not pertinent
12.12 Latent Heat of Vaporization: Not pertinent
12.13 Heat of Combustion: (est.) —4,000 Btu/lb = —2,200 cal/g = —93 X 10⁶ J/kg
12.14 Heat of Decomposition: Not pertinent
12.15 Heat of Solution: Not pertinent
12.16 Heat of Polymerization: Not pertinent
12.25 Heat of Fusion: Data not available
12.26 Limiting Value: Data not available
12.27 Reid Vapor Pressure: Data not available

*Properties refer to undiluted, technical-grade chlordane.

6. FIRE HAZARDS (Continued)

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

CDN	CHLORDANE

12.17 SATURATED LIQUID DENSITY		12.18 LIQUID HEAT CAPACITY		12.19 LIQUID THERMAL CONDUCTIVITY		12.20 LIQUID VISCOSITY	
Temperature (degrees F)	Pounds per cubic foot (estimate)	Temperature (degrees F)	British thermal unit per pound-F (estimate)	Temperature (degrees F)	British thermal unit-inch per hour-square foot-F (estimate)	Temperature (degrees F)	Centipoise (estimate)
52	100.400	60	.300	60	1.209	130	58.980
54	100.400	61	.300	61	1.209	140	51.140
56	100.299	62	.300	62	1.209	150	44.560
58	100.200	63	.300	63	1.209	160	38.990
60	100.200	64	.300	64	1.209	170	34.270
62	100.099	65	.300	65	1.209	180	30.240
64	100.000	66	.300	66	1.209	190	26.780
66	99.940	67	.300	67	1.209	200	23.810
68	99.879	68	.300	68	1.209	210	21.240
70	99.809	69	.300	69	1.209	220	19.020
72	99.740	70	.300	70	1.209	230	17.080
74	99.669	71	.300	71	1.209	240	15.390
76	99.599	72	.300	72	1.209	250	13.900
78	99.530	73	.300	73	1.209	260	12.590
80	99.459	74	.300	74	1.209	270	11.440
82	99.389	75	.300	75	1.209	280	10.420
84	99.320	76	.300	76	1.209	290	9.516
86	99.250	77	.300	77	1.209	300	8.710

12.21 SOLUBILITY IN WATER		12.22 SATURATED VAPOR PRESSURE		12.23 SATURATED VAPOR DENSITY		12.24 IDEAL GAS HEAT CAPACITY	
Temperature (degrees F)	Pounds per 100 pounds of water	Temperature (degrees F)	Pounds per square inch	Temperature (degrees F)	Pounds per cubic foot	Temperature (degrees F)	British thermal unit per pound-F
	INSOLUBLE	215	.000	215	.00001		NOT PERTINENT
		220	.000	220	.00001		
		225	.000	225	.00002		
		230	.000	230	.00002		
		235	.001	235	.00003		
		240	.001	240	.00005		
		245	.001	245	.00007		
		250	.002	250	.00009		
		255	.002	255	.00012		
		260	.003	260	.00017		
		265	.004	265	.00023		
		270	.006	270	.00031		
		275	.008	275	.00042		
		280	.011	280	.00056		
		285	.015	285	.00074		
		290	.019	290	.00099		
		295	.026	295	.00131		
		300	.035	300	.00174		
		305	.046	305	.00228		
		310	.060	310	.00300		
		315	.079	315	.00391		
		320	.104	320	.00510		
		325	.136	325	.00662		
		330	.177	330	.00856		
		335	.230	335	.01104		
		340	.297	340	.01418		

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Material Safety Data Sheets Collection:

Sheet No. 366
Chlorobenzene

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

Section 1. Material Identification 33

Chlorobenzene (C_6H_5Cl) Description: Produced by chlorinating benzene in the presence of a catalyst. Used in dry cleaning; as a solvent in manufacturing paints, adhesives, polishes, waxes, diisocyanates, natural rubber, and pharmaceuticals; a chemical intermediate for phenol, *o*-, and *p*-chloronitrobenzene, DDT, and aniline; and an intermediate in manufacturing dyestuffs.

Other Designations: CAS No. 0108-90-7, benzene chloride; chlorobenzol; MCB; monochlorobenzene; phenyl chloride.

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

Cautions: Chlorobenzene is a skin and mucous membrane irritant, a fairly strong narcotic, and a central nervous system (CNS) depressant. Chronic inhalation may cause *lung, liver, and kidney damage*. This material is a dangerous fire hazard when exposed to heat or flame.

R	1
I	3
S	2
K	3

NFPA

HMIS
H 2
F 3
R 0
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Chlorobenzene, ca 100%

1989 OSHA PEL	1990-91 ACGIH TLV*	1988 NIOSH REL	1985-86 Toxicity Data†
8-hr TWA: 75 ppm, 350 mg/m³	TWA: 75 ppm, 345 mg/m³	None established	Rat, oral, LD_{50}: 2910 mg/kg; toxic effects not yet reviewed Rat, inhalation, TC_{Lo}: 210 ppm administered for 6 hr to a 6- to 15-day pregnant female produces specific developmental abnormalities
1987 IDLH Level			
2400 ppm			

* In its "Notice of Intended Changes (for 1990-91)," the ACGIH lists a proposed lower level TWA for chlorobenzene: 10 ppm, 46 mg/m³.[0,50]
†See NIOSH, *RTECS* (CZ0175000), for additional mutative, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 270 °F (132 °C) at 760 mm Hg
Melting Point: -50.1 °F (-45.6 °C)
Vapor Pressure: 11.8 mm Hg at 77 °F (25 °C)
Vapor Density (Air = 1): 3.88
Viscosity: 0.790 centipoise at 70 °F (21 °C)
Molecular Weight: 112.56
Specific Gravity (20 °C/4 °C): 1.1058
Water Solubility: Insoluble

Appearance and Odor: A clear, colorless, volatile liquid with a faint, almond-like odor. Threshold odor concentration: 100% recognition, 0.21 ppm.

Section 4. Fire and Explosion Data

Flash Point: 85 °F (29.5 °C), CC	Autoignition Temperature: 1180 °F (638 °C)	LEL: 1.8% v/v	UEL: 9.6% v/v

Extinguishing Media: Use carbon dioxide, dry chemical, halon, water spray, or standard foam to extinguish fires involving chlorobenzene. Use water in flooding quantities as fog since solid streams of water may spread fire. Apply water spray from as far as possible to cool fire-exposed containers.

Unusual Fire or Explosion Hazards: Chlorobenzene is dangerous when exposed to heat or flame. Vapor may travel to an ignition source and flash back.

Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Do not extinguish fire unless flow can be stopped. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

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

Chemical Incompatibilities: Chlorobenzene is incompatible with strong oxidizers; contact may cause fires and explosions. It reacts violently with dimethyl sulfoxide. Silver perchlorate forms a solvated, shock-sensitive salt with chlorobenzene (explosion). Chlorobenzene is potentially explosive with powdered sodium or phosphorus trichloride + sodium.

Conditions to Avoid: Avoid all heat and ignition sources and incompatible materials.

Hazardous Products of Decomposition: Thermal oxidative decomposition products of chlorobenzene can include soot, hydrogen chloride, phosgene, and carbon monoxide.

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Section 6. Health Hazard Data

Carcinogenicity: The NTP, IARC, and OSHA do not list chlorobenzene as a carcinogen.
Summary of Risks: Chlorobenzene is a fairly strong narcotic and can cause central nervous system (CNS) depression. Overexposure is irritating to the eyes, nasal passages, and upper respiratory tract. It is moderately toxic by inhalation or ingestion and can be absorbed slowly through the skin. Short exposures to liquid may cause skin irritation and defatting, while prolonged or repeated skin contact may result in dermatitis or skin burns. Following absorption of toxic doses, liver and kidney degeneration are also observed. Chlorobenzene may also cause hemolysis.
Medical Conditions Aggravated by Long-Term Exposure: Individuals with skin, liver, kidney, or chronic respiratory disease may be at increased risk from exposure.
Target Organs: Respiratory system, eyes, skin, central nervous system, and liver.
Primary Entry Routes: Inhalation, ingestion, eye and skin contact.
Acute Effects: Symptoms to be expected from acute exposure are headache, eye and upper respiratory tract irritation, dizziness, drowsiness, cyanosis, spastic contractions of extremities, and loss of consciousness, depending on the exposure's concentration and duration. Symptoms of ingestion include pallor, cyanosis, and coma, followed by complete recovery.
Chronic Effects: Frequently repeated contact with chlorobenzene may result in skin burns, eye and upper respiratory tract irritation, headaches, dizziness, somnolence, and dyspeptic disorders (indigestion). Chronic inhalation may result in lung, liver, and kidney damage.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious* person drink 1 to 2 glasses of water. Consult a physician immediately. If vomiting occurs, administer more water.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: In a *conscious* patient, attempt to induce vomiting with Syrup of Ipecac. Consider activated charcoal cathartic. Administer charcoal slurry with saline, water, or sorbitol. In an *unconscious* patient, do gastric lavage with suction.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice a chlorobenzene spill control and counter measure plan (SCCP).* Notify safety personnel, evacuate all unnecessary personnel, eliminate all heat and ignition sources, and provide maximum explosion-proof ventilation. Cleanup personnel should protect against vapor inhalation and contact with liquid. Take up spilled material with a noncombustible absorbent material and place into containers for disposal. For large spills, dike far ahead of spill to contain. Do not release runoff to sewers or waterways since chlorobenzene is harmful to aquatic life in very low concentrations. Aquatic toxicity: A 20-ppm concentration of chlorobenzene administered to bluegill in fresh water during a 96-hr test period is the median tolerance limit (TLm) at which 50% of the aquatic organisms survive. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33), Hazardous Waste No. U037
CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 100 lb (45.4 kg) [* per Clean Water Act, Sec. 311(b)(4), Sec. 307(a), and per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

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

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a well-ventilated, fire-resistant area away from heat and ignition sources and oxidizing agents. Outside or detached storage is preferred. Storage and handling must be suitable for an OSHA Class IC flammable liquid. To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations in production and storage areas. Protect containers from physical damage.
Engineering Controls: Avoid vapor inhalation and contact with liquid. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good personal hygiene and housekeeping procedures.
Other Precautions: Provide a preplacement questionnaire that emphasizes detecting a history of skin, liver, kidney, or chronic respiratory disease.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Chlorobenzene	**IMO Shipping Name:** Chlorobenzene
DOT Hazard Class: Flammable liquid	**IMO Hazard Class:** 3.3
ID No.: UN1134	**ID No.:** UN1134
DOT Label: Flammable liquid	**IMO Label:** Flammable liquid
DOT Packaging Exceptions: 173.118	**IMDG Packaging Group:** II
DOT Packaging Requirements: 173.119	

MSDS Collection References: 38, 73, 84, 85, 89, 100, 101, 103, 124, 126, 131, 132, 133, 136, 138, 139, 140, 143, 146, 148
Prepared by: MJ Allison, BS; Industrial Hygiene Review: DJ Wilson, CIH; Medical Review: AC Darlington, MD; Edited by: JR Stuart, MS

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Sheet No. 5
Chromic Acid and Chromates

Issued: 10/77 Revision: C, 7/91

Section 1. Material Identification

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

R	1
I	4
S	3*
K	0

* Percutaneous (broken skin)

NFPA: 0 / 3 / 1 / OXY

HMIS
H 3
F 0
R 1
PPG†
† Sec. 8

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

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

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

Section 2. Ingredients and Occupational Exposure Limits

Chromic acid, 99% CrO_3

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

1987 IDLH Level
30 mg/m³

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

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

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

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

Section 3. Physical Data*

Boiling Point: Decomposes at 482 °F (250 °C) to $Cr_2O_3 + O_2$
Melting Point: 385 °F (196 °C)
Molecular Weight: 99.98
Specific Gravity: 2.7
Water Solubility: Soluble
Heat of Fusion: 37.7 cal/g
Appearance and Odor: Dark, purplish-red, prismatic, deliquescent (absorbs all moisture from air) crystals, or a granular powder with no detectable odor.

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

Section 4. Fire and Explosion Data

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

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

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

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

Section 5. Reactivity Data

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

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

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

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

Section 6. Health Hazard Data

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

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

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

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

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

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

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

Continue on next page

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Section 6. Health Hazard Data, *continued*

can cause irritant or allergic contact dermatitis, or skin ulceration. Chronic systemic absorption could cause liver or kidney damage.

FIRST AID

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

Skin: Rinse with flooding amounts of water for at least 15 min, and wash with a gentle soap. Promptly remove contaminated clothing. For redness, blistering, or persistent irritation, consult a physician.

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

Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious* person drink 1 to 2 glasses of water. *Do not induce vomiting* since this worsens the victim's condition. *Do not* neutralize this acid.

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

Note to Physicians: After decontamination and neutralization, treatment of acid burns is similar to that of thermal burns, although bullae and loose necrotic tissue should be debrided. Update tetanus status. *For severe acid burns,* fluid resuscitation is critical to prevent mortality from hypovolemia and renal failure. Monitor serial vital signs, urine output, electrolytes, blood count, and urinalysis as clinically indicated. Neuro-vascular compromise distal to a circumferential extremity burn may require escharotomy or fasciotomy. *For inhalation exposures to acids,* a CXR, EKG, ABGs, PFTs, SMA, and CBC may aid in treatment. Evaluate and treat as indicated for reactive airways, upper airway obstruction and noncardiogenic pulmonary edema (possibly delayed onset). Although literature documentation is inadequate, a burst of steroids may help prevent development of sequelae such as reactive airways dysfunction syndrome or bronchilitis obliterans. For ocular exposures to acids, ensure adequate decontamination. Determination of pH may be helpful. A Morgan Lens® and topical anesthesia may aid in irrigation. Perform fluorescein staining and slit lamp evaluation and consult an opthamalogist. Antibiotic ointments, mydriatic/cycloplegics, topical corticosteroids (after epithelial recovery), patching, and possibly anterior chamber paracentesis may be indicated depending on clinical presentation. Acutely and in follow-up, evaluate as indicated for intraocular pressure, lacrimal and lid function, corneal integrity and infection. Urinary chromium is of questionable value.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel and evacuate all unnecessary personnel. Cleanup personnel should protect against dust inhalation and eye contact. Do not handle broken packages unless wearing appropriate personal protective equipment. Keep combustibles (wood, paper, etc.) away from spilled material. Whenever possible, use wet cleanup methods; if not, use vacuum cleanup. Remove spills immediately to prevent dust dispersion. For a water spill, neutralize with agricultural lime, crushed limestone, or sodium bicarbonate. For a land spill, dig a pit, pond, or lagoon to contain material. If time permits, seal these with an impermeable, flexible membrane liner. Dike surface flow with soil, sand or foamed concrete. Follow applicable OSHA regulations (29 CFR 1910.120).

Environmental Transport: If allowed contact with soil, chromic acid, solid, lowers pH and may leach into water sources, causing an effect similar to acid rain's on water sources. This material's carcinogenicity makes it hazardous to the environment in its hexavalent state.

Environmental Degradation: The recommended disposal means are reduction, precipitation, or ion exchange. Landfill disposal is not recommended since it raises soil acidity.

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

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.22): Corrosive waste

RCRA Hazardous Waste (40 CFR 261.33): Not listed

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 10 lb (4.54 kg) [*per Clean Water Act, Sec. 311(b)(4)]†

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

SARA Toxic Chemical (40 CFR 372.65): Not listed

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Tables Z-1-A and Z-2)

† Chromic acid (CAS No. 7738-94-5) is listed.

Section 8. Special Protection Data

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

Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For 0.5-g/m³ concentrations (if not fumes), use any dust and mist respirator except single-use and quarter-mask respirators. For 1.25-g/m³ concentrations, use any powered air-purifying respirator with a high-efficiency particulate filter. For 2.5-m/m³ concentrations, use any air-purifying full facepiece respirator with a high-efficiency particulate filter. For 30-g/m³ concentrations, use any supplied air respirator with a full facepiece and operated in a pressure-demand or other positive-pressure mode. All concentrations may require eye protection. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*

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

Ventilation: Provide general and local ventilation systems to maintain airborne concentrations below occupational exposure levels. Local exhaust ventilation is preferred since it prevents contaminant dispersion into work area by controlling it at its source.[103]

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

Contaminated Equipment: Contact lenses may minimize or worsen eye injuries. In some cases, soft lenses can actually protect eyes, not worsen corneal damage, due to strong chemicals. In other cases, chemical entrapment is presumed a possible hazard. Since contact lens use in industry is controversial, establish your own policy. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.

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

Section 9. Special Precautions and Comments

Storage Requirements: Store in glass bottles, cans, or drums. Protect against physical damage. Separate from combustible, organic, or other easily oxidizable materials. Protect from excess moisture which could cause containers to rust. Do not store on wooden floors. Store away from foodstuffs and flammable liquids and solids.

Engineering Controls: Avoid dust inhalation and skin or eye contact. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good housekeeping procedures.

Other Precautions: Institute preplacement and periodic medical exams of exposed workers with attention to the skin and respiratory tract. Consider preplacement and periodic chest radiographs.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Chromic acid, solid	**IMO Shipping Name:** Chromium trioxide, anhydrous
DOT Hazard Class: Oxidizer	**IMO Hazard Class:** 5.1
ID No.: NA1463	**ID No.:** UN1463
DOT Label: Oxidizer	**IMO Label:** Oxidizer, Corrosive
DOT Packaging Exceptions: 173.153	**IMDG Packaging Group:** II
DOT Packaging Requirements: 173.164	

MSDS Collection References: 26, 38, 73, 85, 100, 101, 103, 124, 126, 127, 132, 133, 136, 138, 139, 140, 143, 142, 145, 148, 159

Prepared by: M Gannon, BA; Industrial Hygiene Review: DJ Wilson, CIH; Medical Review: MJ Upfal, MD, MPH; Edited by: JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 757
Coal Tar Creosote

Issued: 7/91

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*(TM) 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 exposure 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
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Material Safety Data Sheets Collection:

Sheet No. 162
Copper

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

Section 1. Material Identification

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.

R 0
I 4
S 1
K 0

Genium

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

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 acetylenic 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
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OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR

DDT

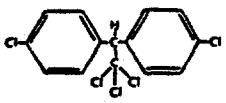
POTENTIAL HUMAN CARCINOGEN

INTRODUCTION

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

SUBSTANCE IDENTIFICATION

- **Formula:** $C_{14}H_9Cl_5$
- **Structure:**



- **Synonyms:** Citox; genitox; dichlorodiphenyltrichloroethane; 1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane
- **Identifiers:** CAS 50-29-3; RTECS KJ3325000; DOT 2761
- **Appearance and odor:** Colorless crystals or white to slightly off-white powder with a slightly aromatic odor

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 354.48
2. Boiling point (at 760 mmHg): 260°C (500°F)
3. Specific gravity (water = 1): 1.56
4. Vapor density (air = 1 at boiling point of DDT): 12.2
5. Melting point: 105-109°C (221-228°F)
6. Vapor pressure at 20°C (68°F): 1.5×10^{-7} mmHg
7. Practically insoluble in water

- **Reactivity**

1. Incompatibilities: DDT should not be stored in iron containers; DDT should not be mixed with iron and aluminum salts or with alkaline materials. Temperatures greater than 100°C (212°F) may cause decomposition.
2. Hazardous decomposition products: Toxic vapors and gases (e.g., hydrogen chloride) may be released in a fire involving DDT.
3. Caution: DDT should be stored in a tightly closed container in a well-ventilated area.

- **Warning properties**

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

EXPOSURE LIMITS

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for DDT is 1 milligram of DDT per cubic meter of air (mg/m³) as a time-weighted average (TWA) concentration over an 8-hour workshift (Skin). The notation "Skin" refers to the potential contribution to overall exposure by the cutaneous route including the mucous membranes and eyes. The National Institute for Occupational Safety and Health (NIOSH) recommends that DDT be controlled and handled as a potential human carcinogen in the workplace and that exposure be minimized to the lowest feasible limit. The NIOSH recommended exposure limit (REL) is 0.5 mg/m³ as a TWA for up to a 10-hour workshift, 40-hour workweek. The NIOSH REL is the lowest concentration reliably detectable by current NIOSH-validated sampling and analytical methods. The American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV®) is 1 mg/m³ as a TWA for a normal 8-hour workday and a 40-hour workweek; the short-term exposure limit (STEL) is 3 mg/m³ (Table 1).

Table 1.—Occupational exposure limits for DDT

	Exposure limits mg/m³
OSHA PEL TWA (Skin)*	1
NIOSH REL TWA (CA)†	0.5§
ACGIH TLV® TWA	1

* (Skin): Potential contribution to overall exposure by the cutaneous route including mucous membranes and eyes.
† (Ca): NIOSH recommends treating as a potential human carcinogen.
§ Lowest reliably detectable level.

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

NOTE: A general ban was ordered by the Environmental Protection Agency on the registration of DDT, effective December 31, 1972. Effective the same date, the ban for uses of DDT by public health officials in disease control programs and by USDA and the military for health quarantine and prescription drugs use was lifted.

HEALTH HAZARD INFORMATION

• **Routes of exposure**

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

• **Summary of toxicology**

Effects on animals: Acute oral administration of DDT to rats caused tissue destruction (necrosis) of the liver, mild degeneration of kidney tubules, and changes in electroencephalograms. Chronic oral administration of DDT caused decreased fertility in rats and increased mortality of their offspring, toxic effects on the liver (including necrosis, fat deposition, increased weight, and increased enzyme activity), and liver cancer. In mice, chronic oral administration of DDT produced cancers of the liver, lungs, and lymphatic system.

• **Signs and symptoms of exposure**

Short-term (acute): Exposure to DDT can cause a prickling sensation of the tongue, lips, and face, a general feeling of ill health, headache, fatigue, vomiting, dizziness, tremors, convulsions, partial paralysis of the hands, and coma. DDT can also cause irritation of the eyes and skin.

RECOMMENDED MEDICAL PRACTICES

• **Medical surveillance program**

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

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

• **Preplacement medical evaluation**

Prior to placing a worker in a job with a potential for exposure to DDT, the physician should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic or laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the eyes, skin, liver, and reproductive and nervous systems.

A preplacement medical evaluation is recommended in order to detect and assess preexisting or concurrent conditions which may be aggravated or result in increased risk when a worker is exposed to DDT at or below the NIOSH REL. The examining physician should consider the probable frequency, intensity, and duration of exposure, as well as the nature and degree of the condition, in placing such a worker. Such conditions, which should not be regarded as absolute contraindications to job placement, include chronic liver disease. Workers should inform their physicians of their potential for exposures to DDT because internal absorption of this chemical pathologically increases the liver's ability to metabolize and eliminate medications which may be prescribed or taken "over the counter."

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

Occupational health interviews and physical examinations should be performed at regular intervals. Additional examinations may be necessary should a worker develop symptoms that may be attributed to exposure to DDT. The interviews, examinations, and appropriate medical screening and/or biologic monitoring tests should be directed at identifying an excessive decrease or adverse trend in the physiologic function of the eyes, skin, liver, and reproductive and nervous systems as compared to the baseline status of the individual worker or to expected values for a suitable reference population.

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

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

MONITORING AND MEASUREMENT PROCEDURES

• **TWA exposure evaluation**

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

• Method

Sampling and analysis may be performed by collecting DDT vapors with charcoal adsorption tubes followed by desorption with carbon disulfide and analysis by gas chromatography. Detector tubes or other direct-reading devices calibrated to measure DDT may also be used if available. A detailed sampling and analytical method for DDT may be found in the *NIOSH Manual of Analytical Methods* (method number S 274).

PERSONAL PROTECTIVE EQUIPMENT

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

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

SANITATION

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

Change and shower rooms should be provided with separate locker facilities for street and work clothes.

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

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

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

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

COMMON OPERATIONS AND CONTROLS

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

Table 2.—Operations and methods of control for DDT

Operations	Controls
During preparation and handling of insecticide	Process enclosure, local exhaust ventilation, personal protective equipment
During maintenance of equipment and storage containers	Personal protective equipment

EMERGENCY FIRST AID PROCEDURES

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

• Eye exposure

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

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

• Skin exposure

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

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

• Rescue

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

SPILLS AND LEAKS

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

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

1. Ventilate area of spill or leak.
2. For small quantities of liquids containing DDT, absorb on paper towels and place in an appropriate container.
3. Large quantities of liquids containing DDT may be absorbed in vermiculite, dry sand, earth, or a similar material and placed in an appropriate container.
4. If in solid form, DDT may be collected and placed in an appropriate container.
5. DDT dust may be collected by vacuuming with an appropriate high-efficiency filtration system.

WASTE REMOVAL AND DISPOSAL

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

RESPIRATORY PROTECTION

It must be stressed that the use of respirators is the least preferred method of controlling worker exposure and should not normally be used as the only means of preventing or

minimizing exposure during routine operations. However, there are some exceptions for which respirators may be used to control exposure: when engineering and work practice controls are not technically feasible, when engineering controls are in the process of being installed, or during emergencies and certain maintenance operations including those requiring confined-space entry (Table 3).

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

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

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Table 3.—Respiratory protection for DDT

Condition	Minimum respiratory protection*
Any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Planned or emergency entry into environments containing unknown or any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Firefighting	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
Escape only	Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister having a high-efficiency particulate filter
	Any appropriate escape-type self-contained breathing apparatus

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

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Material Safety Data Sheets Collection:

Sheet No. 514
p-Dichlorobenzene

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

Section 1. Material Identification

33

p-Dichlorobenzene ($C_6H_4Cl_2$) **Description:** Derived by chlorinating monochlorobenzene. Used as a general insecticide; a moth repellent; a germicide; a chemical intermediate in the production of polyphenylene sulfide; a plastic used in the electrical and electronics industries; a space deodorant in products such as room deodorizers, urinal and toilet bowl blocks, and diaper pail deodorizers; and in producing 1,2,4 trichlorobenzene.

Other Designations: CAS No. 0106-46-7, 1,4-dichlorobenzene, dichlorocide, Evola,● NCI-c 54955, Paracide,● Paracrystals, Paradi,● paradichlorobenzol, Paramoth,● *p*-chlorophenyl chloride, PDB,● Santochlor.●

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

Cautions: *p*-Dichlorobenzene vapor is an eye and upper respiratory tract irritant. *It is toxic to the liver*. Prolonged exposure to high concentrations may cause weakness, dizziness, and weight loss. Flammable when exposed to heat, flame, or oxidizers.

R	1
I	3
S	1
K	2

NFPA

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

Section 2. Ingredients and Occupational Exposure Limits

p-Dichlorobenzene, ca 100%

1989 OSHA PELs
8-hr TWA: 75 ppm, 450 mg/m³
15-min STEL: 110 ppm, 675 mg/m³

1990-91 ACGIH TLVs
TWA: 75 ppm, 451 mg/m³
STEL: 110 ppm, 661 mg/m³

1988 NIOSH REL
None established

1985-86 Toxicity Data*
Human, oral, TD_{Lo}: 300 mg/kg produced sense organs and special senses (other eye effects); lungs, thorax, or respiration (other changes); and gastrointestinal (hypermotility, diarrhea) effects
Human, eye: 80 ppm

1987 IDLH Level
1000 ppm

* See NIOSH, *RTECS* (CZ4550000), for additional irritative, mutative, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 345 °F (174 °C) at 760 mm Hg
Melting Point: 127.6 °F (53.1 °C)
Vapor Pressure: 10 mm Hg at 130.6 °F (54.8 °C)
Vapor Density (Air = 1): 5.08
Molecular Weight: 147.01
Specific Gravity: 1.248 at 131 °F (55 °C)
Water Solubility: Insoluble

Appearance and Odor: Volatile, white crystals with a distinctive mothball-like odor that becomes very strong at concentrations between 30 and 60 ppm. At concentrations of 80 to 160 ppm, vapors are painful to the eyes and nose. Odors and irritating effects are good warnings against overexposure to *p*-dichlorobenzene; however, individuals may develop tolerance to high concentrations.

Section 4. Fire and Explosion Data

Flash Point: 150 °F (66 °C), CC	Autoignition Temperature: None reported	LEL: 1.7% v/v	UEL: None reported

Extinguishing Media: Use dry chemical, carbon dioxide, alcohol foam, or water spray. Use water spray to cool fire-exposed container, to disperse vapors, or to blanket a pool fire.

Unusual Fire or Explosion Hazards: Explosive and toxic mixtures may form in air when this material is heated, such as in a fire.

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

Section 5. Reactivity Data

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

Chemical Incompatibilities: *p*-Dichlorobenzene is incompatible with strong oxidizers and oxidizing agents.

Conditions to Avoid: Avoid incompatibilities and heat or ignition sources.

Hazardous Products of Decomposition: Thermal oxidative decomposition of *p*-dichlorobenzene includes carbon monoxide, chlorides, and chlorine.

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Section 6. Health Hazard Data

Carcinogenicity: *p*-Dichlorobenzene is an NTP anticipated human carcinogen and an IARC possible human carcinogen (Group 2B) with inadequate human evidence and sufficient animal evidence.
Summary of Risks: This material has a relatively low level of acute or chronic toxicity. It may be irritating to eyes, nose, upper airways, and intestinal tract upon inhalation or ingestion. Limited case reports link acute exposure to hemolytic anemia, jaundice, methemglobinemia, granulomas of the lung, liver atrophy, toxic hepatitis, kidney injury, and allergic pigmentation and purpura (tiny hemorrhages) of the skin. Occupational studies of PDB-exposed workers reveal none of the blood abnormalities noted with similar substances. Vapors may produce painful irritation of the eyes at 50 to 80 ppm and severe discomfort at 160 ppm.
Medical Conditions Aggravated by Long-Term Exposure: Individuals with liver disease should not be exposed to *p*-dichlorobenzene.
Target Organs: Liver, respiratory system, eyes, kidneys, and skin.
Primary Entry Routes: Inhalation and dermal contact.
Acute Effects: Acute exposures to PDB vapor may be irritating to mucous membranes of the eyes and upper respiratory tract. Ingestion of the solid resulted in toxicity to a 3-year old child, with hemolytic anemia, jaundice, and methemglobinemia. Nausea, vomiting, and diarrhea are seen in other cases. Prolonged skin exposure may cause skin irritation.
Chronic Effects: Limited case studies show chronic toxicity with exposure to PDB. Chronic ingestion is linked to anemia, leukemia, and kidney damage. In one case, chemical dependence was noted with signs of withdrawal when ingestion stopped. Chronic vapor exposure is suggested in cases of lung granulomatosis, liver abnormalities, kidney damage, anemia, other blood cell abnormalities, and cataract formation.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious* person drink 1 to 2 glasses of water, then induce vomiting. Consult a physician.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Urinary excretion of 2,5-dichlorophenol, a metabolite of *p*-dichlorobenzene, may be useful as an index of exposure.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, and remove or extinguish all heat and ignition sources. Cleanup personnel should protect against vapor inhalation and skin or eye contact. For liquid spills, take up spilled material with noncombustible absorbent material and place into clean metal containers for disposal. For large liquid spills, dike far ahead of spill to contain liquid. For dry spills, shovel spilled material into clean metal containers for disposal. Runoff to sewers or waterways may create health and explosion hazards. (96-hr LC_{50}, fathead minnow: 4.2 to 30 mg/l, moderately toxic.) Pesticide wastes are toxic. Follow applicable EPA and OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33), Hazardous Waste No. U072
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 100 lb (45.4 kg) [* per Clean Water Act, Sec. 311(b)(4), Sec. 307(a), and per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. A gas mask with organic vapor canister and dust filter is suitable to 1000 ppm. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Neoprene gloves are recommended.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below OSHA PELs and ACGIH TLVs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, dry, well-ventilated area away from all heat and ignition sources and oxidizing agents. *p*-Dichlorobenzene melts at 127 °F (53 °C). Protect containers against physical damage.
Engineering Controls: Avoid dust or vapor inhalation and eye and skin contact (especially when heated). Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good personal hygiene and housekeeping procedures.
Other Precautions: Provide preplacement and annual physical examinations that emphasize the liver (liver function tests), upper respiratory tract, and eyes.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Dichlorobenzene, para, solid	**IMO Shipping Name:** *p*-Dichlorobenzene
DOT Hazard Class: ORM-A	**IMO Hazard Class:** 6.1
ID No.: UN1592	**ID No.:** UN1592
DOT Label: None	**IMO Label:** St. Andrews Cross
DOT Packaging Exceptions: 173.505	**IMDG Packaging Group:** III
DOT Packaging Requirements: 173.510	

MSDS Collection **References:** 1-7, 9, 10, 12, 14, 16, 23, 26, 31, 34, 38, 43, 48, 73, 84, 85, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 138, 139, 140, 142, 143, 146, 148
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 830
1,1-Dichloroethane

Issued: 6/92

Section 1. Material Identification

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1,1-Dichloroethane (CH_3CHCl_2) Description: Derived by various methods; by direct chlorination of ethane, as a side product of chloral manufacture, by treating ethylene and chlorine with calcium chloride, by action of phosphorus chloride on acetaldehyde, and the reaction of hydrogen chloride and vinyl chloride at 20 to 55 °C in the presence of an aluminum, ferric, or zinc chloride catalyst. Found as an air contaminant in submarines and space craft. Its largest industrial use is in the production of 1,1,1-trichloroethane. Also used as a cleansing agent, degreaser, solvent for plastics, oils, and fats, grain fumigant, chemical intermediate; in insecticide sprays, rubber cementing, fabric spreading, paint and varnish removers, in ore flotation, vinyl chloride production, and as a coupling agent in anti-knock gasoline. Formerly used as an anesthetic.

Other Designations: CAS No. 75-34-3; assymetrical dichloroethane; chlorinated hydrochloric ether; ethylidene chloride; ethylidene dichloride.

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

Cautions: 1,1-Dichloroethane is volatile and highly flammable. It is irritating to the eyes and respiratory tract and inhalation of high concentrations causes an anesthetic effect.

R	1
I	3
S	2
K	4

NFPA

HMIS
H 2
F 3
R 0
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

1,1-Dichloroethane, reagent grade (99.7%). Impurities consist of ethyl chloride (0.02%), trichloroethylene (0.08%), butylene oxide (0.08%), ethylene dichloride (0.01%), and unknown (0.14%).

1991 OSHA PEL
8-hr TWA: 100 ppm (400 mg/m³)

1990 IDLH Level
4000 ppm

1990 NIOSH REL
8-hr TWA: 100 ppm (400 mg/m³)

1991-92 ACGIH TLVs*
TWA: 200 ppm (810 mg/m³)
STEL: 250 ppm (1010 mg/m³)

1990 DFG (Germany) MAK
100 ppm (400 mg/m³)
Half-life: < 2hr
Peak Exposure Limit: 200 ppm/30 min. average value/maximum of 4 peaks per shift

1985-86 Toxicity Data†
Mouse, oral, TD_{Lo}: 185 g/kg administered intermittently for 78 wk produced uterine tumors.
Rat, oral, LD_{50}: 725 mg/kg; toxic effects not yet reviewed.‡
Rat, inhalation, TC_{Lo}: 6000 ppm/7 hr administered during 6 to 15 days of pregnancy caused developmental abnormalities of the musculoskeletal system.

* Notice of intended change to 100 ppm/405 mg/m³.
†See NIOSH, *RTECS* (KI0175000), for additional reproductive, tumorigenic and toxicity data.
‡ Considered a possible error since subsequent studies at higher concentrations failed to produce comparative results.[133]

Section 3. Physical Data

Boiling Point: 135 °F (57.3 °C)
Melting Point: -143 °F (-96.98 °C)
Vapor Pressure: 230 mm Hg at 77 °F (25 °C)
Saturated Vapor Density (air = 1.2 kg/m³ or 0.075 lbs/ft³): 2.076 kg/m³ or 0.129 lbs/ft³
Refraction Index: 1.4166 at 68 °F (20 °C)
Surface Tension: 24.75 dyne/cm at 68 °F (20 °C)

Molecular Weight: 98.97
Specific Gravity: 1.174 at 68 °F (20/4 °C)
Water Solubility: Slightly, 0.5%
Other Solubilities: Very soluble in alcohol and ether, soluble in acetone, benzene, and fixed and volatile oils.
Relative Evaporation Rate (BuAc=1): 11.6
Odor Threshold: 49 to 1359 ppm; odor is not sufficient to warn against overexposure

Appearance and Odor: Colorless, mobile, oily liquid with a chloroform odor and a saccharin taste.

Section 4. Fire and Explosion Data

Flash Point: 17 °F (-8.33 °C) CC*	Autoignition Temperature: 856 °F (493 °C)	LEL: 5.6% v/v	UEL: 11.4% v/v

Extinguishing Media: A Class 1B Flammable Liquid. For small fires, use dry chemical, carbon dioxide (CO_2), or "alcohol-resistant" foam. For large fires, use fog or "alcohol-resistant" foam. Water may be ineffective unless used as a "blanket".

Unusual Fire or Explosion Hazards: Vapors may travel to an ignition source and flash back. Container may explode in heat of fire.

Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing will provide only limited protection. If possible without risk, move container from fire area. Apply cooling water to sides of containers until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if this is impossible, withdraw from area and let fire burn. Withdraw immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire. Do not release runoff from fire control methods to sewers (explosion) or waterways.

* 22 °F (-5.5 °C), OC[148]

Section 5. Reactivity Data

Stability/Polymerization: 1,1-Dichloroethane is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Incompatible with strong oxidizers and forms acetaldehyde in contact with caustics. 1,1-Dichloroethane will attack some forms of plastics, rubber, and coatings.

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

Hazardous Products of Decomposition: Thermal oxidative decomposition of 1,1-dichloroethane can produce carbon dioxide (CO_2), irritating hydrogen chloride (HCl) and toxic phosgene ($COCl_2$) fumes.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,[164] NTP,[169] and OSHA[164] do not list 1,1-dichloroethane as a carcinogen. However, the National Cancer Institute has recommended caution due to analogy to other chloroethanes such as 1,2-dichlorothane which are shown to cause cancer in animals.

Summary of Risks: 1,1-Dichloroethane is irritating to the eyes and respiratory system. It causes varying degrees of central nervous system (CNS) disturbance depending on the concentration and duration of exposure. Liver and kidney toxicity is controversial.

Continue on next page

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Section 6. Health Hazard Data, *continued*

Some sources report that severe, acute exposures can cause damage, some quote recent detailed chronic studies which indicate little capacity for damage; still others refute the possibility of acute damage even from very high exposures. In reviewing the data it appears likely that chronic exposure will not cause kidney or liver damage but acute exposures to high concentrations may. There is definite evidence that 1,1-dichloroethane produces liver damage in monkeys, dogs, and rats when exposed to 98 ppm/90 days. It is also unclear whether or not 1,1-dichloroethane is absorbed through the skin. There are reports of absorption (although not in toxic amounts) and others claiming there is no absorption. Given this controversial data it is best to take precautions as if skin absorption, and liver and kidney damage were proven to occur. **Medical Conditions Aggravated by Long-term Exposure:** Chronic respiratory and skin disease, neurological damage, and liver or kidney disorders. **Target Organs:** Skin, CNS, liver, kidney. **Primary Entry Routes:** Inhalation and skin contact. **Acute Effects:** Inhalation symptoms include eye, nose, and throat irritation, headache, dizziness, coughing, staggering, disturbed vision, irregular heartbeat (can result in sudden death), unconsciousness, narcosis, coma, and death due to cardiac or respiratory failure. There is the risk of pulmonary edema (fluid in lungs). Skin contact is irritating and causes defatting, redness and swelling. Vapor contact with the eyes causes irritation, watering eyes and lid inflammation. Splashes to the eyes produces a burning sensation, watering, and lid inflammation. **Chronic Effects:** Repeated skin contact can cause a rash and scaliness. Repeated inhalation may have neurological effects.

FIRST AID *Emergency personnel should protect against contamination.*

Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Do *not* allow victim to rub or keep eyes tightly shut. Immediately consult an ophthamlologist. **Skin:** 1,1-Dichloroethane vaporizes easily and poses an inhalation hazard as well. *Quickly and carefully* remove contaminated clothing; *1,1-dichloroethane is flammable!* Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. After vomiting, give 2 tbsp activated charcoal in 8 oz water to drink.

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

Note to Physicians: Proper ventilation is the main treatment for acute exposure. Be prepared to support respiration if needed. Monitor liver function studies, urine analysis, and creatinine with acute and chronic exposure.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources. Cleanup personnel should protect against inhalation and skin contact. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and using nonsparking tools, place in a suitable container. For large spills, dike far ahead of liquid spill for disposal or reclamation. Do not allow 1,1-dichloroethane to enter confined areas such as a sewer because of potential explosion. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Degradation:** In soil, 1,1-dichloroethane volatilizes rapidly but may leach into groundwater. In water it will volatilize from a pond, lake, or river with a half-life of 6 to 9 days, 5 to 8 days, and 24 to 32 hr, respectively. In the atmosphere it will degrade by reaction with photochemically produced hydroxyl radicals with a 62 day half-life. It may also be carried back to soil via rain.

Ecotoxicity Values: *Artemia salina*, brine shrimp, TLm 320 mg/L/24 hr; *Lagodon rhomboides*, pinperch, TLm 160 mg/L/24 hr; *Poecilia reticulata*, guppies, LC_{50} 202 ppm/7 days.

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

EPA Designations
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U076
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg)
[* per RCRA, Sec. 3001 & CWA, Sec. 307(a)]

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

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH/MSHA-approved respirator. For < 1000 ppm, use any supplied-air respirator or SCBA. For < 2500 ppm, use any supplied-air respirator operated in a continuous flow mode. For < 4000 ppm, use any supplied-air respirator or SCBA with a full facepiece. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent repeated or prolonged skin contact. Polyvinyl alcohol is recommended as suitable material for PPG. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Thoroughly decontaminate personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from ignition sources and incompatibles (Sec. 5). Label containers to indicate the contents' high flammability. Periodically inspect containers for cracks and leaks. To prevent static sparks, electrically ground and bond all equipment used in 1,1-dichloroethane manufacture, use, storage, transfer, and shipping.

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

Administrative Controls: Consider preplacement and periodic medical exams of exposed workers emphasizing the skin, CNS, liver, and kidney. Educate workers about the hazards of 1,1-dichloroethane and the necessary precautions to reduce or prevent exposure.

Transportation Data (49 CFR 172.102)

IMO Shipping Name: 1,1-Dichloroethane
IMO Hazard Class: 3.2
ID No.: UN2362
IMO Label: Flammable Liquid
IMDG Packaging Group: II

MSDS Collection **References:** 73, 89, 101, 103, 126, 127, 131, 132, 133, 136, 140, 148, 149, 153, 159, 162, 163, 164, 167, 168, 171

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

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Material Safety Data Sheets Collection:

Sheet No. 703
1,2-Dichloroethylene

Issued: 4/90

Section 1. Material Identification

1,2-Dichloroethylene Description: An industrial solvent composed of 60% cis- and 40% trans-isomers. Both isomers, cis and trans, are made by partial chlorination of acetylene. Used as a general solvent for organic materials, lacquers, dye extraction, thermoplastics, organic synthesis, and perfumes. The trans-isomer is more widely used in industry than either the cis-isomer or the mixture. Toxicity also varies between the two isomers.
Other Designations: CAS No. 0540-59-0; $C_2H_2Cl_2$; acetylene dichloride; *cis*-1,2-dichloroethylene; *sym*-dichloroethylene; *trans*-1,2-dichloroethylene, dioform.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.

R 1
I 2
S 2
K 1

NFPA

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

Section 2. Ingredients and Occupational Exposure Limits

1,2-Dichloroethylene, ca 100%

OSHA PEL
8-hr TWA: 790 mg/m³, 200 ppm

ACGIH TLV, 1989-90
TLV-TWA: 790 mg/m³, 200 ppm

NIOSH REL, 1987
790 mg/m³, 200 ppm

Toxicity Data*
Rat, oral, LD_{50}: 770 mg/kg; toxic effects not yet reviewed
Frog, inhalation, TC_{Lo}: 117 mg/m³ inhaled for 1 hr affects the peripheral nerve and sensation (flaccid paralysis without anesthesia); behavior (excitement); lungs, thorax, or respiration (respiratory depression)

* See NIOSH, *RTECS* (KV9360000), for additional toxicity data.

Section 3. Physical Data

Boiling Point: 119 °F/48 °C
Melting Point: -56 to -115 °F/-49 to -82 °C/
Vapor Pressure: 180 to 264 torr at 68 °F/20 °C
Vapor Density (Air = 1): 3.4
Molecular Weight: 96.95 g/mol
Specific Gravity (H_2O = 1 at 39 °F/4 °C): 1.27 at 77 °F/25 °C
Water Solubility: Insoluble

Appearance and Odor: A colorless, low-boiling liquid with a pleasant odor.

Section 4. Fire and Explosion Data

Flash Point: 37 °F/2.8 °C, CC	Autoignition Temperature: 860 °F/460 °C	LEL: 5.6% v/v	UEL: 12.8% v/v

Extinguishing Media: Use dry chemical, CO_2, halon, water spray, or standard foam. Water may be ineffective unless used to blanket the fire.
Unusual Fire or Explosion Hazards: This material's vapors are a dangerous fire hazard and moderate explosion hazard when exposed to any heat or ignition source or oxidizer.
Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and a fully encapsulating suit. Vapors may travel to heat or ignition sources and flash back. Stay upwind and out of low areas. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: This material is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: This material is incompatible with alkalies, nitrogen tetraoxide, difluoromethylene, strong oxidizers, and dihypofluorite. When in contact with copper or copper alloys or by reaction with potassium hydroxide, explosive chloroacetylene may be released.
Conditions to Avoid: Addition of hot liquid to cold 1,2-dichloroethylene may cause sudden emission of vapor that could flash back to an ignition source.
Hazardous Products of Decomposition: Thermal oxidative decomposition of 1,2-dichloroethylene can produce highly toxic fumes of chlorine (Cl).

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Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists 1,2-dichloroethylene as a carcinogen.
Summary of Risks: 1,2-Dichloroethylene's most important effect is its irritation of the central nervous system (CNS) and narcosis. This material is toxic by inhalation, ingestion, and skin contact. It is also irritating to the eyes. The trans-isomer at 2200 ppm causes nausea, vertigo, and burning of the eyes. The trans-isomer is twice as potent as the cis-isomer. If renal effects occur, they are transient.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Central nervous system, eyes, respiratory system.
Primary Entry Routes: Inhalation, ingestion, skin and eye contact.
Acute Effects: Inhalation of 1,2-dichloroethylene causes narcosis, respiratory tract irritation, nausea, vomiting, tremor, weakness, central nervous depression, and epigastric (the abdomen's upper midregion) cramps. Contact with the liquid causes eye and skin (on prolonged contact) irritation. Ingestion causes slight depression to deep narcosis.
Chronic Effects: None reported.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed. Have trained personnel administer 100% oxygen, preferably with humidification.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have a *conscious* person drink 1 to 2 glasses of water, then induce repeated vomiting until vomit is clear.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Intravenous injections of calcium gluconate may relieve cramps and vomiting. Treat central nervous system effects symptomatically.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice a 1,2-dichloroethylene spill control and countermeasure plan (SCCP).* Notify safety personnel, remove all heat and ignition sources, evacuate hazard area, and provide adequate ventilation. Cleanup personnel should protect against vapor inhalation and skin or eye contact. Absorb small spills on paper towels. After evaporating the 1,2-dichloroethylene from these paper towels in a fume hood, burn the paper in a suitable location away from combustible material. Collect and atomize large quantities in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 100 lb (45.4 kg) [* per RCRA, Sec. 3001, per Clean Water Act, Sec. 307(a)]†
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1)
† Listed as 1,2-*trans*-dichloroethylene.

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.
Warning: Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. 1,2-dichloroethylene attacks some forms of plastics, rubber, and coatings.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL and ACGIH TLV (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, well-ventilated area away from all incompatible materials (Sec. 5) and oxidizing materials. Outside or detached storage is preferred. If stored inside, place containers in a standard flammable liquids storage cabinet or room. Protect containers from physical damage.
Engineering Controls: Avoid vapor inhalation and skin and eye contact. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. 1,2-dichloroethylene is a dangerous fire hazard. All engineering systems should be of maximum explosion-proof design and electrically grounded and bonded. Provide preplacement questionnaires which emphasize detecting a history of chronic respiratory disease.
Transportation Data (49 CFR 172.101, .102): Not listed

MSDS Collection References: 7, 26, 38, 73, 84, 85, 87, 88, 100, 101, 103, 109, 126, 127, 136, 137
Prepared by: MJ Allison, BS; Industrial Hygiene Review: DJ Wilson, CIH; Medical Review: MJ Hardies, MD

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OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR DIELDRIN

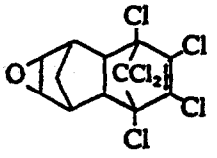
POTENTIAL HUMAN CARCINOGEN

INTRODUCTION

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

SUBSTANCE IDENTIFICATION

- **Formula:** $C_{12}H_8Cl_6O$
- **Structure:**



- **Synonyms:** Dieldrex; dieldrine; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro,endo,exo-1,4:5,8-dimethanonaphthalene; illoxol; octalox
- **Identifiers:** CAS 60-57-1; RTECS IO1750000; DOT 2761
- **Appearance and odor:** Light brown crystals with a mild chemical odor

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 380.90
2. Boiling point (at 760 mmHg): Decomposes
3. Specific gravity (water = 1): 1.75
4. Vapor density (air = 1 at boiling point of dieldrin): 13.2
5. Melting point: 176°C (349°F)
6. Vapor pressure at 20°C (68°F): 1.8×10^{-7} mmHg
7. Solubility in water, mg/l water at 25°-29°C (77°-84°F): 0.186

- **Reactivity**

1. Incompatibilities: Dieldrin may react with concentrated mineral acids, acid catalysts, acid oxidizing agents, phenols, or reactive metals.
2. Hazardous decomposition products: Hydrochloric acid fumes and other chlorinated decomposition products may be released in a fire involving dieldrin.
3. Caution: Dieldrin should be stored in a tightly closed container in a well-ventilated area.

- **Flammability**

Nonflammable

- **Warning properties**

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

EXPOSURE LIMITS

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for dieldrin is 0.25 milligrams of dieldrin per cubic meter of air (mg/m³) as a time-weighted average (TWA) concentration over an 8-hour workshift (Skin). The notation "Skin" refers to the potential contribution to overall exposure by the cutaneous route including the mucous membranes and eyes. The National Institute for Occupational Safety and Health (NIOSH) recommends that dieldrin be controlled and handled as a potential human carcinogen in the workplace and that exposure be minimized to the lowest feasible limt. The NIOSH recommended exposure limit (REL) is 0.15 mg/m³ as a TWA for up to a 10-hour workshift, 40-hour workweek. The NIOSH REL is the lowest concentration reliably detectable by current NIOSH-validated sampling and analytical methods. The American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV®) is 0.25 mg/m³ (Skin) as a TWA for a normal 8-hour workday and a 40-hour workweek (Table 1).

Table 1.—Occupational exposure limits for dieldrin

	Exposure limits mg/m³
OSHA PEL TWA (Skin)*	0.25
NIOSH REL TWA (Ca)†	0.15§
ACGIH TLV® (Skin)	0.25

* (Skin): Potential contribution to overall exposure by the cutaneous route including mucous membranes and eyes.
† (Ca): NIOSH recommends treating as a potential human carcinogen.
§ Lowest reliably detectable level.

NOTE: Most uses of dieldrin were suspended by the Environmental Protection Agency, effective October 18, 1974. The only

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

uses allowed are direct soil application, seed treatment if labeled "not for food use," dipping of plant roots and tops, subsurface termite control, and hot-caps.

HEALTH HAZARD

• Routes of exposure

Dieldrin may cause adverse health effects following exposure via inhalation, ingestion, or dermal or eye contact. Dermal absorption is substantially increased when dieldrin is dissolved in organic solvents.

• Summary of toxicology

1. *Effects on animals:* Acute oral administration of dieldrin to rats caused liver and kidney degeneration. Chronic oral administration of dieldrin produced enlarged livers and increased liver enzyme activities in mice and rats, liver and lung cancers in mice, and adrenal cancer in rats. Dieldrin fed to pregnant mice and hamsters caused increased fetal deaths, congenital anomalies, and growth retardation in the offspring.
2. *Effects on humans:* Dieldrin is a neurotoxin and may cause adverse health effects following exposure via inhalation, ingestion, or dermal or eye contact.

• Signs and symptoms of exposure

1. *Short-term (acute):* Exposure to dieldrin can cause hyperirritability, headache, dizziness, nausea, vomiting, blood in the urine, tremors, convulsions, and coma.
2. *Long-term (chronic):* Exposure to dieldrin can cause dermatitis, weight loss, muscular twitching, and convulsions.

RECOMMENDED MEDICAL PRACTICES

• Medical surveillance program

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

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

• Preplacement medical evaluation

Prior to placing a worker in a job with a potential for exposure to dieldrin, the physician should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic or laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the skin, eyes, liver, kidneys, and hematopoietic (blood-cell-forming), reproductive, and nervous systems.

A preplacement medical evaluation is recommended in order to detect and assess preexisting or concurrent conditions which may be aggravated or result in increased risk when a worker is exposed to dieldrin at or below the NIOSH REL. The examining physician should consider the probable frequency, intensity, and duration of exposure, as well as the nature and degree of the condition, in placing such a worker. Such conditions, which should not be regarded as absolute contraindications to job placement, include: preexisting chronic diseases of the skin, liver, kidneys, and hematopoietic and reproductive systems. Workers should inform their physicians of their potential for exposures to dieldrin because internal absorption of this chemical pathologically increases the liver's ability to metabolize and eliminate medications which may be prescribed or taken "over the counter." The physician should obtain baseline values for liver function tests and a complete blood count with a reticulocyte count.

• Periodic medical screening and/or biologic monitoring

Occupational health interviews and physical examinations should be performed at regular intervals. Additional examinations may be necessary should a worker develop symptoms that may be attributed to exposure to dieldrin. The interviews, examinations, and appropriate medical screening and/or biologic monitoring tests should be directed at identifying an excessive decrease or adverse trend in the integrity and physiologic function of the eyes, skin, liver, kidneys, and hematopoietic, reproductive, and nervous systems as compared to the baseline status of the individual worker or to expected values for a suitable reference population.

• Medical practices recommended at the time of job transfer or termination

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

• Sentinel health events

1. Acute SHE's include: Non-autoimmune hemolytic anemia.
2. Delayed onset SHE's include: Cataract, toxic hepatitis, and non-autoimmune hemolytic anemia.

MONITORING AND MEASUREMENT PROCEDURES

• **TWA exposure evaluation**

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

• **Method**

Sampling and analysis may be performed by collecting dieldrin with glass fiber filters followed by extraction with isooctane and analysis by gas chromatography. A detailed sampling and analytical method for dieldrin may be found in the *NIOSH Manual of Analytical Methods* (method number S283).

PERSONAL PROTECTIVE EQUIPMENT

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

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

SANITATION

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

Change and shower rooms should be provided with separate locker facilities for street and work clothes.

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

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

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

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

COMMON OPERATIONS AND CONTROLS

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

Table 2.—Operations and methods of control for dieldrin

Operations	Controls
During formulation and handling of insecticide	Personal protective equipment, local exhaust ventilation
During maintenance of equipment and storage containers	Personal protective equipment

EMERGENCY FIRST AID PROCEDURES

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

• **Eye exposure**

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

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

• **Skin exposure**

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

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

• **Rescue**

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

SPILLS AND LEAKS

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

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

1. Ventilate area of spill or leak.
2. Dieldrin solid may be collected and placed in an appropriate container.
3. Dieldrin dust may be collected by vacuuming with an appropriate high-efficiency filtration system.
4. For small quantities of liquids containing dieldrin, absorb on paper towels and place in an appropriate container.
5. Large quantities of liquids containing dieldrin may be absorbed in vermiculite, dry sand, earth, or a similar material and placed in an appropriate container.

WASTE REMOVAL AND DISPOSAL

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

RESPIRATORY PROTECTION

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

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

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

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Table 3.—Respiratory protection for dieldrin

Condition	Minimum respiratory protection*
Any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Planned or emergency entry into environments containing unknown or any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Firefighting	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
Escape only	Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister having a high-efficiency particulate filter
	Any appropriate escape-type self-contained breathing apparatus

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

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Section 1. Material Identification

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2,4-Dinitrotoluene [$C_6H_3CH_3(NO_2)_2$] Description: The most important isomer of dinitrotoluene derived by nitration of toluene with nitric acid in the presence of concentrated sulfuric acid to yield about 80% 2,4- and 20% 2,6-isomers from which the 2,4-isomer is not usually separated. Used in manufacturing explosives and dyes, in inorganic synthesis, as a chemical intermediate, a plasticizer, and a modifier for smokeless powders in the munitions industry.
Other Designations: CAS No. 121-14-2, (2,4-dinitrotoluene); CAS No. 25321-14-6 (all isomers), DNT, dinitrotoluol, methyldinitrobenzene, NCI-CO1865.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(TM) for a suppliers list.

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

NFPA
1
3 3
-

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

Cautions: 2,4-Dinitrotoluene is combustible and explosive. This material is highly toxic by skin absorption, inhalation, and ingestion.

Section 2. Ingredients and Occupational Exposure Limits

2,4-Dinitrotoluene, ca 80% 2,4- and 20% 2,6-, with <5% other isomers

1990 OSHA PEL (Skin)
8-hr TWA: 1.5 mg/m³

1990 IDLH Level
200 mg/m³, *all isomers. Treat as a potential human carcinogen.*

1990 NIOSH REL (Skin)
TWA: 1.5 mg/m³, *all isomers**

1991-92 ACGIH TLV (Skin)†
TWA: 1.5 mg/m³, *all isomers*

1990 DFG (Germany) MAK
Danger of cutaneous absorption
MAK-A2

1985-86 Toxicity Data‡
Rat, oral, LD_{50}: 268 mg/kg; toxic effects not yet reviewed
Rat, oral, TD_{Lo}: 2620 mg/kg administered for 78 continuous weeks caused skin and appendage tumors
Rat, oral, TD_{Lo}: 3094 mg/kg administered to a 13-week-old male produced effects on fertility (pre-implantation mortality)

* NIOSH recommends controlling potential carcinogens at the lowest possible level.
† Notice of intended change to 0.15 mg/m³
‡ See NIOSH, *RTECS* (XT1575000), for additional irritation, mutation, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 482 °F (250 °C)
Melting Point: 158 °F (70 °C); decomposes spontaneously at 536 °F (280 °C)
Vapor Pressure: 1 mm Hg at 68 °F (20 °C)
Vapor Density (air = 1): 6.27
Refraction Index: 1.442
Molecular Weight: 182.14
Specific Gravity: 1.3 *liquid*, 1.5 *solid* at 68 °F (20 °C)
Water Solubility: Insoluble
Other Solubilities: Soluble in alcohol, acetone, benzene, carbon disulfide, ether, and pyridine

Appearance and Odor: Orange to yellow crystalline solid or liquid with a slight odor.

Section 4. Fire and Explosion Data

Flash Point: 404 °F (207 °C), CC	Autoignition Temperature: None reported	LEL: None reported	UEL: None reported

Extinguishing Media: For small fires, use dry chemical, carbon dioxide (CO_2), water spray, or regular foam. For large fires, use water spray, fog, or regular foam.
Unusual Fire or Explosion Hazards: 2,4-Dinitrotoluene is combustible and can become highly explosive when exposed to heat, friction, or contamination. 2,4-Dinitrotoluene's explosive energy is approximately 85% of TNT (a well-known, powerful explosive). Closed containers may rupture violently when heated. DNT decomposes spontaneously at 482 °F (250 °C, anaerobic) and 536 °F (280 °C, self-sustaining) and causes an explosion if confined. Contamination of DNT with organic materials lowers the decomposition temperature and increases the risk of explosion.
Special Fire-fighting Procedures: Since fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing is *ineffective* for fires involving DNT. Use extreme caution and fight fire from as far away as possible. Apply cooling water to container sides until long after fire is extinguished. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from area and let fire burn. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: 2,4-Dinitrotoluene is explosive when exposed to heat, friction, or contamination. It can be detonated but only by a very strong initiator. DNT is slightly sensitive to impact shock, with the liquid form less so than the solid form.
Chemical Incompatibilities: 2,4-Dinitrotoluene is incompatible with organic materials; strong reducing agents such as sodium sulphide, zinc powder, sodium hyposulphite, and metallic hydrides; strong oxidizing agents such as bichromates, peroxides, and chlorates (especially during transit); caustics; and metals such as tin and zinc. DNT corrodes some forms of plastics, rubber, and coatings.
Conditions to Avoid: Exposure to heat, friction, and incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of 2,4-dinitrotoluene can produce carbon dioxide (CO_2) and toxic nitrogen oxides (NO_x).

Section 6. Health Hazard Data

Carcinogenicity: In 1990 reports, NIOSH recommends treating dinitrotoluene as a potential human carcinogen. The ACGIH and Germany (DFG) list it as Class A2 (probably carcinogenic to humans) and MAK-A2 (unmistakably carcinogenic in animals only), respectively. However, neither NIOSH, ACGIH, or MAK specify *which* or *how many* isomers are involved.
Summary of Risks: Highly toxic 2,4-dinitrotoluene is dangerous through all routes of human exposure. Skin absorption is more prevalent than inhalation (due to low vapor pressure) and ingestion. Cyanosis and anemia are the usual manifestations of exposure.
Medical Conditions Aggravated by Long-Term Exposure: Persons with blood disorders may be at increased risk.
Target Organs: Blood, liver, central nervous (CNS) and cardiovascular (CVS) systems.
Primary Entry Routes: Skin absorption, inhalation, ingestion.
Acute Effects: Skin absorption and inhalation cause many of the same effects. The major effect of exposure to DNT is cyanosis (a purplish discoloration of skin and mucous membranes due to lack of oxygenated blood) which occurs when methemoglobin (brownish blood pigment of the blood that cannot

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Section 6. Health Hazard Data, *continued*

combine reversibly to molecular oxygen) concentration in the blood reaches 15% or more. Other possible symptoms include headache, irritability, dizziness, weakness, nausea, vomiting, dyspnea (difficulty in breathing), drowsiness, and unconsciousness. If treatment is not prompt, death may occur usually by cardiovascular collapse. Ingestion can cause irritation of mouth and stomach, stomach cramps, and diarrhea. In addition to absorption symptoms, skin contact can cause irritation, small blisters, redness, swelling, ulceration, and necrosis (death of living tissue). Contact with eyes may produce irritation, redness and swelling of eyelids, pain on exposure to light, and severe eye damage. If molten, 2,4-dinitrotoluene can cause thermal burns. Ingestion of alcohol at time of exposure can increase an individual's susceptibility to toxicity.

Chronic Effects: Repeated or prolonged exposure to DNT may cause anemia (a deficiency in red blood cells, hemoglobin, or both). 2,4-Dinitrotoluene affects the liver's drug-metabolizing enzymes and is a liver mutagen and carcinogen in rodents.

FIRST AID *Emergency personnel should protect against contamination.*

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

Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash entire body from head to foot with soap and water. Pay special attention to the hair, scalp, finger and toenails, nostrils, and ear canals. Repeat skin cleansing if the methemoglobin concentration appears to rise after 3 to 4 hr. Carefully dispose of contaminated clothing.

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

Ingestion: Never give anything by mouth to an unconscious or convulsing person. Consult a poison control center. Unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting.

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

Note to Physicians: Determine the methemoglobin concentration in the blood every 3 to 6 hr. Urine excretion of dinitrotoluene in excess of 25 mg/L of urine indicates significant absorption. Consider giving intravenously 10 mL of 1% methylene blue solution at or below a 2-mL/min rate for victims with methemoglobin levels above 20%. Watch patient for 48 hr after apparent recovery to detect relapsing cyanosis and advanced anemia.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off all ignition sources—no flames, flares, or smoking in hazard area. Cleanup personnel should wear fully encapsulating vapor-protective clothing for spills with no fire. Use a water spray to reduce vapors. For small spills, carefully place in suitable, clean, dry containers (steel drums are preferred). Remove containers from area. For large spills, flush area with hot water to remove solid DNT and contain any liquid runoff. Cool and settle solid for disposal in steel drums. Follow applicable OSHA regulations (29 CFR 1910.120).

Environmental Transport: DNT released into water absorbs slightly to sediments and suspended solids with an estimated half-life of 438 days. When released into the atmosphere, DNT has an estimated half-life of 8 hr.

Soil Absorption/Mobility: DNT is slightly mobile in soil.

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

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U105

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Reportable Quantity (RQ), 10 lb (4.54 kg) [* per RCRA, Sec. 3001, Clean Water Act, Sec. 311(b)(4), and Clean Water Act, Sec. 307(a)]

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

Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

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

Section 8. Special Protection Data

Goggles: Wear protective face shields (8-in. minimum), per OSHA eye- and face-protection regulations (29 CFR 1910.133). Since contact lens use in industry is controversial, establish your own policy.

Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, cleaning, and convenient, sanitary storage areas.

Other: Wear chemically protective gloves, boots, aprons, and gauntlets (butyl rubber is the most effective material for protective clothing) to prevent all skin contact.

Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[163]

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

Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Separate contaminated clothing so that personnel who handle, dispose of, or clean it have no direct contact with it. Remove this material from your shoes and clean personal protective equipment.

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

Section 9. Special Precautions and Comments

Storage Requirements: Avoid physical damage to containers. Store in cool, dry, well-ventilated area away from incompatibles. DNT is normally stored as a molten liquid; be sure to keep hot water coils lower than 194 °F (90 °C).

Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control the airborne contaminants and to maintain concentrations at the lowest possible level. Totally enclosed equipment systems are preferred. Be aware of mist escaping from hot charges, leaking lines, steaming operations, and hot drainage ditches because they are sources of serious skin exposure and worker environment contamination.

Administrative Controls: Suggested measures of protection include respiratory protection, job rotation, exposure time limitations, and use of protective clothing and whole body protection. Consider preplacement and periodic medical examinations of exposed workers that include blood and urine analysis, and liver function tests.

Transportation Data (49 CFR 172.102)

IMO Shipping Name: Dinitrotoluenes, solid; Dinitrotoluenes, molten

IMO Hazard Class: 6.1; 6.1

ID No.: UN1600; UN2038

IMO Label: Poison; Poison

IMDG Packaging Group: II; II

MSDS Collection References: 26, 38, 73, 89, 100, 101, 103, 126, 127, 136, 139, 140, 142, 148, 149, 153, 159, 162, 163, 164

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CHEMTOX RECORD 3317 LAST UPDATE OF THIS RECORD: 03/04/91
NAME: 1,3,5,7-TETRAZOCINE, OCTAHYDRO-1,3,5,7-TETRANITRO-
SYNONYMS: CYCLOTETRAMETHYLENETETRANITRAMINE; CYCLOTETRAMETHYLENETETRANITRAMINE, containing at least 10%-25% water (DOT); CYCLOTETRAMETHYLENE TETRANITRAMINE, dry (DOT); HMX; HMX (DOT); beta HMY; HW 4; LX 14-0; OCTOGEN; OKTOGEN; TETRAMETHYLENETETRANITRAMINE; UN 0226 (DOT)
CAS: 2691-41-0 RTECS: XF7450000
FORMULA: C4H8N8O8 MOL WT: 296.20
WLN: T8N CN EN GNTJ ANW CNW ENW GNW
CHEMICAL CLASS: Nitro compound

See other identifiers listed below under Regulations.

PROPERTIES

PHYSICAL DESCRIPTION:
BOILING POINT: NA
MELTING POINT: NA
FLASH POINT: NA
AUTO IGNITION: NA
VAPOR PRESSURE:
UEL: NA
LEL: NA
VAPOR DENSITY: No data
SPECIFIC GRAVITY:
DENSITY: g/cc or 0 lb/gal
WATER SOLUBILITY:

INCOMPATIBILITIES:

REACTIVITY WITH WATER: No data on water reactivity
REACTIVITY WITH COMMON MATERIALS: No data
STABILITY DURING TRANSPORT: No Data
NEUTRALIZING AGENTS: No data
POLYMERIZATION POSSIBILITIES: No data

TOXIC FIRE GASES: None reported other than possible unburned vapors
ODOR DETECTED AT (ppm): Unknown
ODOR DESCRIPTION: Unknown SOURCE: Unspecified
100 % ODOR DETECTION: No data

REGULATIONS

DOT HAZARD CLASS: No class given
DOT GUIDE:
DOT ID NUMBER:
DOT SHIPPING NAME:
STCC NUMBER:

CLEAN AIR ACT: Not covered
EPA WASTE NUMBER:
CERCLA REF:
RQ DESIGNATION: Not listed
SARA TPQ VALUE: Not listed
SARA Sect. 312
categories:
No category

UNITED STATED POSTAL SERVICE MAILABILITY:
Not given

TOXICITY DATA

TARGET ORGANS:
SYMPTOMS: Source:

CONC IDLH: Unknown

NIOSH REL: Not given

'TLV.CALC' LINE 27. [B10] Variable has not been assigned a value. Zero used.
'TLV.CALC' LINE 27. [B10] Variable has not been assigned a value. Zero used.
'TLV.CALC' LINE 28. [B10] Variable has not been assigned a value. Zero used.
'TLV.CALC' LINE 28. [B10] Variable has not been assigned a value. Zero used.
ACGIH TLV: STEL =0 ppm*STEL =0 mg/M3
ACGIH STEL: Not specified

OSHA PEL: Not in Table Z-1-A

CARCINOGEN?: STATUS:

CARCINOGEN LISTS:
IARC: Not listed
MAK: Not listed
NIOSH: Not listed
NTP: Not listed
ACGIH: Not listed
OSHA: Not listed

LD50 value: ori-rat LD50:6490 mg/kg

OTHER SPECIES TOXICITY DATA: (Source: NIOSH RTECS 1990)

ori-rat LD50:6490 mg/kg
ivn-rat LD50:25 mg/kg
unr-rat LD50:7300 mg/kg
ori-mus LD50:1500 mg/kg
unr-mus LD50:2700 mg/kg
ivn-dog LDLo:40 mg/kg
ori-rbt LD50:50 mg/kg
skn-rbt LD50:530 mg/kg
ivn-rbt LD50:10 mg/kg
ori-gpg LD50:300 mg/kg
ivn-gpg LD50:28 mg/kg

Reproductive toxicity (1990 RTECS):
This chemical has no known mammalian reproductive toxicity.

PROTECTION AND FIRST AID

PROTECTION SUGGESTED
FROM THE CHRIS MANUAL:

INITIAL INCIDENT RESPONSE

US Department of Transportation Guide to Hazardous Materials Transport Information - Publication DOT 5800.5 (1990).
DOT SHIPPING NAME:
DOT ID NUMBER:
No guide information for this compound.

Genium Publishing Corporation
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Material Safety Data Sheets Collection:

Sheet No. 758
Iron

Issued: 7/91

Section 1. Material Identification

Iron (Fe) Description: Occurs naturally as the second most abundant metal (~5%) in the earth's crust. Its commercial form usually contains some carbon, phosphorus, silica, sulfur, and manganese. It has four naturally occurring isotopes: 54, 56, 57 and 58, and six artificial ones: 52, 53, 55, 59, 60, and 61. Iron is purified by smelting ore with limestone and coke in blast furnaces (purity 91 to 92 %), or by continuous direct reduction of iron ore with limestone heated to 1699 °F (926 °C), melted at 3499 °F (1926 °C), and then reduced to iron at 2998 °F (1648 °C) with powdered coal (purity 99%). The powder form is obtained by treating ore or scrap metal with hydrochloric acid to give ferrous chloride solution, then filtrating, vacuum crystallizing, dehydrating, and reducing it at 1472 °F (800 °C) to metallic iron (briquettes or powder); or by thermal decomposition of iron carbonyl. Solid iron is used to alloy with carbon, manganese, chromium, nickel, and other elements to form steel. Its radioisotopes (^{55}Fe and ^{59}Fe) are used in biological tracer studies. The powder form is used in metallurgy products, magnets, high-frequency cores, and auto parts; and as a catalyst in ammonia synthesis.
Other Designations: CAS No. 7439-89-6, Ancor En 80/150,® Armco iron,® carbonyl iron, Loha,® Suy B-2.®
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

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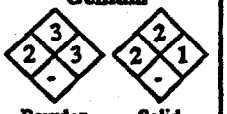

Powder Solid

R	1	HMIS	
I	2	H	2
S	1	F	2
K	1	R	1
		PPG*	
		* Sec. 8	

Cautions: Iron is moderately toxic by ingestion and inhalation of iron dusts and powder. The powder form is pyrophoric (ignites spontaneously upon exposure to air and other substances).

Section 2. Ingredients and Occupational Exposure Limits

Iron, ca 91 to 99%

1990 OSHA PEL	1990-91 ACGIH TLV	1990 NIOSH REL	1985-86 Toxicity Data†
8-hr TWA: 10 mg/m³*	TWA: 5 mg/m³*	5 mg/m³*	Rabbit, intraperitoneal, LD_{Lo}: 20 mg/kg; no toxic effect noted

*As iron oxide fumes.
† See NIOSH, *RTECS* (NO4565500), for additional toxicity data.

Section 3. Physical Data

Boiling Point: 4982 °F (2750 °C)
Melting Point: 2795 °F (1535 °C)
Vapor Pressure: 1 mm Hg at 3248 °F (1787 °C)
Electrical Resistivity: 9.71 μΩ/cm at 68 °F (20 °C)
Molecular Weight: 55.847
Density/Specific Gravity: 7.86 at 68 °F (20 °C)
Water Solubility: Insoluble

Appearance and Odor: Pure, solid iron is a silvery-white or gray, soft, ductile, malleable (can be rolled, hammered, or bent), slightly magnetic (becoming more so as it is alloyed; for example, steel) metal. It is available as ingots, wire, sheets, or powder. The powder form is black-gray.

Section 4. Fire and Explosion Data

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

Extinguishing Media: For small fire, use water spray, carbon dioxide (CO_2), or regular foam. For large fires, use water spray or regular foam. Apply cooling water spray to fires-exposed container sides until fire is well out. If possible with no risk, remove containers from area.
Unusual Fire or Explosion Hazards: Since finely divided iron powder is pyrophoric and ignites upon exposure to air at normal temperatures, fires and dust explosions can occur in ducts or separators used to remove the dust during grinding and polishing operations.
Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Fight fire from as far a distance as possible. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

*Although no flash point or autoignition temperature is reported, remember that the powder form is pyrophoric and can ignite spontaneously in air at room temperatures.

Section 5. Reactivity Data

Stability/Polymerization: Iron is stable in dry air, but readily oxidizes in moist air to form rust. Highly divided powder forms are very unstable and can ignite spontaneously in air.
Chemical Incompatibilities: Solid or powdered iron ignites or explodes on contact with acetaldehyde, ammonium peroxodisulfate, chloroformamidinium, chloric acid, ammonium nitrate, halogens, dinitrogen tetraoxide, nitryl fluoride, polystyrene, sodium acetylide, potassium dichromate, peroxyformic acid, and nitryl fluoride. Hot iron wire burns in chlorine gas and iron with water forms rust.
Conditions to Avoid: Avoid generation of iron dusts and contact with the materials listed above.
Hazardous Products of Decomposition: Thermal oxidative decomposition of iron can produce toxic iron oxide fumes.

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Section 6. Health Hazard Data

Carcinogenicity: In 1990 reports, the IARC, NTP, and OSHA do not list iron as a carcinogen although the mining of one particular ore, hematite, may be associated with an increased risk of lung cancer in miners. No other iron ores are identified specifically as a carcinogen.
Summary of Risks: Occupational exposures usually result from dust or fume inhalation during mining, ore preparation, production, and refining of the metal and its alloys. Acute and chronic toxicity can occur. Although rare, occupational toxicity by ingestion has occurred. Its effects are the same as those by ingestion of large amounts of iron tablets.
Medical Conditions Aggravated by Long-Term Exposure: Chronic respiratory diseases.
Target Organs: Eyes, respiratory tract, liver, and pancreas.
Primary Entry Routes: Eyes, inhalation, and ingestion.
Acute Effects: Inhalation may be irritating to the respiratory tract. Eye contact may cause conjunctivitis (inflammation of the eye's lining), and deposition of iron particles can leave a "rust ring" or brownish stain on the cornea. Iron's acute toxicity results primarily from accidental or suicidal ingestions (e.g., overdose of iron-containing vitamin pills). Initially, the patient may have vomiting, abdominal pain, bloody diarrhea, hematemesis (vomiting blood), lethargy, and shock. After several hours, the patient may improve, but should be observed carefully, as toxicity may progress to development of profound shock, severe acidosis (increased acidity in blood), cyanosis (bluish skin discoloration), and fever. Two to four days after exposure, liver damage may occur. Within several weeks after exposure, in several rare cases, gastrointestinal fibrosis (scarring) has occurred with obstruction of the digestive tract. Iron overdose may be fatal.
Chronic Effects: Chronic inhalation can produce mottling (spotting) of lungs (siderosis). This condition is often without symptoms and has been referred to as "benign radiopaque pneumoconiosis." Ingestion of greater than 50 to 100 mg of iron per day may result in pathological iron deposition in body tissues. Symptoms include fibrosis (scarring) of the pancreas, diabetes mellitus, and liver cirrhosis. Repeated iron ingestion can produce cardiac toxicity.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. Consult poison control center.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Management of iron poisoning by ingestion is complex and beyond this MSDS's scope. Consult a medical toxicologist.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel. Isolate hazard area, deny entry, and stay upwind. Shut off all ignition sources–no flares, smoking, or flames in hazard area. Avoid dust generation by cleaning small spills with a damp mop. Since finely divided iron powder is explosive, take special care during cleanup. For large spills, flush material with a stream of water and dike for later disposal. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed
OSHA Designations
Listed (as iron oxide fumes) as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Since contact lens use in industry is controversial, establish your own policy.
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator.
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent any skin contact.
Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Avoid physical damage to containers. Store in a cool, dry, well-ventilated area away from flammable gases or liquids, oxidizing materials, or organic peroxides (Sec. 5).
Engineering Controls: Avoid dust inhalation. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Regularly service the ducting at grinding and polishing machines and finishing belts to maintain efficiency of exhaust ventilation and prevent explosion. Remote control operations of machinery is advisable when at all possible.

Transportation Data (49 CFR 172.101)
DOT Shipping Name: Iron mass *or* sponge, *not properly oxidized*
DOT Hazard Class: Flammable solid
ID No.: NA1383
DOT Label: Flammable solid
DOT Packaging Exceptions: None
DOT Packaging Requirements: 173.174

MSDS Collection References: 26, 73, 103, 124, 126, 127, 132, 136, 138, 139, 143, 146, 148, 149, 159
Prepared by: M Gannon, BA; Industrial Hygiene Review: DJ Wilson, CIH; Medical Review: MJ Upfal, MD, MPH; Edited by: JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 713
Lead (Inorganic)

Issued: 8/90

Section 1. Material Identification

Lead (Inorganic) (Pb) Description: Exists widely throughout the world in a number of ores. Its main commercial source is galena (lead sulphide). Lead mineral is separated from crude ores by blast-furnace smelting, drossing, or electrolytic refining. Lead is used mostly in manufacturing storage batteries. Other uses are in manufacturing tetraethyllead and both organic and inorganic lead compounds in ceramics, plastics, and electronic devices; in producing ammunition, solder, cable covering, sheet lead, and other metal products (brass, pipes, caulking); in metallurgy; in weights and as ballast; as a chemical intermediate for lead alkyls and pigments; as a construction 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.

R	0	Genium
I	4	
S	-	
K	0	

HMIS
H 3
F 1
R 0
PPG*
* Sec. 8

Cautions: *Inorganic lead is a potent systemic poison.* Organic lead (for example, tetraethyl lead) has severe, but different, health effects. Occupational lead poisoning is due to inhalation of dust and fumes. Major affected organ systems are the nervous, blood, and reproductive systems, and kidneys. Health impairment or disease may result from a severe acute short- or long-term exposure.

Section 2. Ingredients and Occupational Exposure Limits

Lead (inorganic) fumes and dusts, as Pb, ca 100%

1989 OSHA PELs (Lead, inorganic compounds)
8-hr TWA: 50 µg/m³
Action Level TWA*: 30 µg/m³

29 CFR 1910.1025 Lead Standard
Blood Lead Level: 40 µg/100 g

1989-90 ACGIH TLV (Lead, inorganic, fumes and dusts)
TLV-TWA: 150 µg/m³

1988 NIOSH REL
10-hr TWA: <100 µg/m³

1985-86 Toxicity Data†
Human, inhalation, TC_{Lo}: 10 µg/m³ affects gastrointestinal tract and liver
Human, oral, TD_{Lo}: 450 mg/kg ingested over 6 yr affects peripheral and central nervous systems
Rat, oral, TD_{Lo}: 790 mg/kg affects multigeneration reproduction

* Action level applies to employee exposure without regard to respirator use.
† See NIOSH, *RTECS* (OF7525000), for additional mutative, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 3164 °F (1740 °C)
Melting Point: 621.3 °F (327.4 °C)
Vapor Pressure: 1.77 mm Hg at 1832 °F (1000 °C)
Viscosity: 3.2 cp at 621.3 °F (327.4 °C)
Molecular Weight: 207.20
Specific Gravity (20 °C/4 °C): 11.34
Water Solubility: Relatively insoluble in hot or cold water*

Appearance and Odor: Bluish-white, silvery, gray, very soft metal.

* Lead dissolves more easily at a low pH.

Section 4. Fire and Explosion Data

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

Extinguishing Media: Use dry chemical, carbon dioxide, water spray, or foam to extinguish fire.
Unusual Fire or Explosion Hazards: Flammable and moderately explosive in the form of dust when exposed to heat or flame.
Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective equipment. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Lead is stable at room temperature in closed containers under normal storage and handling conditions. It tarnishes on exposure to air. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Mixtures of hydrogen peroxide + trioxane explode on contact with lead. Lead is incompatible with sodium azide, zirconium, disodium acetylide, and oxidants. A violent reaction on ignition may occur with concentrated hydrogen peroxide, chlorine trifluoride, sodium acetylide (with powdered lead), ammonium nitrate (below 200 °C with powdered lead). Lead is attacked by pure water and weak organic acids in the presence of oxygen. Lead is resistant to tap water, hydrofluoric acid, brine, and solvents.
Conditions to Avoid: Rubber gloves containing lead may ignite in nitric acid.
Hazardous Products of Decomposition: Thermal oxidative decomposition of lead can produce highly toxic fumes of lead.

Section 6. Health Hazard Data

Carcinogenicity: Although the NTP and OSHA do not list lead as a carcinogen, the IARC lists it as probably carcinogenic to humans, but having (usually) no human evidence. However, the literature reports instances of lead-induced neoplasms, both benign and malignant, of the kidney and other organs in laboratory rodents. Excessive exposure to lead has resulted in neurologic disorders in infants. Experimental studies show lead has reproductive and teratogenic effects in laboratory animals. Human male and female reproductive effects are also documented.
Summary of Risks: Lead is a potent, systemic poison that affect a variety of organ systems, including the nervous system, kidneys, reproductive system, blood formation, and gastrointestinal (GI) system. The most important way lead enters the body is through inhalation, but it can also be ingested when lead dust or unwashed hands contaminate food, drink, or cigarettes. Much of ingested lead passes through feces without absorption into the body. Adults may absorb only 5 to 15% of ingested lead; children may absorb a much larger fraction. Once in the body, lead enters the bloodstream and circulates to various organs. Lead concentrates and remains in bone for many years. The amount of lead the body stores increases as exposure continues, with possibly cumulative effects. Depending on the dose entering the body, lead can be deadly within several days or affect health after many years. Very high doses can cause brain damage (encephalopathy).
Medical Conditions Aggravated by Exposure: Lead may aggravate nervous system disorders (e.g., epilepsy, neuropathies), kidney diseases, high blood pressure (hypertension), infertility, and anemia. Lead-induced anemia and its effect on blood presssure can aggravate cardiovascular disease.

Continue on next page

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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 Sheet

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GENIUM PUBLISHING CORP.

No. 216

MAGNESIUM METAL
(Ribbons/Turnings)

Issued: August 1987

SECTION 1. MATERIAL IDENTIFICATION

MATERIAL NAME: MAGNESIUM METAL (RIBBONS/TURNINGS)
DESCRIPTION (Origin/Uses): Prepared by electrolysis of a mixture of magnesia and mercuric oxide. Used in alloys of light metals, in pyrotechnics, flashbulbs and flares; as a Grignard reagent; for recovery of titanium.
OTHER DESIGNATIONS: Mg; NIOSH *RTECS* #OM2100000; CAS #7439-95-4
TRADE NAMES/VENDORS: MAGNESIUM METAL, Reade Manufacturing Co.
MANUFACTURER/SUPPLIER: Available from several suppliers, including:
Reade Manufacturing Co., Ridgeway Blvd., Lakehurst, NJ 08733; Telephone: (201) 657-6451
COMMENTS: Combustible magnesium metal in the form of fine powder, thin sheets, and turnings is easily ignited and burns with intense heat. Powders form explosive mixtures in air that can be ignited by a spark.

HMIS			
H	1		
F	3	R	1
R	3	I	1
PPE*		S	1
* See sect. 8		K	4

SECTION 2. INGREDIENTS AND HAZARDS

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

* Current 1987-88 ACGIH TLV

Comments: Primarily hazardous as a combustible metal.

SECTION 3. PHYSICAL DATA

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

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

Appearance and odor: Silvery white metal. Odorless.

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

SECTION 4. FIRE AND EXPLOSION DATA

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

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

SECTION 5. REACTIVITY DATA

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

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SECTION 6. HEALTH HAZARD INFORMATION

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

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

SECTION 8. SPECIAL PROTECTION INFORMATION

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

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

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

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Material Safety Data Sheets Collection:

Sheet No. 148
Manganese Metal/Powder

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

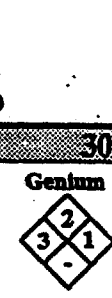
Section 1. Material Identification

30

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

R 1
I 3
S 1
K -

Genium



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

Section 2. Ingredients and Occupational Exposure Limits

Manganese, ca 100%

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

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

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

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

Section 3. Physical Data

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

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

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

Section 4. Fire and Explosion Data

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

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

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

Section 5. Reactivity Data

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

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Section 6. Health Hazard Data

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

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

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

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

Primary Entry: Inhalation, ingestion.

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

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

FIRST AID

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

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

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

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

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

Section 7. Spill, Leak, and Disposal Procedures

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

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

OSHA Designations

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

EPA Designations

RCRA Hazardous Waste (40 CFR 261.33): Not listed

CERCLA Hazardous Substance (40 CFR 302.4): Not listed

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

Listed as a SARA Toxic Chemical (40 CFR 372.65)

Section 8. Special Protection Data

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

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

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

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

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

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

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

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

Section 9. Special Precautions and Comments

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

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

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

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

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

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GENIUM PUBLISHING CORP.

No. 26

MERCURY
(Revision C)
Issued: September 1981
Revised: August 1988

SECTION 1. MATERIAL IDENTIFICATION — 26

Material Name: MERCURY

Description (Origin/Uses): Used in barometers, thermometers, hydrometers, and pyrometers; in mercury arc lamps producing ultraviolet rays; in switches and fluorescent lamps; as a catalyst in oxidations of organic compounds; in alloys; in explosives; and for extracting gold and silver from ore.

Other Designations: Colloidal Mercury; Metallic Mercury; Quicksilver; Hg; Hydrargyrum;
CAS No. 7439-97-6

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

Comments: Inorganic and organic mercury compounds are highly toxic, as is pure mercury.

Genium

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

SECTION 2. INGREDIENTS AND HAZARDS

	%	EXPOSURE LIMITS
Mercury, CAS No. 7439-97-6	Ca 100	**OSHA PEL** Ceiling: 1 mg per 10 m³ **ACGIH TLV (Skin*), 1987-88** TLV-TWA: 0.05 mg/m³ as Hg (Mercury Vapor) **Toxicity Data**** Rabbit, Inhalation, LC_{Lo}: 29 mg/m³ (30 Hrs)

*Mercury can be absorbed through intact skin, which contributes to overall exposure.
**See NIOSH, *RTECS* (OV4550000), for additional data with references to reproductive, mutagenic, and tumorigenic effects.

SECTION 3. PHYSICAL DATA

Boiling Point: 673°F (357°C)
Specific Gravity (H_2O = 1): 13.546 at 68°F (20°C)
Vapor Pressure: 0.0018 Torr at 77°F (25°C)
Water Solubility (%): Insoluble
Molecular Weight: 201 Grams/Mole
Melting Point: -37.93°F (-38.85°C)

Appearance and Odor: A silver, heavy liquid; odorless. **Danger:** Mercury vapor has no warning properties.

SECTION 4. FIRE AND EXPLOSION DATA

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

Extinguishing Media: *Mercury does not burn. Use extinguishing agents that will put out the surrounding fire.

Unusual Fire or Explosion Hazards: When exposed to the high temperatures that occur during a fire, mercury can vaporize to form extremely toxic fumes.

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

Mercury is stable in closed containers at room temperature under normal storage and handling conditions. It cannot undergo hazardous polymerization.

Chemical Incompatibilities: Hazardous reactions involving mercury and acetylene, ammonia, boron phosphodiiodide, chlorine, chlorine dioxide, methyl azide, sodium carbide, nitric acid, oleum, and sulfuric acid are reported (Genium ref. 84).

Conditions to Avoid: Do not expose mercury to incompatible chemicals.

Hazardous Products of Decomposition: Extremely toxic mercury metal fumes are likely to be produced during fires.

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SECTION 6. HEALTH HAZARD INFORMATION

Mercury is not listed as a carcinogen by the NTP, IARC, or OSHA.
Summary of Risks: Mercury is very toxic due to its liquid and fat solubility, lack of charge, and membrane permeability. It is a slowly cumulative poison that concentrates in the brain, kidneys, and liver. It is very hazardous when spilled or heated. Mercury and its vapor are rapidly absorbed by the membranes lining the respiratory tract, the gastrointestinal (GI) tract, and the skin. Mercury is a teratogen (causes physical defects in embryos). **Medical Conditions Aggravated by Long-Term Exposure:** Preexisting problems of the target organs can be worsened. Provide preplacement and periodic medical exams emphasizing the target organs. **Target Organs:** Skin, eyes, respiratory system, central nervous system (CNS), kidneys. **Primary Entry:** Skin absorption/contact, inhalation. **Acute Effects:** Erosion of the respiratory/GI tracts, nausea, vomiting, bloody diarrhea, shock, headache, metallic taste. Inhalation of high concentrations for short periods can cause pneumonitis, chest pain, dyspnea, coughing, stomatitis, gingivitis, and salivation. **Chronic Effects:** Tremors, emotional problems, loss of concentration, depression, drowsiness, fatigue, insomnia, loss of memory, kidney problems, eye lesions, vision disturbances, sore mouth and throat, problems with the sense of taste or smell, nosebleeds, nasal inflammation, loss of weight or appetite, poor hand-eye coordination, awkwardness, and unsteadiness, as well as dermatitis. **FIRST AID: Eyes.** Immediately flush eyes, including under the eyelids, gently but thoroughly with plenty of running water for at least 15 minutes. **Skin.** Immediately wash the affected area with soap and water because of the increased exposure from skin absorption. **Inhalation.** Remove exposed person to fresh air; restore and/or support his or her breathing as needed. Have medical personnel administer oxygen to treat the chemical pneumonitis that may develop. **Ingestion.** Never give anything by mouth to someone who is unconscious or convulsing. Note to physician: If indicated by degree of ingestion, saline cathartics and charcoal should be used. Chelation therapy with d-penicillamine may also be indicated.

GET MEDICAL HELP (IN PLANT, PARAMEDIC, COMMUNITY) FOR ALL EXPOSURES. Seek prompt medical assistance for further treatment, observation, and support after first aid. Treatment of chronic mercury poisoning requires expert medical care. At the first signs, immediately remove the exposed person from further exposure and have him or her examined and treated by a physician trained in occupational mercury poisoning.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, restrict access to the spill area to necessary personnel, and provide adequate ventilation. Clean up spills promptly. Specialized equipment and/or techniques may be required to safely deal with large mercury spills; if large quantities of mercury are used in the workplace, detailed, prior spill-management planning is recommended. Collect spilled mercury by using a suction pump and an aspirator bottle with a long capillary tube. For finely divided mercury in inaccessible cracks, corners, etc., treatment with calcium polysulfide and excess sulfur is recommended to convert the mercury globules into mercury sulfide. Vacuum cleaners may be used if they are equipped with specially designed mercury-absorbent exhaust filters. Collect the mercury into tightly sealed containers for later disposal or reclamation. Cleanup personnel must use the recommended personal protective equipment (see sect. 8).
Waste Disposal: Consider reclamation, recycling, or destruction rather than disposal in a landfill. Do not pour mercury down a drain. Mercury is very harmful to the environment. Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations
Air Contaminant (29 CFR 19010.1000 Subpart Z)

EPA Designations (40 CFR 302.4)
RCRA Hazardous Waste No. U151
CERCLA Hazardous Substance, Reportable Quantity: 1 lb (0.454 kg)*

*Per the Clean Water Act, § 407 (a); Clean Air Act, § 112; and Resource Conservation and Recovery Act, § 3001.

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing of mercury may occur, wear a full face shield or splash guard. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Use a NIOSH-approved respirator per the *NIOSH Pocket Guide to Chemical Hazards* for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow OSHA respirator regulations (29 CFR 1910.134). **Other:** Wear impervious gloves, boots, aprons, gauntlets, etc., to prevent any contact with mercury and the skin.
Ventilation: Install and operate general and local ventilation systems powerful enough to continuously maintain airborne levels of mercury below the OSHA PEL standard cited in section 2.
Safety Stations: Make emergency eyewash stations, washing facilities, and safety/quick-drench showers available in work areas.
Contaminated Equipment: Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them. Do *not* wear contact lenses in any work area. Remove contaminated clothing and launder it before wearing it again; clean mercury from shoes and equipment. Separate work and street clothes; store work clothes in special lockers and always shower before changing to street clothes.
Comments: Practice good personal hygiene; always wash thoroughly after using this material. Keep it off of your clothing and equipment. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do *not* eat, drink, or smoke in any work area.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store mercury in a cool, dry, well-ventilated area in tightly closed unbreakable polyethylene containers. Protect these containers from physical damage.
Special Handling/Storage: Construct storage areas to have smooth, hard, nonporous floors with no cracks or spaces so that spilled mercury globules do not form in inaccessible areas.
Comments: Mercury evaporates slowly, but if it is spilled it can form many tiny globules that evaporate much faster than a single pool of it will. In an unventilated area, significant concentration of mercury vapor can develop from this enhanced evaporation effect. This poisonous vapor is particularly hazardous if breathed over a long period of time, so spills or releases of mercury require very meticulous cleaning procedures.
Transportation Data (49 CFR 172.101-2)

DOT Shipping Name: Mercury, Metal	**DOT Label:** None	**IMO Class:** 8
DOT Hazard Class: ORM-B	**DOT ID No.** NA2809	**IMO Label:** Corrosive

References: 1, 2, 8, 26, 38, 84-94, 100.

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Material Safety Data Sheets Collection:

Sheet No. 311
Methyl Chloroform

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

Section 1. Material Identification

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

R	1	Genium
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HMIS
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* Sec. 8

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

Section 2. Ingredients and Occupational Exposure Limits

Methyl chloroform, ca 92 to 97%*

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

1990 IDLH Level
1000 ppm

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

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

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

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

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

Section 3. Physical Data

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

Section 4. Fire and Explosion Data

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

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

Section 5. Reactivity Data

Stability/Polymerization: Methyl chloroform is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization can occur in contact with aluminum trichloride.
Chemical Incompatibilities: Methyl chloroform is incompatible with sodium hydroxide, nitrogen tetroxide, oxygen (liquid or gas), strong oxidizers, and chemically active metals like aluminum, zinc, and magnesium powders; reacts violently with caustics to form dichloroacetylene; reacts slowly with water to form hydrochloric acid; forms shock sensitive mixtures with potassium; and polymerizes in contact with aluminum trichloride.
Conditions to Avoid: Exposure to moisture, strong ignition sources, and arc-welding units, and contact with incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition (temperatures >500 °F, contact with hot metals, or under UV rays) of methyl chloroform can produce carbon dioxide (CO_2) and toxic dichloroacetylene, hydrogen chloride, and phosgene gases.

Section 6. Health Hazard Data

Carcinogenicity: The IARC (Class 3, inadequate evidence),[164] NTP,[142] and OSHA[164] do not list methyl chloroform as a carcinogen.
Summary of Risks: Methyl chloroform is considered one of the least toxic of the liquid chlorinated hydrocarbons. It is irritating to eyes, skin, and respiratory tract. Although low in systemic toxicity, methyl chloroform is an anesthetic capable of causing death at high concentrations (>15,000 ppm), generally in poorly ventilated, enclosed areas. Quick and complete recovery is observed after prompt removal of unconscious persons from area of exposure. Like many other solvents, methyl chloroform sensitizes the heart to epinephrine (blood pressure-raising hormone) and may induce cardiac arrhythmias and arrest.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Skin, eyes, central nervous (CNS) and cardiovascular (CVS) systems.

Continue on next page

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Section 6. Health Hazard Data, *continued*

Primary Entry Routes: Inhalation, skin contact. **Acute Effects:** Methyl chloroform defats the skin causing irritation, redness, dryness, and scaling. Contact with eyes produces irritation and mild conjunctivitis. Vapor inhalation can cause headache, dizziness, equilibrium disturbances, and in high concentrations may lead to CNS depression, unconsciousness, and coma. During a 60-min exposure period these effects are observed: 100 ppm is the observed odor threshold, at 500 ppm there is obvious odor and decreased reaction time, 1000 ppm causes slight equilibrium loss, at 5000 ppm there is definite incoordination, and 20,000 ppm produces surgical strength anesthesia with possible death. Mild liver and kidney dysfunction may occur after CNS depression recovery. Although unlikely, if ingestion occurs, symptoms include nausea, vomiting, diarrhea, and possible esophageal burns. The acute lethal human dose is ~500 to 5000 mg/kg. **Chronic Effects:** None reported.

FIRST AID

Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. *Do not* allow victim to rub or keep eyes tightly shut. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician.

Inhalation: Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center, and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. When deciding whether to induce vomiting, carefully consider amount ingested, time since ingestion, and availability of medical help. If large amounts are recently ingested (absorption into the body is not yet likely to have occurred), and medical help or transportation to a medical facility is not readily available, induce vomiting. Otherwise, vomiting is not recommended since aspiration of vomitus can produce chemical pneumonitis.

Note to Physicians: Do not use adrenaline or sympathomimetic amines in treatment because of the increased cardiac sensitivity involved.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate area, deny entry, and stay upwind. Shut off all ignition sources. If possible without risk, shut off leak. Cleanup personnel should wear fully encapsulating vapor-protective clothing. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material. Using nonsparking tools, place in suitable containers for disposal or reclamation. For large spills, dike far ahead of liquid spill for later disposal or reclamation. Report any release in excess of 1000 lb. Follow applicable OSHA regulations (29 CFR 1910.120).

Environmental Transport: In water, methyl chloroform's half-life is hours to weeks depending on wind and mixing conditions. It is very persistent in groundwater. On land it volatilizes due to its high vapor pressure and leaches extensively. When released to the atmosphere, methyl chloroform can be transported long distances and returned to earth via rain. It is slowly degraded by reaction with hydroxyl radicals and has a half-life of 6 months to 25 years. The Natural Resources Defenses Council reported recently that methyl chloroform depletes ozone.

Ecotoxicity Values: *Pimephales promelas* (fathead minnow), LC_{50}: 52.8 mg/L/96 hr; *Poecilia reticulata* (guppy), LC_{50}: 133 ppm/7 day.

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

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U226

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Reportable Quantity (RQ), 1000 lb (454 kg) [* per RCRA, Sec. 3001, CWA, Sec. 307(a), and CAA, Sec. 112]

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

Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

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

Section 8. Special Protection Data

Goggles: Wear splash-proof, protective chemical safety goggles or faceshields, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy.

Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

Other: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent repeated or prolonged skin contact. Viton and butyl rubber [with breakthrough times (BTs) of >8 hr and 4 to 7.9 hr, respectively] are recommended materials for protective gear. *Do not use* neoprene, polyvinyl chloride (PVC), natural rubber, or polyethylene because these materials have a BT of <1 hr.

Ventilation: Provide general and local exhaust (in some cases, explosion-proof) ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into work area by controlling it at its source.[103]

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

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

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

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in cool, dry, well-ventilated (use pressure-vacuum ventilation) area away from ignition sources, arc-welding operations, and incompatibles (Sec. 5). Regularly monitor inhibitor levels. *Do not* store in aluminum containers or use pressure-spraying equipment when methyl chloroform is involved.

Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. To prevent static sparks, electrically ground and bond all equipment used in methyl chloroform manufacturing, use, storage, transfer, and shipping.

Administrative Controls: Consider preplacement and periodic medical exams of exposed workers that emphasize CNS, CVS, liver and skin.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: 1,1,1-Trichloroethane
DOT Hazard Class: ORM-A
ID No.: UN2831
DOT Label: None
DOT Packaging Exceptions: 173.505
DOT Packaging Requirements: 173.605

IMO Shipping Name: 1,1,1-Trichloroethane
IMO Hazard Class: 6.1
ID No.: UN2831
IMO Label: St. Andrews Cross
IMDG Packaging Group: III

MSDS Collection References: 26, 38, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 148, 153, 159, 162, 163, 164

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Material Safety Data Sheet

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GENIUM PUBLISHING CORP.

No. 303
METHYL ETHYL KETONE
(Revision C)

Issued: September 1979
Revised: March 1986

SECTION 1. MATERIAL IDENTIFICATION

MATERIAL NAME: METHYL ETHYL KETONE

OTHER DESIGNATIONS: MEK, Butanone, 2-Butanone, Ethyl Methyl Ketone, $CH_3COCH_2CH_3$, ASTM D740, CAS #0078-93-3

MANUFACTURER/SUPPLIER: Available from many suppliers, including:
Ashland Chemical Company, Industrial Chemicals & Solvents Div., PO Box 2219, Columbus, OH 43216;
Telephone: (614) 889-3844

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

SECTION 2. INGREDIENTS AND HAZARDS

	%	HAZARD DATA
Methyl Ethyl Ketone; (C_4H_8O)	ca 100	8-hr TWA 200 ppm* or 590 mg/m^3
		Human, Inhalation TCLo: 100 ppm/5 min.
* Current OSHA PEL and ACGIH (1985-86) TLV. NIOSH (1978) proposed a 10-hr TWA of 200 ppm.		Rat, Oral, LD_{50}: 2.7 g/kg
		Rabbit, Skin, LD_{50}: 13 g/kg

SECTION 3. PHYSICAL DATA

Boiling Point, 1 atm ... 176°F (80°C)
Vapor Pressure @ 20°C ... 72
Vapor Density (Air = 1) ... 2.5
Viscosity @ 25°C, cp ... 0.40
Solubility in Water @ 20°C, wt. % ... 27.1

Specific Gravity (20/4°C) ... 0.805
Volatiles, vol. % ... ca 100
Evaporation Rate (BuAc = 1) ... 5.7
Freezing Point ... -122.8°F (-86°C)
Molecular Weight ... 72.12

Appearance and odor: Colorless liquid with a moderately sharp, fragrant, mintlike odor. Unfatigued, odor recognition threshold (100% of test panel) is 6-10 ppm.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temp.	Flammability Limits In Air % by Vol.	LOWER	UPPER
20°F (-6.7°C) CC	960°F (516°C)		1.8	10.0

EXTINGUISHING MEDIA: Dry chemical, carbon dioxide, alcohol foam, water spray. Use water spray to disperse vapors and to flush spills away from exposures. A stream of water can scatter flames. Water may be ineffective in extinguishing fire but should be used to help control fire and keep fire-exposed containers cool. Methyl ethyl ketone is a dangerous fire hazard and a moderate explosion hazard when exposed to heat or flame. Vapors can flow along surfaces to a distant ignition source and flash back.

Fire fighters should wear self-contained breathing apparatus in enclosed areas.

SECTION 5. REACTIVITY DATA

Methyl ethyl ketone is a stable material in closed containers at room temperature under normal storage and handling conditions. It does not polymerize.

This material is an OSHA Class IB Flammable Liquid. It is incompatible with oxidizing agents that can cause spontaneous ignition and violent reaction. Ignition is caused by reaction with potassium t-butoxide.

Thermal-oxidative degradation products can include carbon monoxide, carbon dioxide, and various hydrocarbons.

MEK can attack many plastics, resins, and rubber.

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SECTION 6. HEALTH HAZARD INFORMATION | TLV

Methyl ethyl ketone is not listed as a carcinogen by the NTP, IARC, or OSHA. Inhalation of methyl ethyl ketone vapors can irritate the eyes, nose, and respiratory tract. Exposure to high concentrations will produce headache; dizziness; and, in extreme cases, unconsciousness. It can have a narcotic effect; however, its irritancy will often preclude exposure to narcotic concentrations. Prolonged or repeated skin contact may cause drying, cracking, irritation, and dermatitis. Eye contact may cause irritation and burning sensations. Ingestion can irritate the digestive tract; ingestion of several ounces can cause narcosis and acidosis.**

FIRST AID: SKIN CONTACT: Wash area of contact with soap and water. Remove contaminated clothing immediately. EYE CONTACT: Immediately wash with plenty of water, including under the eyelids. If irritation persists, get medical attention. INHALATION: Remove victim to fresh air. If required, restore breathing. Keep warm and at rest. Get immediate medical attention! INGESTION: If victim is conscious and medical help is not readily available, give him 3 glasses of water or milk to drink to induce vomiting. Get medical help as soon as possible* with special attention to acidosis.**

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

** P.G. Kopelman, "Severe Metabollic Acidosis After Ingestion of Butanone," *Brit. Med. J.* 286 (1986):21

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Notify safety personnel and implement containment procedures. Remove all sources of heat or ignition. Provide optimum (explosion-proof) ventilation.

Cleanup personnel should use protection against inhalation of vapors and contact with liquid. Use foam to control vapors. Contain spills using absorbent material (dry sand or vermiculite). Use nonsparking tools. Mix well and place in appropriate container for disposal. Flush trace residues with much water. Do not flush to sewers or open waterways.

DISPOSAL: Waste may be burned in an approved incinerator or disposed of by a licensed disposal firm. Follow Federal, state, and local regulations.

EPA Hazardous Waste No. U159 (40 CFR 261); the primary hazardous properties of MEK are ignitability and toxicity (40 CFR 261.33).

SECTION 8. SPECIAL PROTECTION INFORMATION

Provide general and local exhaust fume ventilation to met TLV requirements. Exhaust hoods should have a minimum velocity of 100 lfm (linear feet per minute). Exhaust fans and other electrical services must be of explosion-proof construction.

For emergency and nonroutine work above the TLV an approved, full-facepiece, organic-vapor, canister gas mask is recommended; but for unknown concentrations or those above or about 3000 ppm, self-contained or air-supplied respirators (positive pressure) are needed.

Use chemical safety goggles where liquid contact with the eyes is possible. Do not use contact lenses when working with solvents; soft lenses may absorb irritants and all lenses concentrate them. Use impervious gloves. Where splashing may occur, use a face shield, apron, and other protective clothing as needed to prevent skin contact. An eyewash station must be available near the workplace. A safety shower is desirable when large amounts of this material are used. Methyl n-butyl ketone has caused neurotoxic effects, and studies have shown that MEK may trigger these effects. (K. Saida, et al., *J. Neuropathology and Exp. Neurology* 35 [May 1976]: 207).

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Store in a clean, cool, well-ventilated area away from heat, ignition, and oxidizing agents. Containers should be electrically interconnected and grounded for liquid transfers to prevent static sparks. Storage and use areas should be No Smoking areas. Use nonsparking tools. Small amounts should be handled in approved safety cans with proper labeling. Emptied containers may retain hazardous product residues (vapor or liquid). Electrical services must meet code requirements.

Avoid skin and eye contact. Avoid breathing vapors. Do not ingest. Avoid contact with copper or copper-bearing materials. Wash thoroughly after handling.

DOT Classification: Flammable Liquid ID No.: UN1193 Label: Flammable Liquid

Data Source(s) Code: 1-9, 12, 14, 19-21, 23, 26, 27, 34, 38, 47, 82, 84. CK

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Approvals

Indust. Hygiene/Safety

Medical Review

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Material Safety Data Sheet

from Genium's Reference Collection
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GENIUM PUBLISHING CORP.

No. 310
METHYLENE CHLORIDE
(Revision F)

Issued: September 1985
Revised: November 1988

SECTION 1. MATERIAL IDENTIFICATION

27

Material Name: METHYLENE CHLORIDE

Description (Origin/Uses): Used widely in paint removers, as a solvent for plastics, as a degreasing agent, in propellant mixtures for aerosol sprays, and as a blowing agent in foams.

Other Designations: Dichloromethane; Freon 30®; Methane Dichloride; Methylene Bichloride; Methylene Dichloride; CH_2Cl_2; CAS No. 0075-09-2

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

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

NFPA
1 2 0 -

SECTION 2. INGREDIENTS AND HAZARDS/EXPOSURE LIMITS

Methylene Chloride, ca 100%

OSHA PEL
8-Hour TWA: 500 ppm
Ceiling: 1000 ppm Acceptable Maximum Peak above the Ceiling: 2000 ppm for 5 Minutes in Any 2-Hour Period

ACGIH TLV, 1988-89
TLV-TWA: 50 ppm, 175 mg/m³
(Adopted 1988-89)

Toxicity Data*
Rat, Oral, LD_{50}: 2136 mg/kg
Human, Inhalation, TC_{Lo}: 500 ppm (8 Hours)

*See NIOSH, *RTECS* (PA8050000), for additional data with references to irritative, reproductive, mutagenic, and tumorigenic effects.

SECTION 3. PHYSICAL DATA

Boiling Point: 103.55°F (39.75°C) at 76 Torrs
Melting Point: -142°F (-96.7°C)
Vapor Density (Air = 1): 2.9
Vapor Pressure: 440 Torrs at 77°F (25°C)

Molecular Weight: 84.94 Grams/Mole
Solubility in Water (%): 1% by Weight
Specific Gravity (H_2O = 1): 1.3255 at 68°F (20°C)
% Volatile by Volume: Ca 100

Appearance and Odor: A clear, colorless, volatile liquid; distinctive, penetrating, ethereal odor. The odor will not serve as a useful warning property because concentrations of 100 ppm are not easily perceptible. Most persons can detect this odor at above 300 ppm.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point*	Autoignition Temperature: 1033°F (556°C)	LEL: 12% v/v	UEL: 19% v/v

Extinguishing Media: *Methylene chloride is not flammable under ordinary conditions. However, flammable vapor-air mixtures can form at approximately 212°F (100°C). Use water spray to cool fire-exposed containers and to flush spills away from exposures. Use extinguishing agents that will put out the surrounding fire. **Unusual Fire or Explosion Hazards:** Methylene chloride vapor is heavier than air and may collect and concentrate in low-lying, confined spaces. The high vapor pressure of methylene chloride means that when it is spilled, its vapor concentration in air can increase rapidly. If this vapor is heated, an explosion hazard is associated with the vapor-air mixture. Containers of this material may rupture violently if they are involved in fires. **Special Fire-fighting Procedures:** Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode.

SECTION 5. REACTIVITY DATA

Stability/Polymerization: Methylene chloride is stable in closed containers during routine operations. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Methylene chloride can react dangerously with nitrogen tetroxide, liquid oxygen, potassium, sodium, sodium-potassium alloys, lithium, potassium hydroxide with N-methyl-N-nitroso urea, potassium *t*-butoxide, and finely powdered aluminum and magnesium. **Conditions to Avoid:** Avoid all exposure to sources of ignition, heat, and incompatible chemicals. Prolonged exposure to water may cause hydrolysis to highly corrosive hydrochloric acid when the temperature is above 140°F (60°C). In oxygen-enriched atmospheres or when heated (>212°F [100°C]), methylene chloride vapor can be readily ignited. **Hazardous Products of Decomposition:** Exposure to high temperature (from open flame, hot surfaces, uninsulated steam lines, welding arcs, etc.) can produce toxic and corrosive thermal-oxidative products of decomposition such as hydrogen chloride, carbon monoxide, and even small quantities of phosgene gas, which is extremely poisonous.

SECTION 6. HEALTH HAZARD INFORMATION

Carcinogenicity: Methylene chloride is listed as a suspected human carcinogen by the ACGIH (which classifies it as a group A2 carcinogen). **Summary of Risks:** Accidental contact of liquid methylene chloride with skin or eyes causes painful irritation and possible burns if not promptly removed. Exposure by way of contaminated gloves, clothing, or paint remover formulations can produce these same irritant effects. Long-term exposure to mild or moderate doses of methylene chloride may cause a delayed (24 to 48 hours) onset of dizziness, headache, mental confusion, slurred speech, double vision, and sleeplessness. Medical recovery can be slow. Overexposure to methylene chloride can cause elevated levels of carboxy hemoglobin in the blood (this same effect results from overexposure to carbon monoxide). **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Skin, eyes, respiratory system, CNS, liver, kidneys, and blood. **Primary Entry:** Inhalation, skin contact/absorption. **Acute Effects:** Headache, giddiness, stupor, irritability, fatigue, tingling in the limbs, and narcosis that is not usually fatal if the exposure is terminated before anesthetic death occurs. **Chronic Effects:** The ACGIH classification of this material as a suspected human carcinogen implies that cancer is a possible effect of chronic exposure to methylene chloride. **FIRST AID:** Eyes. Immediately flush eyes, including under the eyelids, gently but thoroughly with

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SECTION 6. HEALTH HAZARD INFORMATION, cont.

flooding amounts of running water for at least 15 minutes. Skin. Rinse the affected area with flooding amounts of water and then wash it with soap and water. Inhalation. Remove the exposed person to fresh air; restore and/or support his or her breathing as needed. Have qualified medical personnel administer oxygen as required. Note to Attending Physician: Do not administer adrenalin. Ingestion. Unlikely. Should this type of exposure occur, do not induce vomiting because of the danger of aspiration. If spontaneous vomiting should occur, position the exposed person's head below his or her trunk to resist aspiration. Get medical help (in plant, paramedic, community) for all exposures. Seek prompt medical assistance for further treatment, observation, and support after first aid. Note to Physician: Absorbed methylene chloride is stored in body fat and metabolizes to carbon monoxide. This produced carbon monoxide increases and sustains carboxyhemoglobin levels in the blood, which concommitantly reduces the oxygen-carrying capacity of the blood. NIOSH advises preplacement and annual medical exams that emphasize liver, kidney, eye, skin, CNS, and respiratory system functions and a complete blood count. Simultaneous exposure to tobacco smoke, alcohol, and carbon monoxide, along with heavy manual labor, increases the body burden of a worker as well as the toxic hazards of the methylene chloride. In significant exposures, serum methylene chloride levels are of no clinical importance. Neurologic and hepatic status as well as carboxy hemoglobin should be monitored.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, evacuate unnecessary personnel, eliminate all sources of ignition immediately, and provide adequate explosion-proof ventilation. Cleanup personnel need protection against this liquid's contact with the skin or eyes as well as inhalation of its vapor. Contain large spills and collect waste or absorb it with an inert material such as sand, earth, or vermiculite. Use nonsparking tools to place waste liquid or absorbent into closable containers for disposal. Keep waste out of sewers, watersheds, and waterways. **Waste Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000 Subpart Z).
EPA Designations (40 CFR 302.4)
RCRA Hazardous Waste, NO. U080
CERCLA Hazardous Substance, Reportable Quantity: 1000 lbs (454 kg), per the Clean Water Act (CWA), § 307 (a), and the Resource Conservation and Recovery Act (RCRA), § 3001.

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing is possible, wear a full face shield. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Use a NIOSH-approved respirator per Genium reference 88 for the maximum-use concentrations and/or exposure limits cited in section 2. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (spills or cleaning reactor vessels and storage tanks), wear an SCBA. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious neoprene, PVA, or Viton gloves, boots, aprons, and gauntlets, etc., to prevent any skin contact with liquid methylene chloride. **Ventilation:** Install and operate general and local maximum, explosion-proof ventilation systems powerful enough to maintain airborne levels of acetone below the exposure limits cited in section 2. Local exhaust ventilation is preferred because it prevents dispersion of the contaminant into the general work area by eliminating it at its source. Consult the latest edition of Genium reference 103 for detailed recommendations. Floor or sump ventilation may be necessary. **Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work areas. **Contaminated Equipment:** Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Do *not* wear contact lenses in any work area. Remove contaminated clothing and launder it before wearing it again; clean this material from shoes and equipment. **Other:** Because the health effects of carbon monoxide and methylene chloride are additive (see sect. 6), workplaces should be equipped with automatic sensing equipment that identifies workroom atmospheric levels of both of these materials. **Comments:** Practice good personal hygiene; always wash thoroughly after using this material and before eating, drinking, smoking, using the toilet, or applying cosmetics. Keep it off your clothing and equipment. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do *not* eat, drink, or smoke in any work area. Do not inhale methylene chloride vapor.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store methylene chloride in closed, moisture-proof containers in a cool, dry, well-ventilated area away from sources of ignition, strong oxidizers, caustics, and incompatible chemicals (see sect. 5). Protect containers from physical damage. **Special Handling/Storage:** Prevent moist air from entering storage containers. Provide ventilation at the floor level in storage areas because methylene chloride vapor is denser than air. Installation of a dryer and a safety seal on each tank is recommended. Aluminum is not recommended for use as a storage material; appropriate storage materials include galvanized iron, black iron, or steel. **Engineering Controls:** Make sure all engineering systems (production, transportation) are of maximum explosion-proof design. Electrically ground and bond all containers and pipelines used in shipping, transferring, reacting, production, and sampling operations to prevent generating static sparks.

Transportation Data (49 CFR 172.101-2)
DOT Shipping Name: Dichloromethane *or* Methylene Chloride
DOT Hazard Class: ORM-A
ID No. UN1593
DOT Packaging Requirements: 49 CFR 173.605
DOT Packaging Exceptions: 49 CFR 173.505

IMO Shipping Name: Dichloromethane
IMO Hazard Class: 6.1
IMO Label: Saint Andrew's Cross (X)*
IMDG Packaging Group: III

*Harmful-Stow away from Foodstuffs.

References: 1, 26, 38, 84-94, 100, 116, 117, 120, 122.

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Prepared by PJ Igoe, BS
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Material Safety Data Sheets Collection:

Sheet No. 723
Nickel Metal

Issued: 8/90

Section 1. Material Identification

Nickel (Ni) Description: Found in ores in combination with sulphur, oxygen, antimony, arsenic, and/or silica. The Orford (sodium sulfide and electrolysis) and the Mond (nickel carbonyl) processes are used to refine nickel. Used in electroplating, casting operations for machine parts, manufacturing acid-resisting and magnetic alloys and tapes, synthesizing acrylic esters; in surgical and dental prostheses, coinage, catalytic gasification 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*[75] 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	4 / 2 / 0	1 / 2 / 0 / -
I	3		
S	2		
K	1		
		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/m³	TLV-TWA: 1 mg/m³	0.015 mg/m³	Dog, intravenous, LD_{Lo}: 10 mg/kg Guinea pig, oral, LD_{Lo}: 5 mg/kg Rat, implant, TD_{Lo}: 250 mg/kg

* See NIOSH, *RTECS* (QR5950000), for additional mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 4946 °F (2730 °C)
Melting Point: 2651 °F (1455 °C)
Vapor Pressure: 1 mm at 3290 °F (1810 °C)
Atomic Weight: 58.71
Density: 8.90 at 25 °C
Water Solubility: Insoluble

Appearance and Odor: A silvery-white, hard, malleable and ductile metal.

Section 4. Fire and Explosion Data

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

Extinguishing Media: Smother with suitable dry powder or use large amounts of water.
Unusual Fire or Explosion Hazards: Nickel is combustible as dust or powder. Raney nickel ignites spontaneously in air. Nickel carbonyl (*MSDS Collection*, No. 226), a highly toxic substance, may form under fire conditions.
Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since nickel dust or powder is toxic if inhaled, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective equipment. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Nickel is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Nickel can react violently with fluorine, ammonium nitrate, hydrogen + dioxane, performic acid, selenium, sulfur, ammonia, hydrazine, phosphorus, and titanium + potassium chlorate. Nickel is also incompatible with oxidants. Raney nickel catalysts may initiate hazardous reactions with sulfur compounds, *p*-dioxane, hydrogen, hydrogen + oxygen, ethylene + aluminum chloride, magnesium silicate, methanol, and organic solvents + heat.
Conditions to Avoid: Avoid incompatibilities.
Hazardous Products of Decomposition: Thermal oxidative decomposition of nickel can produce highly toxic nickel carbonyl.

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Section 6. Health Hazard Data

Carcinogenicity: The IARC and NTP classify nickel as, respectively, a human carcinogen (Group 1) and an anticipated human carcinogen.
Summary of Risks: Nickel dust or fume is a respiratory irritant that with chronic exposure may cause nasal or lung cancer in humans. The average latency period for the induction of these cancers appears to be about 25 yr (within a 4- to 51-yr range). Experimental studies show nickel also has neoplastigenic, tumorigenic, and teratogenic effects in laboratory animals. Hypersensitivity to nickel is common and can cause conjunctivitis, allergic contact dermatitis, and asthma. The allergic contact dermatitis ("nickel-itch," a pink papular erythema with pustulation and ulceration) usually clears within one week, but sensitization is permanent.
Medical Conditions Aggravated by Long-Term Exposure: Chronic pulmonary, upper respiratory tract, and skin disorders. Carcinoma of the paranasal sinuses, larynx, and lung may also develop.
Target Organs: Nasal cavities, lungs, skin.
Primary Entry Routes: Inhalation, dermal contact, and ingestion.
Acute Effects: Exposure to nickel fumes can cause upper respiratory tract irritation (with nonproductive cough, rapid breathing, dyspnea, chest tightness), metal fume fever (chills, fever, flu-like symptoms), asthma, inflammation of the lungs (noninfectious pneumonia), eye (conjunctiva) irritation, nausea, vomiting, and abdominal pain. Dermal contact causes "nickel itch." Ingesting large doses causes nausea, vomiting, and diarrhea.
Chronic Effects: Prolonged or repeated contact can cause nickel sensitization. Symptoms of sensitization include nickel dermatitis with eczematous skin and lichenification (hardened and leathery skin). Chronic inhalation exposure can cause chronic pulmonary irritation, chronic thickening of the mucous membranes of the nose, nasal sinusitis, anosmia (loss or impairment of the sense of smell), and perforation of the nasal septum. Chronic exposure to dust and fumes may cause carcinoma of paranasal sinuses, larynx, and lung.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Since oral toxicity for elemental nickel is low, inducing vomiting is seldom necessary. In cases of severe vomiting or diarrhea, treat for fluid replacement.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Chronic exposure to nickel dust may cause *eosinophilic pneumonitis* (Loeffler's syndrome) which responds well to systemic cortico-steroids. There are cases of host rejection of nickel-containing prostheses after development of nickel sensitivity.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, remove all heat and ignition sources, and provide maximum explosion-proof ventilation. Cleanup personal should protect against vapor inhalation and dermal contact. Avoid dust generation. Using nonsparking tools, carefully scoop spilled material into appropriate containers for reclamation or disposal. After completing material pickup, wash spill site. Do not release to sewers or waterways. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.454 kg) [* per Clean Water Act, Sec. 307(a)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

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

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, dry, well-ventilated area away from incompatible materials (Sec. 2). Protect against physical damage. Store Raney nickel under inert gas or water in tightly closed containers away from heat or ignition sources, acids, caustics, and oxidizing materials.
Engineering Controls: Minimize all possible exposures to potential carcinogens. Avoid vapor inhalation and dermal contact. Use only with appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good personal hygiene and housekeeping procedures.
Other Precautions: Provide preplacement and periodic medical examinations that emphasize the skin, nasal cavities, and lungs, including a 14" x 17" chest roentgenogram and urine nickel determinations.

Transportation Data (49 CFR 172.102)
IMO Shipping Name: Nickel catalyst, wetted with not less than 40% water or other suitable liquid, by weight, finely divided, activated, or spent
IMO Hazard Class: 4.2
ID No.: UN1378
IMO Label: Spontaneously combustible
IMDG Packaging Group: II

MSDS Collection **References:** 26, 38, 73, 84, 85, 88, 89, 90, 100, 101, 103, 109, 124, 126, 132, 133, 134, 136, 138, 139, 140, 142, 143
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheet

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GENIUM PUBLISHING CORP.

No. 439

NITROBENZENE
(Revision A)
Issued: July 1980
Revised: April 1989

SECTION 1. MATERIAL IDENTIFICATION •28

Material: NITROBENZENE

Description (Origin/Uses): Prepared by treating benzene with a mixture of nitric acid (HNO_3) and sulfuric acid (H_2SO_4). Used as an intermediate in the manufacture of aniline and benzidine; also used in some shoe and metal polishes.

Other Designations: Nitrobenzol; Essence of Mirbane; Oil of Mirbane; $C_6H_5NO_2$; CAS No. 0098-95-3

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

Comments: Simultaneous exposure to ethanol aggravates the poisonous effects of exposure to nitrobenzene. Workers must not drink alcoholic beverages before or after their shifts.

NFPA: 2 / 3 / 0 / -

HMIS			
H	3	I	4
F	2	S	2†
R	0	K	2
PPG*		†Absorption risk is high	

*See sect. 8

SECTION 2. INGREDIENTS AND OCCUPATIONAL EXPOSURE LIMITS

Nitrobenzene, ca 100%

OSHA PEL (Skin*)	ACGIH TLV (Skin*), 1988-89	Toxicity Data†
8-hr TWA: 1 ppm, 5 mg/m³	TLV-TWA: 1 ppm, 5 mg/m³	Woman, Oral, TD_{Lo}: 200 mg/kg
		Rat, Oral, LD_{50}: 640 mg/kg

*This material can be absorbed through intact skin, which contributes to overall exposure.
†See NIOSH, *RTECS* (DA6475000), for additional data with references to irritative, reproductive, and mutagenic effects.

SECTION 3. PHYSICAL DATA

Boiling Point: 410 °F (210 °C)
Melting Point: 42.8 °F (6 °C)
Vapor Density (Air = 1): 4.25
Vapor Pressure: <1 Torr
Molecular Weight: 123 g/mol
Solubility in Water (%): Slight
Specific Gravity (H_2O = 1): 1.205 at 59 °F (15 °C)

Appearance and Odor: A colorless to pale yellow oily liquid or bright yellow solid crystals; a distinctive odor of volatile almond oil. Its identification threshold is 4.7 parts per billion (ppb).

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point: 190 °F (88 °C) CC	Autoignition Temperature: 900 °F (482 °C)	LEL: 1.8% v/v	UEL: Not Found

Extinguishing Media: Use dry chemical, "alcohol" foam, carbon dioxide (CO_2), or a water spray to put out fires involving nitrobenzene. Water spray can be used to disperse vapor, to cool fire-exposed containers, and to flush nonignited spills or vapor away from sensitive exposures such as incompatible chemicals or sources of ignition. **Unusual Fire or Explosion Hazards:** Nitrobenzene vapor is more than 4 times heavier than air (see sect. 3); it can flow along surfaces, collect in low-lying, confined areas, reach a distant source of ignition, and flash back to its source. This vapor can easily form an explosive mixture with air, especially if the nitrobenzene is heated (heating will cause more nitrobenzene vapor to be given off). **Special Fire-fighting Procedures:** Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode.

SECTION 5. REACTIVITY DATA

Stability/Polymerization: Nitrobenzene is stable in closed containers during routine operations at room temperature. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Nitrobenzene is an oxidizing agent that can react dangerously with reducing agents such as nitric acid (HNO_3); phenol (C_6H_5OH) and aluminum chloride ($AlCl_3$); aniline and glycerine; silver perchlorate ($AgClO_4$); dinitrogen tetroxide (N_2O_4); caustics; and reactive metals such as tin or zinc. **Conditions to Avoid:** Prevent exposure to sources of heat and ignition or to incompatible chemicals. **Hazardous Products of Decomposition:** Thermal oxidative degradation of nitrobenzene can produce toxic gases such as carbon monoxide (CO) and oxides of nitrogen (NO_x).

SECTION 6. HEALTH HAZARD INFORMATION

Carcinogenicity: Nitrobenzene is not listed as a carcinogen by the NTP, IARC, or OSHA.

Summary of Risks: Nitrobenzene is a deadly poison that can be rapidly absorbed through intact skin. It reacts with hemoglobin in the blood to form methemoglobin, which seriously depletes the blood's oxygen-carrying capacity. The onset of even potentially fatal methemoglobinemia is insidious; severe symptoms can be delayed for up to 4 hours. The exposed person may feel well and have no complaints; he or she may exhibit signs of cyanosis such as blue lips, nose, and ears, which are noticeable but not uncomfortable; headache is commonly the first symptom of intoxication and may become more intense as the condition progresses. Workers can be exposed to dangerous levels of this poison without immediately discernible health effects. Cyanosis, anemia, and deleterious effects on the central nervous system (CNS) and the cardiovascular system (CVS) can develop following significant occupational exposure to nitrobenzene. **Medical Conditions Aggravated by Long-Term Exposure:** Disorders of the heart, liver, and blood. **Target Organs:** Skin, eyes, blood, liver, kidneys, testicles, and CVS. **Primary Entry:** Inhalation, skin contact/absorption. **Acute Effects:** Symptoms of occupational exposure to nitrobenzene include headache, vertigo, vomiting, nausea, dizziness, anemia, atoxia, shortness of breath, rapid pulse, and irritation of the skin and eyes. Coma and death may ensue. **Chronic Effects:** Chronic exposure produces a reversible anemia. *(cont'd.)*

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SECTION 6. HEALTH HAZARD INFORMATION, continued

FIRST AID: Eyes. Immediately flush eyes, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 minutes. Skin. Completely remove nitrobenzene from the exposed person's body. Immediately remove all clothing and wash the entire body from head to foot with soap and water. Pay special attention to the ear canals, fingernails, toenails, hair, and scalp because they are sources of continuing absorption of this poison. Inhalation. Remove the exposed person to fresh air; restore and/or support his or her breathing as needed. Have qualified medical personnel administer oxygen to alleviate the headache and general sense of weakness that characterize nitrobenzene intoxication. Keep exposed person warm and at rest until medical help is available. Ingestion. Unlikely. If accidental ingestion should occur, have the exposed person drink 1 to 2 glasses of water, then induce vomiting. **Comments:** Do not expose workers with existing heart, liver, or blood disorders to nitrobenzene. Screen prospective employees by testing them for hypersensitivity to hemolytic chemicals such as nitrobenzene. Alcohol ingestion and a heated environment may increase susceptibility. Instruct employees on methemoglobinemia signs and symptoms. Get in-plant, paramedic, or community medical help for all exposures. Seek prompt medical assistance for further treatment and support after first aid. **Physician's Note:** Determine the methemoglobin concentration in the blood; repeat this test hourly for at least 24 hr until a definite decline is noted. Repeat thorough skin cleaning if the methemoglobin level rises after 3 or 4 hr. Patients usually return to normal within 24 to 48 hr if all absorption sources are eliminated. Administer oxygen, using intermittent positive-pressure breathing (IPPB) if its available.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: *Treat accidental bulk releases of nitrobenzene as emergencies.* Prior planning and designing of emergency response routines are necessary. Notify safety personnel, evacuate nonessential personnel, eliminate sources of heat and ignition, and provide adequate explosion-proof ventilation, particularly at floor level (see sect. 4). Cleanup personnel must wear a complete set of personal protective equipment (see sect. 8) to protect the skin and eyes against any contact with this liquid poison or inhalation of its vapor. Shovel, scoop, or vacuum the released nitrobenzene and place it into appropriate containers for disposal. **Waste Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000 Subpart Z)

EPA Designations

Listed as RCRA Hazardous Waste No. U169 (40 CFR 261.33)

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1000 lb (454 kg) [*per CWA, §311(b)(4) and 307(a); and RCRA, §3001]

Listed as a SARA Extremely Hazardous Substance (40 CFR 355), Threshold Planning Quantity (TPQ): 10000 lb

Listed as a SARA Toxic Chemical* (40 CFR 372.65) [*EPA Form R may apply to your facility; see 40 CFR 372.85 for instructions]

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing of nitrobenzene is possible, wear a full face shield. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Wear a NIOSH-approved respirator per Genium reference 88 for the maximum-use concentrations and/or exposure limits cited in section 2. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (leaks or cleaning reactor vessels and storage tanks), wear an SCBA. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, and gauntlets to prevent any contact of nitrobenzene with your skin. **Ventilation:** Install and operate general and local maximum-explosion-proof ventilation systems powerful enough to maintain airborne concentrations of this material below the OSHA PEL standard cited in section 2. Local exhaust ventilation is preferred because it prevents dispersion of the contaminant into the general work area by eliminating it at its source. Consult the latest edition of Genium reference 103 for detailed recommendations. **Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work areas. **Contaminated Equipment:** Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Do *not* wear contact lenses in any work area. Remove contaminated clothing and launder it before wearing it again; clean this material from your shoes and equipment. **Comments:** The health effects of nitrobenzene are so dangerous that persons exposed to it should be periodically instructed in safe-handling procedures and in recognizing the symptoms of developing cyanosis (see sect. 6). Practice good personal hygiene; always wash thoroughly after using this material and before eating, drinking, smoking, using the toilet, or applying cosmetics. Keep it off your clothing and equipment. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do *not* eat, drink, or smoke in work areas. Avoid all skin contact with this liquid and inhalation of its vapor.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store nitrobenzene in closed containers in a cool, dry, well-ventilated, low fire-risk area away from incompatible chemicals (see sect. 5) and sources of heat or ignition. Protect these containers from physical damage; shield them from direct sunlight. **Engineering Controls:** Electrically ground and bond all containers and equipment used in shipping, receiving, or sampling operations in production or storage areas to prevent static sparks.

Transportation Data (49 CFR 172.101-2)

DOT Shipping Name: Nitrobenzene, Liquid	IMO Shipping Name: Nitrobenzene
DOT Hazard Class: Poison B	IMO Hazard Class: 6.1
DOT ID No.: UN1662	IMO Label: Poison
DOT Label: Poison	IMDG Packaging Group: II
DOT Packaging Requirements: 49 CFR 173.346	
DOT Packaging Exceptions: 49 CFR 173.345	

References: 1, 6, 26, 38, 84-94, 100, 116, 118, 119, 122

Prepared by: PJ Igoe, BS; Industrial Hygiene Review: DJ Wilson, CIH; Medical Review: W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 313
Perchloroethylene

Issued: 11/78 **Revision: E, 9/92**

Section 1. Material Identification

Perchloroethylene (C_2Cl_4) Description: By chlorination of hydrocarbons and pyrolysis of the carbon tetrachloride that is formed, or by catalytic oxidation of 1,1,2,2-tetrachloroethane. Used in dry cleaning and textile processing, metal degreasing, insulating fluid and cooling gas in electrical transformers, production of adhesives, aerosols, paints, and coatings; as a chemical intermediate, a solvent for various applications, extractant for pharmaceuticals, a pesticide intermediate, and an antihelminthic (parasitic worm removal) agent in veterinary medicine.
Other Designations: CAS No. 127-18-4, Ankilostin, carbon dichloride, Didakene, ethylene tetrachloride, Perchlor, Perclene, Perk, Tetracap, tetrachloroethylene.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

Cautions: Perchloroethylene is a central nervous system depressant, causes liver and kidney damage (from acute or chronic exposures), and is considered an IARC Class 2B carcinogen (animal sufficient evidence, human inadequate data).

R 1
I 3
S 2*
K 0
* Skin absorption

NFPA
0 / 2 / 0 / -

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

Section 2. Ingredients and Occupational Exposure Limits

Perchloroethylene, < 99%. Impurities include a small amount of amine or phenolic stabilizers.

1991 OSHA PEL
8-hr TWA: 25 ppm (170 mg/m³)

1990 IDLH Level
500 ppm

1990 NIOSH REL
NIOSH-X Carcinogen
Limit of Quantitation: 0.4 ppm

1992-93 ACGIH TLVs
TWA: 50 ppm (339 mg/m³)
STEL: 200 ppm (1357 mg/m³)

1990 DFG (Germany) MAK
TWA: 50 ppm (345 mg/m³)
Category II: substances with systemic effects
Half-life: < 2 hr
Peak Exposure Limit: 100 ppm, 30 min average value, 4/shift

1985-86 Toxicity Data*
Man, inhalation, TC_{Lo}: 280 ppm/2 hr caused conjunctival irritation and anesthesia.
Human, lung: 100 mg/L caused unscheduled DNA synthesis.
Rat, oral, LD_{50}: 3005 mg/kg: caused somnolence, tremor, and ataxia.
Rat, inhalation, TC_{Lo}: 200 ppm/6 hr given intermittently over 2 years produced leukemia and testicular tumors.
Rabbit, eye: 162 mg caused mild irritation.
Rabbit, skin: 810 mg/24 hr caused severe irritation.

* See NIOSH, *RTECS* (KX3850000), for additional irritation, mutation, reproductive, tumorigenic, & toxicity data.

Section 3. Physical Data

Boiling Point: 250 °F (121.2 °C)
Freezing Point: -8 °F (-23.35 °C)
Vapor Pressure: 13 mm Hg at 68 °F (20 °C)
Surface Tension: 31.74 dyne/cm at 68 °F (20 °C)
Viscosity: 0.84 cP at 77 °F (25 °C)
Refraction Index: 1.50534 at 68 °F (20 °C)
Molecular Weight: 165.82
Density: 1.6311 at 59 °F (15/4 °C)
Water Solubility: 0.02% at 77 °F (25 °C)
Other Solubilities: Miscible with alcohol, ether, benzene, chloroform, and oils.
Odor Threshold: 47 to 71 ppm (poor warning properties since olfactory fatigue is probable)
Evaporation Rate: 0.15 gal/ft²/day at 77 °F (25 °C)
Saturated Vapor Density (Air = 0.075 lb/ft³ or 1.2 kg/m³): 0.081 lb/ft³ or 1.296 kg/m³

Appearance and Odor: Colorless liquid with an ether-like odor.

Section 4. Fire and Explosion Data

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

Extinguishing Media: For small fires, use dry chemical, carbon dioxide (CO_2). For large fires, use water spray, fog, or regular foam.
Unusual Fire or Explosion Hazards: Vapors are heavier than air and collect in low-lying areas.
Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Apply cooling water to sides of container until well after fire is out. Stay away from ends of tanks. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Perchloroethylene is stable up to 932 °F (500 °C) in the absence of catalysts, moisture, and oxygen but deteriorates rapidly in warm, moist climates. It is slowly decomposed by light. Amine or phenolic stabilizers are usually added. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Slowly (faster in presence of water) corrodes aluminum, iron, and zinc. It is incompatible with chemically active metals (i.e., barium, beryllium, and lithium (explodes with lithium shavings), strong oxidizers, sodium hydroxide, caustic soda, potash, and nitric acid. Perchloroethylene forms an explosive mixture with dinitrogen tetraoxide and reacts with activated charcoal at 392 °F (200 °C) to yield hexachloroethane and hexachlorobenzene. **Conditions to Avoid:** Contact with moisture and incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of perchloroethylene can produce carbon dioxide and toxic chlorine, hydrogen chloride, and phosgene gas (also produced by contact with UV light).

Section 6. Health Hazard Data

Carcinogenicity: Perchloroethylene is listed as a carcinogen by The IARC (Group 2B, animal sufficient evidence, human inadequate data),[164] NTP (Class 2, reasonably anticipated as a carcinogen, with limited human evidence and sufficient animal evidence),[169] NIOSH (Class-X, carcinogen defined with no further explanation),[164] and DFG (MAK-B, justifiably suspected of having carcinogenic potential)[164]. There is some controversy regarding human carcinogenicity because even though there is an increased number of cancers of the skin, colon, lung, urogenital tract, and lympho-sarcomas; the dry cleaning workers studied were also exposed to other chemicals. **Summary of Risks:** Perchloroethylene is stored in the fatty tissue and slowly metabolized with the loss of chlorine. The half-life of its urinary metabolite (trichloroacetic acid) is 144 hours. Perchloroethylene exerts the majority of its toxicity on the central nervous system causing symptoms ranging from light-headedness and slight 'inebriation' to unconsciousness. Liver damage is possible after severe acute or minor long-term exposure. It has a synergistic effect with toluene.

Continue on next page

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Section 6. Health Hazard Data, *continued*

Medical Conditions Aggravated by Long-Term Exposure: Nervous, liver, kidney, or skin disorders. **Target Organs:** Liver, kidney, eyes, upper respiratory tract, skin, and central nervous system. **Primary Entry Routes:** Inhalation and skin and eye contact. **Acute Effects:** Exposure to high levels can cause liver damage which may take several weeks to develop. Vapor exposure can cause slight smarting of the eyes and throat (in high concentrations). In human studies, exposure to 2000 ppm/5 min caused mild CNS depression; 600 ppm/10 min caused numbness around the mouth, dizziness, and incoordination; 100 ppm/7 hr caused mild eye, nose, and throat irritation, flushing of the face and neck, headache, somnolence; and slurred speech. Skin contact may produce dermatitis because of perchloroethylene's defatting action (more common after repeated exposure). Direct eye contact causes tearing and burning but no permanent damage. Ingestion is rare but can cause irritation of the lips, mouth and gastrointestinal tract, irregular heartbeat, nausea & vomiting, diarrhea (possibly blood stained), drowsiness, unconsciousness, and risk of pulmonary edema (fluid in lungs). **Chronic Effects:** Prolonged exposure can cause impaired memory, extremity (hands, feet) weakness, peripheral neuropathies, impaired vision, muscle cramps, liver damage (fatty degeneration, necrosis, yellow jaundice, and dark urine) and kidney damage (oliguric uremia, conjestion and granular swelling).

FIRST AID ***Rescuers must not enter areas with potentially high perchloroethylene levels without a self-contained breathing apparatus.*** **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. ***Never administer adrenalin!*** **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. Be sure victim's head is positioned to avoid aspiration of vomitus into the lungs. **Note to Physicians:** Monitor level of consciousness, EEG (abnormalaties may indicate chronic toxicity), blood enzyme levels (for 2 to 3 wk after exposure), EKG, adequacy of respirations & oxygenation, and liver and kidney function. ***BEIs:*** C_2Cl_4 in expired air (10 ppm), sample prior to last shift of work week; C_2Cl_4 in blood (1 mg/L), sample prior to last shift of work week; trichloroacetic acid in urine (7 mg/L), sample at end of workweek.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources (although noncombustible, it forms toxic vapors from thermal decomposition). For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers for later disposal. For large spills, dike far ahead of spill and await reclamation or disposal. Report any release in excess of 1 lb. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** If released to soil, perchloroethylene evaporates and some leaches to groundwater. It may absorb slightly to soils with heavy organic matter. Biodegradation may be important in anaerobic soils. In water, it is subject to rapid volatilization with an estimated half-life from <1 day to several weeks. In air, it exists mainly in the vapor-phase and is subject to photooxidation with a half-life of 30 minutes to 2 months. **Ecotoxicity Values:** Guppy (*Poecilia reticulata*), LC_{50} = 18 ppm/7 days; fathead minnow (*Pimephales promelas*), LC_{50} = 18.4 mg/L/96 hr, flow through bioassay. **Disposal:** Consider recovery by distillation. A potential candidate for rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C) or fluidized bed incineration at 842 to 1796 °F (450 to 980 °C). Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U210
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 100 lb (45.4 kg) [* per CWA Sec. 307 (a)]
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

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

Section 8. Special Protection Data

Goggles: Wear a faceshield (8 inch minimum) per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For any detectable concentration, use a supplied-air respirator or SCBA with a full facepiece operated in pressure demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. ***Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*** If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made of butyl rubber, Neoprene, or Viton to prevent skin contact. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from sunlight, and incompatibles. Do not store sludge from vapor degreasers in tightly-sealed containers and keep outside until disposal is arranged. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Check stabilizer levels frequently and ventilation equipment (air velocity, static pressure, air valve) at least every 3 months. Install an air dryer in ventlines to storage tanks to prevent moisture from rusting and weakening the tank and contaminating or discoloring its contents. Purge all tanks before entering for repairs or cleanup. Build a dike around storage tanks capable of containing all the liquid. Ground tanks to prevent static electricity. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers that emphasize liver, kidney, and nervous system function, and the skin. Alcoholism may be a predisposing factor.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Tetrachloroethylene
DOT Hazard Class: 6.1
ID No.: UN1897
DOT Packing Group: III
DOT Label: Keep away from food
Special Provisions (172.102): N36, T1

Packaging Authorizations
a) Exceptions: 173.153
b) Non-bulk Packaging: 173.203
c) Bulk Packaging: 173.241

Quantity Limitations
a) Passenger Aircraft or Railcar: 60 L
b) Cargo Aircraft Only: 220 L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: 40

MSDS Collection References: 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 140, 148, 149, 153, 159, 163, 164, 167, 168, 171, 174, 175, 176, 180.
Prepared by: M Gannon, BA; Industrial Hygiene Review: D Wilson, CIH; Medical Review: W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 355
Phenol

Issued: 9/80 Revision: C, 11/90

Section 1. Material Identification 33

Phenol (C_6H_5OH) Description: One of many aromatic compounds in coal tar. Made by alkylating benzene with propylene then oxidizing the resulting cumene to produce phenol and acetone. Used as a feedstock in manufacturing various phenolic resins, caprolactum, bis-phenol-A, and other chemicals and drugs; a disinfectant; a fuel-oil sludge inhibitor; a reagent in chemical analysis; in producing or manufacturing a large variety of aromatic compounds including fertilizers, illuminating gas, coke, explosives, lampblack, paints, paint removers, asbestos goods, wood preservatives, textiles, perfumes, bakelite, rubber, and other plastics; in medical and industrial organic compounds and dyes; and in germicidal paints and slimicides. Phenol has been identified in cigarette smoke and automobile exhaust.

Other Designations: CAS No. 0108-95-2, carbolic acid, hydroxybenzene, monohydroxy benzene, oxybenzene, phenic acid, phenyl alcohol, phenyl hydroxide.

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

R 1
I 4
S 3*
K 2
* Skin absorption

NFPA

HMIS
H 3
F 2
R 0
PPG†
† Sec. 8

Cautions: Phenol has a marked corrosive effect on any tissue. Eye contact may cause severe damage and *blindness*. Its primary entry route is through *skin absorption*. Systemic absorption may cause *liver and kidney damage, convulsions (seizures), or death.*

Section 2. Ingredients and Occupational Exposure Limits

Phenol, ca 100%

1989 OSHA PEL (Skin)
8-hr TWA: 5 ppm, 19 mg/m³

1990-91 ACGIH TLV (Skin)
TWA: 5 ppm, 19 mg/m³

1988 NIOSH REL
TWA: 5 ppm, 19 mg/m³
Ceiling: 15.6 ppm, 60 mg/m³

1985-86 Toxicity Data*
Mammal, inhalation, LC_{50}: 74 mg/m³
Rat, oral, LD_{50}: 317 mg/kg; toxic effects include behavorial changes (convulsions or effect on seizure threshold)
Rabbit, eye, TC_{Lo}: 5 mg produces severe irritation

1987 IDLH Level
250 ppm

* See NIOSH, *RTECS* (SJ3325000), for additional irritative, mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 359.15 °F (181.75 °C) at 760 mm Hg
Melting Point: 109.4 °F (43 °C)
Vapor Pressure: 0.3513 mm Hg at 77 °F (25 °C)
Vapor Density (Air = 1): 3.24
pH: 6 (aqueous solution)
Molecular Weight: 94.11
Specific Gravity (20 °C/4 °C): 1.0576
Water Solubility: 1 g dissolves in about 15 ml H_2O
Viscosity: 12.7 centipoise at 64.9 °F (18.3 °C)

Appearance and Odor: White crystalline solid with a characteristic sharp medicinal sweet, tangy odor detectable above 0.05 ppm. Phenol turns pink or red if it contains impurities or is exposed to heat or light.

Section 4. Fire and Explosion Data

Flash Point: 175 °F (79 °C), CC	Autoignition Temperature: 1319 °F (715 °C)	LEL: 1.7% v/v	UEL: 8.6% v/v

Extinguishing Media: Use water spray, carbon dioxide, dry chemical, or alcohol-type foam to extinguish fires involving phenol. Do not use a solid stream of water since the stream scatters and spreads fire. Use water spray to cool fire-exposed tanks/containers.

Unusual Fire or Explosion Hazards: Phenol presents a moderate fire hazard when exposed to heat, flame, or oxidizers. When heated, it emits toxic fumes and vapors that form explosive mixtures with air. Air mixtures containing 3 to 10% phenol are explosive. Solid phenol burns with difficulty, giving off heavy smoke.

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

Section 5. Reactivity Data

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

Chemical Incompatibilities: In general, phenol is incompatible with strong oxidizing agents and halogens. It coagulates colodion and proteins. A potentially explosive reaction occurs with formaldehyde, peroxydisulfuric acid, peroxymonosulfuric acid, sodium nitrite + heat, and aluminum chloride + nitromethane (at 110 °C/100 bar). A violent reaction occurs with butadiene, sodium nitrite + trifluoroacetic acid, and aluminum chloride + nitrobenzene at 248 °F (120 °C). Combining phenol with mineral oxidizing acids results in fire; with acetaldehyde results in violent condensation; with isocyanates results in heat generation and violent polymerization, with calcium hypochlorite results in an exothermic reaction producing toxic fumes which may ignite; and with nitrides results in heat and flammable gas generation. Hot phenol is corrosive to many metals, including aluminum, lead, magnesium, and zinc. Reaction with these materials causes phenol to discolor.

Conditions to Avoid: Avoid heating phenol above 122 °F (90 °C).

Hazardous Products of Decomposition: Thermal oxidative decomposition of phenol can produce oxides of carbon and water.

Section 6. Health Hazard Data

Carcinogenicity: The NTP, IARC, and OSHA do not list phenol as a carcinogen. Although no specific evidence of human cancer exists, its carcinogenicity to mice emphasizes the need for precaution when handling this material. Phenol also causes human mutations (genetic changes).

Summary of Risks: Phenol is a general protoplasmic poison that is corrosive to any living tissue it contacts. Toxicity most likely results from dermal (skin) contact or ingestion. Skin absorption occurs readily with a rapid onset of symptoms or death (within 30 min to several hours). Contact with eyes may cause severe damage and blindness. Ingestion of 1 g may be fatal. Although phenol is irritating to the respiratory tract, due to its low volatility and good warning properties, inhalation is typically less of a concern. Chronic toxic effects are uncommon, but may include digestive disturbances, neurological disorders, skin rash (dermatitis), and liver and kidney damage.

Medical Conditions Aggravated by Long-Term Exposure: Individuals with chronic respiratory disorders, pre-existing skin disorders, convulsive disorders, or kidney or liver abnormalities may be at increased risk from phenol exposure.

Target Organs: Liver, kidneys, nervous system, and skin.

Primary Entry Routes: Skin absorption, eye contact, ingestion, and inhalation.

Acute Effects: Skin contact results in white, wrinkled discoloration, followed by a severe burn or systemic poisoning if removed improperly.

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Section 6. Health Hazard Data, *continued*

Phenol ingestion can cause gangrene and corrosion of lips, mouth, throat, esophagus, and stomach if not properly decontaminated (see First Aid). Although not immediately painful, skin contact can cause serious burns and systemic toxicity. In addition to skin burns and respiratory tract irritation, systemic absorption may cause pallor, anorexia (appetite loss), nausea, vomiting, diarrhea, weakness, muscle aches, darkened urine, headache, tinnitus (ringing in ears), sweating, convulsions, cyanosis (bluish coloration of lips and/or fingertips), shock, unconsciousness, respiratory failure, and death. After ingestion, major percutaneous (skin), or inhalation exposures, collapse and death can be rapid. Ingestion can cause severe tissue corrosion or gangrene affecting lips, mouth, throat, esophagus, and stomach. Eye contact can cause severe corrosive damage to the eye (conjunctival edema, corneal opacification, and hypesthesia) and possible blindness.

Chronic Effects: Chronic phenol poisoning is rarely reported. Symptoms include vomiting, difficulty swallowing, diarrhea, appetite loss, headache, fainting, dizziness, darkened urine, and mental disturbances. Chronic exposure can cause death from liver and kidney damage. Repeated skin contact with phenol or phenol-bearing products can result in dermatitis with dark pigmentation (ochronosis) of skin and whites of eyes (sclerae).

FIRST AID

Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water for at least 15 min. Consult a physician immediately.

Skin: Speedy action is critical. Flood exposed area with water and quickly remove contaminated clothing. *As soon as possible*, repeatedly spray or swab with the decontaminating agent polyethyleneglycol-300 (PEG). Immerse extremities in PEG. Rescue personnel should protect themselves from skin contact with phenol. Do not use greases, powders, or ointments to treat phenol burns. *Never* delay phenol removal if PEG is not readily available. Use soap and water instead.

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

Ingestion: *Speed is essential in the treatment of oral poisoning*. Immediately consult a physician and poison center. Never give anything by mouth to an unconscious or convulsing person. Administer to that *conscious* person 15 to 30 cc castor oil or another vegetable oil, and be prepared to induce vomiting upon a physician's advice. Vegetable oils slow phenol absorption and reduce local damage.

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

Note to Physicians: Treat ingestion with gastric lavage using 40% aqueous Bacto-Peptone, milk, or water until phenolic odor is eliminated. Then give 15 to 50 cc castor or vegetable oil. Debride necrotic skin. Monitor vital signs, fluid status, electrolytes, BUN, renal and hepatic function, and electrocardiogram. Manage sedation, seizures, renal failure, and fluid electrolyte imbalances symptomatically as indicated.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, remove all heat and ignition sources, and provide maximum explosion-proof ventilation. Cleanup personnel should protect against vapor inhalation and skin and eye contact with a self-contained breathing apparatus and full personal protective clothing and equipment. Absorb small spills with some noncombustible inert material and place in a closed metal container for disposal. Dike large spills and allow material to cool and solidify. Using nonsparking tools, shovel solid into steel containers for disposal. Thoroughly flush spill area with water, use caustic soda solution for neutralization, and collect flushings and wash water for disposal. Do not allow phenol to enter sewers, watersheds, or waterways. Follow applicable OSHA regulations (29 CFR 1910.120). Notify proper authorities including the National Response Center (800-424-8802).

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

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33)

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Reportable Quantity (RQ), 1000 lb (454 kg) [* per Clean Water Act, Sec. 311(b)(4), Sec. 307(a), and per RCRA, Sec. 3001]

Listed as a SARA Extremely Hazardous Substance (40 CFR 355): RQ, 1000 lb; Threshold Planning Quantity (TPQ), 500/10,000 lb

Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

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

Section 8. Special Protection Data

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

Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. Where potential exists for exposures near or over 19 mg/m^3, use a MSHA/NIOSH-approved full facepiece respirator with an organic vapor cartridge/canister and dust/mist prefilter. Increased protection is obtained from full facepiece powered-air purifying respirators. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*

Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact. ACGIH recommends neoprene or butyl rubber as good-to-excellent protective materials.

Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL and ACGIH TLV (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]

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

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

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

Section 9. Special Precautions and Comments

Storage Requirements: Store in closed containers in a cool, dry, well-ventilated area away from heated surfaces, open flame, and ignition sources. Outside or detached storage is preferred. Protect containers from physical damage.

Engineering Controls: Enclose all operations, eliminating all possible phenol exposure routes. Educate workers about phenol's hazards and potential dangers. Use only with appropriate personal protective gear and adequate ventilation. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Provide local exhaust ventilation at the site of chemical release. Practice good personal hygiene and housekeeping procedures.

Medical Surveillance: Provide preplacement or periodic medical examinations that emphasize central nervous system (CNS), hepatic, renal, and skin. Tests should include BUN, creatinine, LFTs, and urinalysis. Phenol can be detected in urine in free or conjugated forms. The ACGIH biological exposure index (BEI) is 250 mg total phenol/g creatinine or 15 mg/hr.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Phenol	IMO Shipping Name: Phenol
DOT Hazard Class: Poison B	IMO Hazard Class: 6.1
ID No.: UN1671	ID No.: UN1671
DOT Label: Poison	IMO Label: Poison
DOT Packaging Exceptions: 173.364	IMDG Packaging Group: II
DOT Packaging Requirements: 173.369	

MSDS Collection References: 1, 2-12, 15, 19, 23, 24, 26, 31, 34, 37, 38, 59, 73, 79, 84, 85, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 138-140, 143, 146, 148, 149

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Material Safety Data Sheets Collection:

Sheet No. 683
Polychlorinated Biphenyls (PCBs)

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

Section 1. Material Identification

39

Polychlorinated Biphenyls [$C_{12}H_{10-n}Cl_n$ (n=3, 4, 5)] Description: A class of nonpolar chlorinated hydrocarbons with a biphenyl nucleus (two benzene nuclei connected by a single C-C bond) in which any or all of the hydrogen atoms have been replaced by chlorine. Commercial PCBs are mixtures of chlorinated biphenyl isomers with varying degrees of chlorination. Prepared industrially by the chlorination of biphenyl with anhydrous chlorine in the presence of a catalyst such as ferric chloride or iron filings. Except for limited research and development applications, PCBs have not been produced in the US since 1977. When large quantities of PCBs were manufactured in the US, they were marketed under the tradename Aroclor (Monsanto) and were characterized by four digit numbers. The first two digits indicating biphenyls (12), triphenyls (54), or both (25, 44); the last two digits indicating the weight percent of chlorine. PCBs' thermal stability, nonflammability, and high dielectric capability made them very useful in electrical equipment. Formerly used as additives in hydraulic fluids, heat transfer systems, lubricants, cutting oils, printer's ink, fire retardants, asphalt, brake linings, automobile body sealants, plasticizers, adhesives, synthetic rubber, floor tile, wax extenders, dedusting agents, pesticide extenders, and carbonless reproducing paper. PCBs are still used in certain existing electrical capacitors and transformers that require enhanced electrical protection to avoid heating from sustained electric faults.

Other Designations: CAS No. 1336-36-3, Aroclor, Clophen, Chlorextol, chlorinated biphenyls, chlorinated diphenyl, chlorinated diphenylene, chloro biphenyl, chloro-1,1-biphenyl, Dykanol, Fenclor, Inerteen, Kaneclor, Montar, Noflamol, Phenoclor, Pyralene, Pyranol, Santotherm, Sovol, Therminol FR-1

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

NFPA
1 / 2 / 0 / –

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

Caution: 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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Material Safety Data Sheets Collection:

Sheet No. 534
Picric Acid

Issued: 4/85 Revision: A, 1/93

Section 1. Material Identification

Picric Acid [$C_6H_2OH(NO_2)_3$] Description: Derived by nitration of a mixture of phenolsulfonic acids (produced by reacting with phenol); reacting dinitrochlorobenzene with sodium hydroxide or sodium carbonate followed by nitration; or treating benzene with nitric acid and mercuric nitrate. Used as an explosive *generally* found mixed with suitable proportions of dinitrophenol to minimize its corrosion of metal and formation of shock-sensitive salts. The mixtures are available under the names Lyddite, Melinite, Pertite, Shellite, and Shimose. Also used as a dye for silk and wool, germicide and fungicide, chemical intermediate for metal picrates and other derivatives, textile mordant; in the leather industry, electric batteries, rocket fuels, sensitization of photographic emulsions, removal of gelatin from hectograph images; for etching copper and steel; in forensic chemistry; and formerly by veterinarians to destroy tapeworms in sheep.

Other Designations: CAS No. 88-89-1, carbozotic acid; 2-hydroxy-1,3,5-trinitrobenzene; nitroxanthic acid; phenol trinitrate; picral; picronitric acid; 1,3,5-trinitrophenol; 2,4,6-trinitrophenol. CAS# 14798-26-6 refers to picric acid, *ion* (1-).

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

Cautions: Picric acid is explosive and very shock-sensitive, especially when dry. It may cause dermatitis, skin discoloration, and damage to the liver and kidneys.

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* Skin absorption

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HMIS
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PPE-Sec

Section 2. Ingredients and Occupational Exposure Limits

Picric acid, ca 100%. Normally in solution with 10 to 20% water.

1992 OSHA PEL (skin)
Transitional and Final Rule Limits: 8-hr TWA: 0.1 mg/m^3

1990 IDLH Level
100 mg/m^3

1992-93 ACGIH TLV
TWA: 0.1 mg/m^3

1991 DFG (Germany) MAK (skin)
TWA: 0.1 mg/m^3 (*total dust*)
Category I: Local irritants
Peak exposure Limit: 0.2 mg/m^3, 5 min. momentary value, 8/shift

1992 NIOSH REL
TWA: 0.1 mg/m^3
STEL: 0.3 mg/m^3

1992 Toxicity Data*
Rabbit, oral, LD_{Lo}: 120 mg/kg caused hypermotility, diarrhea, increased body temperature, and convulsions or effect on seizure threshold.
Guinea Pig, oral, LD_{Lo}: 100 mg/kg
E. Coli: 1800 ppm caused microbial mutatio without S9.

* See NIOSH, *RTECS* (TJ7875000), for additional mutation and toxicity data.

Section 3. Physical Data

Boiling Point: Explodes above 572 °F (300 °C)
Melting Point: 252 °F (122 °C)
Vapor Pressure: <1 mm Hg at 68 °F (20 °C)
Molecular Weight: 229.11
Density: 1.763

Water Solubility: Slightly soluble, 1g/ 78 mL water at 77 °F (25 °C) and 15 mL boiling water.
Other Solubilities: Soluble in acetone, methanol, pyridine; in 12 mL alcohol, 10 mL benzene, 35 mL chloroform, and 65 mL ether.

Appearance and Odor: Odorless, yellow crystals with a very bitter taste.

Section 4. Fire and Explosion Data

Flash Point: 302 °F (150 °C)	Autoignition Temperature: 572 °F (300 °C)	LEL: None reported	UEL: None reported

Extinguishing Media: A Class IIIB combustible liquid (NFPA classification even though a solid to semi-solid). Fight fire with water spray, fog, or foam. *Do not* use carbon dioxide or halogenated agents.

Unusual Fire or Explosion Hazards: Explosive decomposition is likely if picric acid becomes involved in fire.

Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Fight fire from as far away as possible. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from area and let fire burn. Do not release runoff from fire control methods to sewers or waterways; dike for proper disposal.

Section 5. Reactivity Data

Stability/Polymerization: Picric acid is highly unstable and capable of explosive decomposition. It becomes increasingly shock, heat, and friction sensitive as it loses moisture. Picric acid should be kept wet (at least 10% with water) for safety purposes. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Include albumin, alkaloids, gelatin, uronium perchlorate (forms powerful explosive), aluminum + water (ignites after a delay period), ammonia, concrete (forms explosive salts such as calcium picrate), plaster, salts; metals including copper, lead, and zinc (corrodes the metal to form shock-sensitive metallic salts); and all oxidizable materials. Salts are more explosive-sensitive than picric acid itself.

Conditions to Avoid: Exposure to heat, ignition sources, and incompatibles. *Do not* allow picric acid to dry out or remain in contact with metals.

Hazardous Products of Decomposition: Thermal oxidative decomposition of picric acid can produce toxic nitrogen oxide (NO_x) gases.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(183) NTP,(169) and OSHA(183) do not list picric acid as a carcinogen. **Summary of Risks:** Picric acid is irritating to the skin and can result in dermatitis. Sensitized individuals showed dermatitis at lower concentrations than those who developed systemic poisoning; indicating that desensitization or adaption reactions may occur. Systemic poisoning results from inhalation, ingestion and skin absorption. Heavy exposures can cause yellow staining (*not* jaundice) of the skin and conjunctiva along with 'yellow vision', and blood, liver, and kidney damage. **Medical Conditions Aggravated by Long-Term Exposure:** Skin, blood, liver, and kidney disorders. **Target Organs:** Eyes, skin, blood, liver, and kidneys. **Primary Entry Routes:** Inhalation, ingestion, skin and eye contact/absorption. **Acute Effects:** Dust and fumes can cause eye irritation and corneal injury may result from solution splashes. Systemic poisoning via inhalation, ingestion, or skin absorption can cause headache, dizziness, nausea, vomiting, diarrhea, and abdominal pain. Heavy exposures can cause red blood cell destruction resulting in...

Continue on next page

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Section 6. Health Hazard Data, *continued*

hematuria (dark red urine due to broken RBC's), hemorrhagic kidney inflammation and lesions with decreased or ceased urination, acute hepatitis, convulsions, coma, and death. Ingestion of 1 to 2 grams has caused severe poisoning. Chronic Effects: Dermatitis characterized by swelling, papules, vesicles, peeling and scaling. The face is usually involved, especially around the eyes and sides of the nose.

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 (clean or dispose of carefully-picric acid is explosive, especially when dry!). Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. Inhalation: Remove exposed person to fresh air and support breathing as needed. Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting.

Note to Physicians: Picramic acid in the urine is 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 all ignition sources. Cleanup personnel should protect against exposure and be aware of picric acid's explosive capabilities. Wet spill before attempting to pick up. Never sweep or vacuum dry material. Wet down spill and absorb with sodium bicarbonate or sand-soda ash mixture (90:10 mixture). Carefully scoop into glass containers (make sure material contains at least 10% water) for reclamation or disposal. Large spills may need the attention of explosives experts. Prevent entry into sewers, drains, and waterways. Follow applicable OSHA regulations (29 CFR 1910.120). Ecotoxicity Values: Rainbow trout (*Salmo gairdneri*), LC_{50} = 109.6 mg/L/96 hr; American oysters (*Crassostrea virginica*), LC_{50} = 254.9 mg/L/14 hr; Bluegill (*Lepomis macrochirus*), LC_{50} = 193 mg/L/24 hr. Environmental Degradation: In water, picric acid may undergo direct photolysis to picramic acid in alkaline but not acidic waters. It is not expected to bioaccumulate. With a pKa of 0.38, picric acid is expected to exist largely in the anionic form and therefore atmospheric partitioning is not expected to occur. In soil, it is not expected to volatilize and absorption to soil or leaching capabilities cannot be predicted. It appears to be resistant to aerobic degradation. Disposal: If disposing of picric acid contained in a jar, gently tilt bottle to see if crystals roll over each other. If they do, the acid is dry and capable of explosion—contact personnel trained in explosives. Dried crystals may also be present within threads of screw top containers and present a detonation hazard when opening container. Small amounts of picric acid may be disposed of by diluting to at least 2000 ppm and flushing down the drain with flooding amounts of water (only if your facility is connected to a municipal sewage system). Controlled incineration in a rotary-kiln incinerator equipped with particulate abatement and wet scrubber devices or deliberate detonation using a detonator or booster explosive (*never* treat a large amount at one time) are other possible methods. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

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

Listed as a SARA Toxic Chemical (40 CFR 372.65)

Listed as a RCRA Hazardous Waste (40 CFR 261.23): No. D003, Characteristic of Reactivity

Listed "Unlisted Hazardous Waste, Characteristic of Reactivity" as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 100 lb (45.4 kg) [* per RCRA, Sec. 3001]

OSHA Designations

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

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or 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 < 0.5 mg/m^3, use dust and mist (D&M) respirator. For < 1 mg/m^3, use any D&M respirator except single-use and quarter-mask respirators. For < 2.5 mg/m^3, use any powered, air-purifying respirator with a D&M filter or any supplied-air respirator (SAR) operated in continuous-flow mode. For < 5 mg/m^3, use any air purifying, full facepiece respirator with a high-efficiency particulate filter. For < 100 mg/m^3, use any SAR operated in pressure-demand or positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. Other: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. Contaminated Equipment: Separate contaminated work clothes from street clothes and launder before reuse. Remove picric acid from your shoes and clean PPE. Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage/Handling Requirements: Store in glass *not* metal containers (picric acid corrodes metal) and wet screw tops before sealing. Keep in a cool, dry, well-ventilated area away from ignition sources and incompatibles. Store in as small a quantity as possible and keep moist (at least 10% water-check periodically). Outside or detached storage is preferred. *Do not* store on concrete floors (can form explosive calcium picrate). 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. Enclose all processes and employ automatic/mechanical handling techniques and wet methods where possible. Administrative Controls: Consider preplacement and periodic medical exams of exposed workers with emphasis on the skin, liver, blood, and kidneys.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Picric Acid (> 10% water)
DOT Hazard Class: 4.1
ID No.: NA1344
DOT Packing Group: I
DOT Label: Flammable solid
Special Provisions (172.102): A19, A20, N41

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

Quantity Limitations
a) Passenger Aircraft or Railcar: Forbidden
b) Cargo Aircraft Only: Forbidden

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

MSDS Collection References: 26, 73, 100, 101, 103, 124, 126, 127, 132, 136, 139, 148, 149, 153, 159, 167, 183, 184

Prepared by: M Gannon, BA; Industrial Hygiene Review: D Wilson, CIH; Medical Review: AC Darlington, MPH, MD

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IDENTIFIERS

CHEMTOX RECORD 2419 LAST UPDATE OF THIS RECORD: 03/04/91
NAME: CYCLONITE
SYNONYMS: CYCLONITE; CYCLOTRIMETHYLENENITRAMINE;
CYCLOTRIMETHYLENETRINITRAMINE;
CYCLOTRIMETHYLENETRINITRAMINE (DOT);
ESAIDRO-1,3,5-TRINITRO-1,3,5-TRIAZINA (Italian); HEKSOGEN
(Polish); HEXAHYDRO-1,3,5-TRINITRO-s-TRIAZINE;
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZIN (German);
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE; HEXOGEEN (Dutch);
HEXOGEN; HEXOGEN (Explosive); HEXOGEN 5W; HEXOLITE;
PBX(AF) 106; RDX; T4; TRIMETHYLEENTRINITRAMINE (Dutch);
TRIMETHYLENETRINITRAMINE; sym-TRIMETHYLENETRINITRAMINE;
TRINITROCYCLOTRIMETHYLENE TRIAMINE;
1,3,5-TRINITRO-1,3,5-TRIAZACYCLOHEXANE;
HEXAHYDRO-1,3,5-TRINITRO-S-TRIAZINE; S-TRIAZINE,
HEXAHYDRO-1,3,5-TRINITRO-;
SYM-TRIMETHYLENETRINITRINITRAMINE;
1,3,5-TRINITRO-1,3,5-TRIZAZCYCLOHEXANE
CAS: 121-82-4 RTECS: XY9450000
FORMULA: C3H6N6O6 MOL WT: 222.15
WLN: T6N CN ENTJ ANW CNW ENW
CHEMICAL CLASS:Nitro compound

See other identifiers listed below under Regulations.

PROPERTIES

PHYSICAL DESCRIPTION:
BOILING POINT: NA
MELTING POINT: 478 K 204.8 C 400.7 F
FLASH POINT: NA
AUTO IGNITION: NA
VAPOR PRESSURE:
UEL: NA
LEL: NA
VAPOR DENSITY: No data
SPECIFIC GRAVITY:
DENSITY: 1.82 20/4
WATER SOLUBILITY:

INCOMPATIBILITIES:

REACTIVITY WITH WATER: No data on water reactivity
REACTIVITY WITH COMMON MATERIALS: No data
STABILITY DURING TRANSPORT: No Data
NEUTRALIZING AGENTS: No data
POLYMERIZATION POSSIBILITIES: No data

TOXIC FIRE GASES: None reported other than possible unburned vapors
ODOR DETECTED AT (ppm): Unknown
ODOR DESCRIPTION: Unknown SOURCE:Unspecified
100 % ODOR DETECTION: No data

REGULATIONS

DOT HAZARD CLASS: Class A explosive
DOT GUIDE: 46
DOT ID NUMBER: UN0072
DOT SHIPPING NAME: HIGH EXPLOSIVE
STCC NUMBER:
CLEAN AIR ACT: Not covered
EPA WASTE NUMBER:
CERCLA REF:
RQ DESIGNATION: Not listed
SARA TPQ VALUE: Not listed
SARA Sect. 312
categories:
Acute toxicity: Toxic. LD50 >50 and <= 500 mg/kg (oral rat).

UNITED STATED POSTAL SERVICE MAILABILITY:
Not given

NFPA CODES:
HEALTH HAZARD (BLUE): Unspecified
FLAMMABILITY (RED) : Unspecified
REACTIVITY (YELLOW): Unspecified
SPECIAL : Unspecified

TOXICITY DATA

TARGET ORGANS:
SYMPTOMS: IRRITATION OF EYES AND RESP. TRACT, ULCERATION OF MUCOUS MEMBRANES, DERMATITIS, HEADACHE, IRRITABILITY, SALIVATION, ANOREXIA, ASTHMA, INSOMNIA, UNCONSCIOUSNESS, CONVULSIONS. Source: HTHC

CONC IDLH: Unknown

NIOSH REL:

ACGIH TLV: TLV = 1.5 mg/M3*STEL =- ppm*STEL = 3 mg/M3*SKIN
ACGIH STEL: 3 mg/M3

OSHA PEL: Final Rule Limits:
TWA = 1.5 mg/M3(SKIN)

CARCINOGEN?: STATUS:

CARCINOGEN LISTS:
IARC: Not listed
MAK: Not listed
NIOSH: Not listed
NTP: Not listed
ACGIH: Not listed
OSHA: Not listed

LD50 value: ori-rat LD50:100 mg/kg

OTHER SPECIES TOXICITY DATA: (Source: NIOSH RTECS 1990)

ori-rat LD50:100 mg/kg
ipr-rat LDLo:10 mg/kg
ivn-rat LDLo:18 mg/kg
ori-mus LD50:59 mg/kg
ivn-mus LD50:19 mg/kg
ori-cat LDLo:100 mg/kg
ori-rbt LDLo:500 mg/kg
ivn-gpg LD50:25 mg/kg

Reproductive toxicity (1990 RTECS):
This chemical is a mammalian reproductive toxin.

PROTECTION AND FIRST AID

PROTECTION SUGGESTED
FROM THE CHRIS MANUAL:

FIRST AID (NIOSH):
EYE:
IRRIGATE WITH WATER
SKIN:
WASH WITH SOAP
INHALATION:
ADMINISTER OXYGEN
INGESTION:

INITIAL INCIDENT RESPONSE

US Department of Transportation Guide to Hazardous Materials Transport Information - Publication DOT 5800.5 (1990).
DOT SHIPPING NAME: HIGH EXPLOSIVE
DOT ID NUMBER: UN0072

ERG90 GUIDE 46

* POTENTIAL HAZARDS *

*FIRE OR EXPLOSION
May explode and throw fragments 1 mile or more if fire reaches cargo.
*HEALTH HAZARDS
Fire may produce irritating or poisonous gases.

* EMERGENCY ACTION *

IF FIRE REACHES CARGO, DO NOT FIGHT FIRE.
IF YOU KNOW OR SUSPECT THAT HEAVILY-ENCASED EXPLOSIVES, SUCH AS BOMBS OR ARTILLERY PROJECTILES ARE INVOLVED, STOP ALL TRAFFIC AND BEGIN TO EVACUATE ALL PERSONS, INCLUDING EMERGENCY RESPONDERS, FROM THE FIRE AREA IN ALL DIRECTIONS FOR 5000 FEET (1 MILE) FOR RAIL CAR OR 4000 FEET (3/4 MILE) FOR TRACTOR/TRAILER.
WHEN HEAVILY-ENCASED EXPLOSIVES ARE NOT INVOLVED, EVACUATE THE AREA FOR 2500 FEET (1/2 MILE) IN ALL DIRECTINS.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
CALL CHEMTREC AT 1-800-424-9300 AS SOON AS POSSIBLE, especially if there is no local hazardous materials team available.
*FIRE
Cargo Fires: DO NOT FIGHT FIRE WHEN IT REACHES CARGO. Withdraw from area and let fire burn.
Truck and Equipment Fires: Try to prevent fire from reaching the explosive cargo compartment. Flood with water; if not water is available use CO_2, dry chemical or earth.
Promptly isolate the scene by removing all persons from the vicinity of the incident of there is a fire. First, move people out of line-of-sight of the scene and away from windows. Then, obtain more information and specific guidance from competent authorities listed on the shipping papers.
*SPILL OR LEAK
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch spilled material.
*FIRST AID
Call emergency medical care.
Use first aid treatment according to the nature of the injury.

Material Safety Data Sheet

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GENIUM PUBLISHING CORP.

No. 181

SILVER

Issued: April 1986

SECTION 1. MATERIAL IDENTIFICATION

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MATERIAL NAME: SILVER
DESCRIPTION: Elemental metal.
OTHER DESIGNATIONS: Ag, Argentum, CAS #7440-22-4.

MANUFACTURER/SUPPLIER: Available from many suppliers.

COMMENTS: Photography products account for 30% of industrial consumption. Additional uses include electrical conductors, coins, silverware, and jewelry.

HMIS
H:1
F:0
R:0
PPE*
*See sect. 8

Not Found

SECTION 2. INGREDIENTS AND HAZARDS

	%	HAZARD DATA
Silver, Ag	99+	TWA 0.1 mg/m^3* TWA 0.01 mg/m^3** ——— Rat, Implant, TD: 2570 mg/kg

* Current (1985-86) ACGIH TLV for silver dust and fume.

** Current (1985-86) ACGIH TLV for soluble silver compounds and OSHA exposure limit.

SECTION 3. PHYSICAL DATA

Boiling Point ... 3833.6°F (2112°C)
Vapor Pressure ... Not Found
Water Solubility ... Insoluble
Vapor Density (Air = 1) ... Not Found
Evaporation Rate ... Not Found

Specific Gravity (H_2O = 1) ... 10.5
Melting Point ... 1763.4°F (961.9°C)
Percent Volatile by Volume ... Not Found
Molecular Weight ... 107.87

Appearance and odor: Ductile and malleable lustrous white metal.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temp.	Flammability Limits In Air	LOWER	UPPER
Not Found	Not Found	Not Found	Not Applicable	Not Applicable

NFPA Classification: Noncombustible.

EXTINGUISHING MEDIA: Use proper extinguisher for surrounding fire.

UNUSUAL FIRE/EXPLOSION HAZARDS: None.

SPECIAL FIRE-FIGHTING PROCEDURES: None.

SECTION 5. REACTIVITY DATA

Silver is stable. Hazardous polymerization cannot occur.

CHEMICAL INCOMPATIBILITIES: Acetylene and silver form an insoluble, explosive acetylide. If silver is treated with nitric acid in the presence of ethyl alcohol, silver fulminate may be formed, which can be detonated.
Ethylenimine forms explosive compounds with silver. Finely divided silver and hydrogen peroxide solutions may explode.
This material is incompatible with oxalic and tartaric acid. Ammonia plus silver may form explosive compounds.
Bromoazide explodes on contact with silver foil.

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SECTION 6. HEALTH HAZARD INFORMATION | TLV

Silver is not considered a carcinogen by the NTP, IARC, or OSHA.
SUMMARY OF RISKS: Silver has no known physiological function in man and will accumulate in most tissues. Chronic accumulation (threshold in excess of 1 gram) in the body can result in argyria, a permanent condition associated with widespread bluish pigmentation of the skin and conjunctiva. TARGET ORGANS: Generally, where contact occurs. PRIMARY ENTRY: Inhalation, long-term handling (causes particles to become embedded in skin), or absorption through sweat glands. ACUTE EFFECTS are associated with soluble silver compounds that may be caustic, causing local irritations or destruction of tissue, depending upon strength of solution. CHRONIC EFFECTS: Argyria may be a local or general effect, depending upon previous exposure. FIRST AID: EYE CONTACT: Flush with water for 15 minutes. Get medical attention.* SKIN CONTACT: Wash skin with soap and water. Argyria from long-term exposure is permanent and cannot be washed away. INHALATION: Remove victim to fresh air. INGESTION: Dilute with water. Get medical attention.*

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

COMMENTS: The original 0.01 mg/m^3 TLV was established to prevent a lifetime body accumulation exceeding 1 gram, where argyria would become evident. Evaluation of 25 years of data has shown 0.01 mg/m^3 to be too conservative; therefore, the ACGIH raised the TLV to 0.1 mg/m^3.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

SPILL/LEAK: Notify safety personnel; prevent entry into sewers or surface waters. Wear respirator where a dusting hazard is anticipated.

WASTE DISPOSAL: Reclaim or sell waste to a commercial reclaimer.

SECTION 8. SPECIAL PROTECTION INFORMATION

GOGGLES are not required unless metal is in the molten state.
GLOVES: Repeated handling may discolor the skin because of skin rubbing against the metal. Cotton gloves will prevent this cosmetic effect.
RESPIRATOR is required where metal dust or fumes are generated with inadequate exhaust ventilation. Air samples should be collected to quantify the exposure levels.
VENTILATION is required where air exposures exceed the TLV-TWA'S.
OTHER: Reclamation of silver from photographic or X-ray film may involve cyanide compounds. Proper precautions must be taken when working with cyanide compounds. See Genium MSDS #13, Potassium Cyanide, for further information.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

STORAGE SEGREGATION: Silver is usually stored in locked cabinets or safes to prevent theft.

ENGINEERING CONTROLS: Exhaust ventilation where TLV-TWA is exceeded.

EPA Hazardous Substance Designation: 40 CFR 260

Data Source(s) Code: 2, 4, 6, 14, 59, 82, 84, NFC 1983. DW

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Approvals	
Indust. Hygiene/Safety	
Medical Review	

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Material Safety Data Sheet

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GENIUM PUBLISHING CORP.

No. 219

SODIUM METAL

Issued: November 1987

SECTION 1. MATERIAL IDENTIFICATION

Material Name: SODIUM METAL

Description (Origin/Uses): Prepared industrially in Down cells and in Castner cells. Used as a dehydrating agent, nuclear reactor coolant, reducing agent, conductor in cables, and in organic synthesis; nonglare lighting for highways, radioactive forms in tracer studies and medicine.

Other Designations: Natrium; Sodium; Sodium, Metallic; Na; NIOSH *RTECS* No. VY0686000; CAS No. 7440-23-5

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

HMIS
H 3
F 1
R 2
PPG*
*See sect. 8

R 2
I NA
S 4
K 1

SECTION 2. INGREDIENTS AND HAZARDS

	%	EXPOSURE LIMITS
Sodium Metal, CAS No. 7440-23-5 Sodium plus water yields sodium hydroxide (NaOH), having the CAS No. 1310-73-2 and the NIOSH *RTECS* No. WB4900000 with the following exposure limits: ACGIH TLV, 1987-88 Ceiling TLV: 2 mg/m³ OSHA PEL 8-Hr TWA: 2 mg/m³ NIOSH REL 15-Min Ceiling: 2 mg/m³	ca 100	Element Sodium: No Exposure Limits Established No Toxicity Data is available for element sodium; however, as Thyroxine, monosodium salt, D-: Rabbit, Oral, TD_{Lo}: 15 mg/kg

SECTION 3. PHYSICAL DATA

Boiling Point: 1621°F (883°C)
Water Solubility: Reacts Violently with Water
Specific Gravity (H_2O = 1): 0.968
Melting Point: 208°F (98°C)
Molecular Weight: 22.99 Grams/Mole
pH: Water Solution Alkaline (pH >7)

Appearance and Odor: Malleable (soft), silver-white solid, oxidizes rapidly in air; waxlike at room temperature. Odorless.

Comments: Solvent solubility: sodium decomposes in alcohol; it is insoluble in ether and benzene, and it dissolves in liquid ammonia to produce a blue solution.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
Flammable Solid	250°F (121°C)	Not Applicable	Not Applicable	Not Applicable

Extinguishing Media: Do *not* use water, "alcohol" foam, carbon dioxide, or halogenated extinguishing agents (Halon®) to put out a fire involving sodium metal. Use graphite powder, soda ash, powdered sodium chloride, or suitable dry powder (Met-L-X® or G-1® graphite powders). Pails are adequate for storing extinguishing agents if the material is kept dry. **Unusual Fire/Explosion Hazards:** Sodium metal is extremely dangerous in contact with moisture or water and releases hydrogen with sufficient heat to cause ignition or explosion. It ignites spontaneously in air or with oxygen, and it burns violently accompanied by explosions that can cause the material to spatter. **Special Fire-fighting Procedures:** Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Fire fighters should move containers from the fire area if possible (see Genium ref. 85). Sodium metal may reignite after the fire is extinguished. Keep it away from drains or sewers; it may create an additional fire hazard. Preplanning and placement of correct extinguishing media is required. **Comments:** This material is dangerous when exposed to air in a heated environment (fire); it will emit toxic fumes of sodium oxide, which will react with water to produce heat, hydrogen gas, and flammable vapors.

SECTION 5. REACTIVITY DATA

Sodium metal is not stable and may readily undergo violent chemical change without detonation. It will react violently or explosively with water, and it reacts spontaneously in air. **Chemical Incompatibilities:** Sodium metal reacts vigorously or explosively with oxidizing agents. The following materials may cause an explosive reaction: acids (hydrochloric acid, hydrogen fluoride, nitric acid [fuming], and sulfuric acid); air; halides such as aluminum bromide, magnesium chloride, aluminum fluoride, and mercuric iodide; carbon dioxide; ammonia; chlorinated hydrocarbons; hydrogen peroxide; lead oxide; phosphorus; potassium oxides; sulfur; sulfur dioxide; and especially water. **Conditions to Avoid:** Avoid exposing this material to air or moisture. It may ignite spontaneously if it is exposed to moist air. Its violent reaction with water will produce hydrogen gas. **Hazardous Products of Decomposition:** Sodium metal may release these toxic fumes when decomposed: sodium oxide, which can react with moisture or steam to produce heat; sodium hydroxide (corrosive); and flammable hydrogen gas.
Comments: This material is dangerous when exposed to moisture! Keep it dry at all times.

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SECTION 6. HEALTH HAZARD INFORMATION

Sodium metal is not listed as a carcinogen by the NTP, IARC, or OSHA.
Summary of Risks: This material is harmful or fatal if swallowed, inhaled, or absorbed through the skin and mucous membranes. It is corrosive to skin and body tissue. Inhalation may cause upper respiratory tract irritation, inflammation, and pulmonary damage. It may react violently and explosively on contact with wet tissue and generate heat with resultant chemical and thermal burns. The effects of low-dosage exposure are usually reversible after exposure has ended. **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Eyes, skin, mucous membranes, respiratory tract. **Primary Entry:** Skin and eye contact. **Acute Effects:** Sodium metal is corrosive to body tissue. Alkalies penetrate the skin slowly, therefore the extent of damage depends on the amount and duration of exposure. It may cause burns, ulcerations, and tissue death (necrosis). Its fumes are highly irritating. Eye contact will cause burns, conjunctivitis, corneal damage, and corneal opacification with possible blindness. Inhalation of dusts or fumes will cause shortness of breath, headache, nausea and vomiting, and nose and respiratory tract irritation (pneumonitis). If swallowed, this material will cause severe pain, vomiting, diarrhea, and possible collapse. **Chronic Effects:** This material may cause chronic dermatitis, mucous membrane irritation, and lung damage. Corrosive effects may result in permanent impairment.
FIRST AID: Eye Contact. Flush eyes, including under the eyelids, promptly and gently with plenty of running water for 15 minutes. **Skin Contact.** Remove sodium metal-contaminated clothing immediately. Wash the affected area with mild soap and water until all the chemical is removed. In case of chemical burn, treat as indicated. **Inhalation.** Remove victim to fresh air. If he is not breathing, give him artificial respiration, preferably mouth to mouth. If breathing is difficult, give him oxygen. **Ingestion.** If swallowed, and victim is conscious, give him water or milk. Never give anything by mouth to someone who is unconscious.
Comments: Sodium metal reacts with moisture to form sodium hydroxide, which is a severe eye, skin, and mucous membrane irritant. Exposure to this may cause permanent eye and skin damage.

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Do not touch spilled sodium metal. Shut off ignition sources. Do not get water on spilled material or inside material's container because of the danger of violent and explosive reactions. Shovel small dry spills into a clean, dry container and cover it. Wear an SCBA and heavy chemical-resistant gloves.
Waste Disposal: Do not dilute a spill with liquid or dispose of it down any open drain or sewer. Contact your supplier or a licensed contractor for recommendations. Follow Federal, state, and local regulations.
OSHA Designations
Air Contaminant (29 CFR 1910.1000 Subpart Z): Not Listed
EPA Designations (40 CFR 302.4)
RCRA Hazardous Waste, No. D003 (Reactivity)
CERCLA Hazardous Substance, Reportable Quantity: 10 lbs (4.54 kg)
Comments: CERCLA Ratings (Scale 0-3): Health: 3; Fire: 1; Reactivity: 2; Persistence: 3

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Follow the eye- and face-protection guidelines of 29 CFR 1910.133. Wear chemical splash-proof and dust-resistant safety goggles and/or faceshield with approved safety glasses to prevent eye and face contact. There is a potential for violent spattering when using sodium metal. **Gloves:** Wear appropriate, heavy-duty, chemical-resistant gloves. **Respirator:** Where high levels of sodium metal dust, fume, or sodium hydroxide may exist, wear the self-contained breathing apparatus described in section 4. **Other:** Wear protective chemical-resistant apron, boots, and other appropriate protective clothing. **Ventilation:** Use sodium metal only under a chemical fume hood, under localized ventilation, or where general dilution ventilation is adequate.
Safety Stations: Make eyewash stations, washing facilities, and safety showers available in areas of use and handling because sodium metal is corrosive to eyes and body tissue.
Contaminated Equipment: Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Particles may cling to contact lenses, causing corneal injury.
Comments: Practice effective personal hygiene. Keep this material off of your clothes and equipment. Avoid transferring this material from hands to mouth while eating, drinking, or smoking. Do *not* smoke, eat, or drink in any immediate work area. Avoid all contact with sodium metal.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage Segregation: Store sodium metal away from sources of heat, ignition, water, and other liquids. Store it away from oxidizers.
Special Handling/Storage: Protect containers against physical damage. Store this material in airtight containers under an inert atmosphere such as nitrogen or in naphtha or a similar liquid that does not contain water or free oxygen (e.g., coal oil, kerosene, or other liquid hydrocarbons). *Never store sodium metal under halogenated hydrocarbons* such as Freon®, methylene chloride, or 1,1,1-trichloroethane. The storage media is itself a hazard; handle it appropriately. An isolated, well-ventilated, fire-resistant building is recommended for large-quantity storage. Do not store it where automatic sprinklers are present or where water or steam is readily available. Provide enough heat in the storage area to keep material sufficiently dry from condensating moisture. Provide appropriate fire extinguishers for the storage area. Water contamination of storage tanks, reactor vessels, etc., must be scrupulously avoided at all costs. **Comments:** In the absence of water, oxygen, or halides, sodium metal is safe to handle. Remove only that amount of material immediately needed from the storage area. Use a metal container with tightly fitting lid for transport. **Warning:** Sodium metal is a highly reactive material and requires a sustained, conscientious effort by all who work with it for its safe use.
Transportation Data (49 CFR 172.101-2)

DOT Hazard Class: Flammable Solid	DOT Shipping Name: Sodium Metal	DOT ID No. UN1428
DOT Label: Flammable Solid; Dangerous When Wet	IMO Label: Dangerous When Wet	IMO Class: 4.3

References: 1-11, 18, 24, 37, 39, 44, 73, 82, 84, 87-94. OW/PJI

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Approvals	
Indust. Hygiene/Safety	
Medical Review	Geoff Goldsmith, MD

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Material Safety Data Sheets Collection:

Sheet No. 351
Styrene *monomer*

Issued: 8/79 Revision: D, 6/92

Section 1. Material Identification

38

Styrene *monomer* ($C_6H_5CHCH_2$) **Description:** Produced by catalytic dehydrogenation of ethylbenzene at 932 to 1292 °F (500 to 700 °C) at 30 mm Hg; catalyst is a mixture of zinc oxide (86%), aluminum, calcium, and magnesium. Available in technical (99.2% pure) and polymer (99.6% pure) grades. Occurs naturally in the sap of styracaceous plants, in pyrolysis and cracking products of petroleum derivatives, in bituminous-coal and shale-oil tars, in rubber latexes, and as a product of organic substance pyrolysis. Used in the manufacture of a wide range of polymers including polystyrene and copolymer elastomers such as butadiene-styrene rubber or acrylonitrile-butadiene-styrene (ABS); in production of plastics and insulators, as a resin modifying additive, dental filling component, chemical reaction intermediate, and in agricultural products.
Other Designations: CAS No. 100-42-5, cinnamene, Diarex HF 77, ethenylbenzene, NCI-C02200, phenylethylene, styrol, styropor, vinylbenzene.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.
Cautions: Styrene is extremely flammable and polymerizes easily. The vapor is irritating to eyes, skin, and respiratory system and the liquid may cause burns. Inhalation of high concentrations can lead to central nervous system (CNS) depression.

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

NFPA†
3 / 2 / 2 / –

HMIS
H 2
F 3
R 2
PPG‡
‡ Sec. 8

† Rating is for *inhibited* monomer

Section 2. Ingredients and Occupational Exposure Limits

Styrene *monomer*, ca 99.6%, containing inhibitors butylcatechol or hydroquinone

1991 OSHA PELs
8-hr TWA: 50 ppm (215 mg/m³)
15-min STEL: 100 ppm (425 mg/m³)

1990 IDLH Level
5000 ppm

1990 NIOSH RELs
TWA: 50 ppm (215 mg/m³)
STEL: 100 ppm (425 mg/m³)

1991-92 ACGIH TLVs (Skin)
TWA: 50 ppm (213 mg/m³)
STEL: 100 ppm (426 mg/m³)

1990 DFG (Germany) MAKs
Ceiling: 20 ppm (85 mg/m³)
Half-life: < 2 hr
Peak Exposure Limit: 40 ppm, 30 min. average value, 4 per shift

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 20 µg/m³ caused eye effects.
Human, skin: 500 mg (non-standard test, *accident*) caused irritation.
Human, HeLa cell: 28 mmol/L caused unscheduled DNA synthesis.
Rat, oral, LD_{50}: 5000 mg/kg; toxic effects not yet reviewed
Rat, inhalation, LC_{50}: 24 g/m³/ 4 hr produced an antipsychotic effect.

* See NIOSH, *RTECS* (WL3675000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 293 °F (145 °C)
Freezing Point: -23 °F (-31 °C)
Vapor Pressure: 5 mm Hg at 68 °F (20 °C)
Viscosity: 0.751 mPa
Refraction Index: 1.5463 at 68 °F (20 °C)
Odor Threshold Range: 0.15 to 25 ppm
Density: 0.9045 at 25/25 °C
Surface Tension: 32.14 dyne/cm at 66.2 °F (19 °C)
Molecular Weight: 104.2
Saturated Vapor Density (air = 1.2 kg/m³): 1.22 kg/m³ or 0.076 lbs/ft³
Water Solubility: Practically insoluble, 0.3 lbs/100 lbs water; floats on water
Other Solubilities: Soluble in benzene, carbon disulfide, carbon tetrachloride, ethanol, ethyl ether and ketones. Dissolves organic substances and polymers.

Appearance and Odor: Colorless to slightly yellow oily liquid with a sweet, pleasant odor at low levels becoming pungent as levels increase.

Section 4. Fire and Explosion Data

Flash Point: 88 °F (31 °C), CC	Autoignition Temperature: 914 °F (490 °C)	LEL: 1.1% v/v	UEL: 7% v/v

Extinguishing Media: A Class 1C flammable liquid. For small fires, use dry chemical, carbon dioxide (CO_2), or regular foam. For large fires, use fog, or regular foam. Water may be ineffective since styrene tends to float on water; use only when other agents are unavailable.
Unusual Fire or Explosion Hazards: Styrene may accumulate static electricity. Hazardous polymerization can occur causing container to rupture due to heat of fire. Vapors may travel to ignition source and flash back. Styrene poses a vapor explosion hazard indoors, outdoors, and in sewers.
Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing provides only limited protection. Use protective clothing specifically recommended by manufacturer. Apply cooling water to container sides until well after fire is out. If possible without risk, remove container from fire area. Stay away from ends of tanks. For massive fire in cargo area use monitor nozzles or unmanned hose holders; if this is impossible, withdraw from area and let fire burn. Withdraw immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Uninhibited styrene monomer is very unstable and even when inhibited (butylcatechol or hydroquinone) polymerization occurs slowly at room temperature and fast at elevated temperatures or in contact with certain initiators. **Chemical Incompatibilities:** Styrene vapor is explosive when exposed to heat or flame; reacts with oxygen above 104 °F (40 °C) to form a heat-sensitive explosive peroxide. Violent polymerization may be initiated by alkali metal-graphite composites, butyllithium, dibenzoyl peroxide, azoisobutyronitrile or di-*tert*-butyl peroxide. Styrene reacts violently with chlorosulfonic acid, oleum, sulfuric acid, chlorine + iron (II) chloride (above 50 °C) and can react vigorously with oxidizing materials. **Conditions to Avoid:** Exposure to heat and ignition sources, light, and contact with incompatibles.
Hazardous Decomposition Products: Thermal oxidative decomposition of styrene can produce carbon dioxide, acrid smoke and irritating fumes.

Section 6. Health Hazard Data

Carcinogenicity: The IARC[164] lists styrene monomer as a carcinogen; Class 2B (possibly carcinogenic, limited human evidence in the absence of sufficient animal data). **Summary of Risks:** Styrene is irritating to the eyes, skin, and respiratory system. It is absorbed through the skin at 9 to 15 mg/m²/hr (hand and forearm). Inhalation of high concentrations can cause CNS depression but styrene's pungent, irritating odor is usually enough to prevent acute toxic exposures. If heavy exposure occurs, styrene can saturate the body in 30-40 minutes, is distributed throughout the organs and is rapidly eliminated (~85% in 24 hr) either in urine (71%) or expired air (10%). Unexcreted styrene accumulates in adipose tissue (subcutaneous connective tissue containing fat cells). Ovulation and menstrual disorders were observed in women exposed to styrene. In one case, CNS effects were observed in infants whose mother was exposed to chemicals such as styrene during pregnancy. In general, pregnant women may be at elevated risk because styrene crosses the placental barrier. **Target Organs:** CNS, eyes, respiratory system, and skin. **Primary Entry Routes:** Inhalation, skin contact/absorption. **Medical Conditions Aggravated by Long-term Exposure:** Possibly, liver, kidney, blood, skin, and CNS disorders.
Acute Effects: Inhalation of concentrations as low as 50 ppm causes irritation of the eyes, and respiratory tract.

Continue on next page

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Section 6. Health Hazard Data, *continued*

Symptoms include watering eyes and nose, chest heaviness or pain, difficulty breathing, coughing, bluish face and lips, wheezing, headache, nausea, vomiting, dizziness, fatigue, diarrhea and risk of pulmonary edema (fluid in lungs). Skin contact is irritating, with itching, inflammation and possible blisters. Splashes to the eyes cause irritation, watering, lid inflammation, chemical corneal burns, and possibly, serious lesions. Cases of ingestion have not been reported but by analogy to animal studies it could cause irritation of the lips, mouth, and throat; painful swallowing, abdominal pain, nausea, vomiting, state of shock, possible convulsions and risk of pulmonary edema. **Chronic Effects:** Repeated exposure has caused "styrene sickness" described by nausea, vomiting, appetite loss, and general weakness. Occupational asthma may occur rarely. Functional disorders of the nervous system, irritation of the upper airways, and blood changes particularly leukopenia (abnormally low number of circulating, nucleated white or colorless blood cells) and lymphocytosis (increased number of lymphocytes which are involved in the immune system) have also been observed. Medical exams revealed toxic hepatitis in workers exposed to ~50 mg/m^3 styrene for over 5 yr. Prolonged exposure to < 50 mg/m^3 caused certain liver function disorders (protein, pigment, glycogen). Peripheral neuropathies were observed in chronically exposed workers. Repeated or prolonged skin exposure may cause dermatitis with rough, dry, fissured skin due to defatting.

FIRST AID **Eyes:** Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Do *not* allow victim to rub or keep eyes tightly shut. Immediately consult a physician. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not induce vomiting!* Gastric lavage may be indicated if victim is at risk of convulsing but the decision should be carefully weighed since severe esophageal irritation may occur. **Note to Physicians:** For acute exposure, give baseline liver and kidney function tests and obtain urinalysis, CBC, amylase and lipase levels. Monitor arterial blood gases and perform chest X-ray if significant respiratory irritation occurs. Phenylglyoxylic and mandelic acid may be determined in urine.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Cleanup personnel should protect against inhalation and eye and skin contact. Shut off all ignition sources. Use water spray to cool and disperse vapors (this may not prevent ignition in closed spaces). For small spill, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers. For large spills, dike far ahead of liquid spill for later disposal or reclamation. For spills in water, apply activated carbon at 10 X the spilled amount (at least 10,000 ppm) or use barriers or oil spill booms to limit motion. "Universal" gelling agent injected into spill may aid in solidification. Remove material with suction hoses or mechanical dredges. Follow applicable OSHA regulations (29 CFR 1910.120). Report spills in excess of 1000 lb. **Ecotoxicity Values:** TLm, *Pimephales promelas* (fathead minnow), 53.6 mg/L/48 hr; TLm, *Artemia salina* (brine shrimp), 68 mg/L/24 hr and 52 mg/L/48 hr. **Environmental Degradation:** In water, styrene monomer volatilizes rapidly and may be subjected to biodegradation. It is not expected to hydrolyze. In air, styrene will react rapidly with hydroxyl radicals and ozone with a combined calculated half-life of 2.5 to 9 hr. In soil, styrene will biodegrade and leach to groundwater with low to moderate mobility (depending on soil conditions). **Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations Listed as a RCRA Hazardous Waste (40 CFR 261.21 & 261.23): D001 and D003, Characteristic of ignitability and reactivity
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg) [* per CWA, Sec. 311(b)(4)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A & Z-2)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH/MSHA-approved respirator. For < 500 ppm, use any supplied air respirator (SAR) or SCBA. For < 1250 ppm, use any SAR operated in a continuous flow mode. For < 5000 ppm, use any SAR with a full facepiece in positive pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Polyvinyl alcohol is recommended as suitable material for PPG. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Thoroughly decontaminate PPG. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Styrene is corrosive to copper or copper alloy containers. Store in cool (hazardous above 32 °C), dry, well-ventilated area away from incompatibles (Sec. 5). Store small refrigerated amounts in glass containers and large amounts in vented metal tanks in outside or detached storage under an inert blanket (i.e., nitrogen). Install electrical equipment Class 1, Group D. Inhibit styrene during storage to prevent polymerization. Uninhibited vapor may polymerize in vents and cause blockage. To prevent static sparks, electrically ground and bond all equipment used in styrene manufacture, use, storage, transfer, and shipping. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Continuously monitor workplace air levels of styrene. Make sure ducting, piping, and pipe joints are leak tight. Give preference to continuous rather than batch techniques and mechanize manual operations. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers that emphasize the CNS, blood, liver, kidney, and skin. Consider precluding pregnant women from styrene exposure.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Styrene monomer, inhibited
DOT Hazard Class: Flammable liquid
ID No.: UN2055
DOT Label: Flammable liquid
DOT Packaging Exceptions: 173.118
DOT Packaging Requirements: 173.119

IMO Shipping Name: Styrene monomer, inhibited
IMO Hazard Class: 3.3
ID No.: UN2055
IMO Label: Flammable liquid
IMDG Packaging Group: II

MSDS Collection References: 73, 89, 100, 101, 103, 124, 126, 127, 131, 132, 133, 136, 139, 140, 148, 149, 153, 159, 162, 163, 164, 167, 168
Prepared by: M Gannon, BA; Industrial Hygiene Review: DJ Wilson, CIH; Medical Review: AC Darlington, MPH, MD

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Material Safety Data Sheets Collection:

Sheet No. 317
Toluene

Issued: 8/79 Revision: E, 9/92

Section 1. Material Identification

39

Toluene ($C_6H_5CH_3$) Description: Derived from petroleum i.e., dehydrogenation of cycloparaffin fractions followed by the aromatization of saturated aromatic hydrocarbons or by fractional distillation of coal-tar light oil and purified by rectification. Used widely as a solvent (replacing benzene in many cases) for oils, resins, adhesives, natural rubber, coal tar, asphalt, pitch, acetyl celluloses, cellulose paints and varnishes; a diluent for photogravure inks, raw material for organic synthesis (benzoyl & benzilidene chlorides, saccharine, TNT, toluene diisocyanate, and many dyestuffs), in aviation and high octane automobile gasoline, as a nonclinical thermometer liquid and suspension solution for navigational instruments.

Other Designations: CAS No. 108-88-3, Methacide, methylbenzene, methylbenzol, phenylmethane, tolnol, Tolu-sol.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(75) for a suppliers list.

Cautions: Toluene is an eye, skin, and respiratory tract irritant becoming narcotic at high centrations. Liver and kidney damage has occurred. Pregnant women chronically exposed to toluene have shown teratogenic effects. Toluene is highly flammable.

R	1
I	3
S	2*
K	3

* Skin absorption

NFPA: 2 3 0 -

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

Section 2. Ingredients and Occupational Exposure Limits

Toluene, < 100%; may contain a small amount of benzene (~ 1%), xylene, and nonaromatic hydrocarbons.

1991 OSHA PELs
8-hr TWA: 100 ppm (375 mg/m³)
15-min STEL: 150 ppm (560 mg/m³)

1990 IDLH Level
2000 ppm

1990 NIOSH RELs
TWA: 100 ppm (375 mg/m³)
STEL: 150 ppm (560 mg/m³)

1992-93 ACGIH TLV (Skin)
TWA: 50 ppm (188 mg/m³)

1990 DFG (Germany) MAK*
TWA: 100 ppm (380 mg/m³)
Half-life: 2 hr to end of shift
Category II: Substances with systemic effects
Peak Exposure Limit: 500 ppm, 30 min average value, 2/shift

1985-86 Toxicity Data†
Man, inhalation, TC_{Lo}: 100 ppm caused hallucinations, and changes in motor activity and changes in psychophysiological tests.
Human, oral, LD_{Lo}: 50 mg/kg; toxic effects not yet reviewed
Human, eye: 300 ppm caused irritation.
Rat, oral, LD_{50}: 5000 mg/kg
Rat, liver: 30 µmol/L caused DNA damage.

* Available information suggests damage to the developing fetus is probable.
†See NIOSH, *RTECS* (XS5250000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 232 °F (110.6 °C)
Melting Point: -139 °F (-95 °C)
Molecular Weight: 92.15
Density: 0.866 at 68 °F (20/4 °C)
Surface Tension: 29 dyne/cm at 68 °F (20 °C)
Viscosity: 0.59 cP at 68 °F (20 °C)
Refraction Index: 1.4967 at 20 °C/D

Water Solubility: Very slightly soluble, 0.6 mg/L at 68 °F (20 °C)
Other Solubilities: Soluble in acetone, alcohol, ether, benzene, chloroform, glacial acetic acid, petroleum ether, and carbon disulfide.
Vapor Pressure: 22 mm Hg at 68 °F (20 °C); 36.7 mm Hg at 86 °F (30 °C)
Saturated Vapor Density (Air = 0.075 lb/ft³ or 1.2 kg/m³): 0.0797 lb/ft³ or 1.2755 kg/m³
Odor Threshold (range of all referenced values): 0.021 to 69 ppm

Appearance and Odor: Colorless liquid with a sickly sweet odor.

Section 4. Fire and Explosion Data

Flash Point: 40 °F (4.4 °C) CC	Autoignition Temperature: 896 °F (480 °C)	LEL: 1.27% v/v	UEL: 7.0% v/v

Extinguishing Media: Toluene is a Class 1B flammable liquid. To fight fire, use dry chemical carbon dioxide, or 'alcohol-resistant' foam. Water spray may be ineffective as toluene floats on water and may actually spread fire. **Unusual Fire or Explosion Hazards:** Concentrated vapors are heavier than air and may travel to an ignition source and flash back. Container may explode in heat of fire. Toluenes' burning rate = 5.7 mm/min and its flame speed = 37 cm/sec. Vapor poses an explosion hazard indoors, outdoors, and in sewers. May accumulate static electricity. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing provides only limited protection. Apply cooling water to sides of tanks until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from fire and let burn. Withdraw immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire because a BLEVE (boiling liquid expanding vapor explosion) may be imminent. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Toluene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization can't occur. **Chemical Incompatibilities:** Strong oxidizers, concentrated nitric acid, nitric acid + sulfuric acid, dinitrogen tetroxide, silver perchlorate, bromine trifluoride, tetranitromethane, and 1,3-dichloro-5,5-dimethyl-2,4-imidazolididione. **Conditions to Avoid:** Contact with heat, ignition sources, or incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of toluene can produce carbon dioxide, and acrid, irritating smoke.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(169) and OSHA(164) do not list toluene as a carcinogen. **Summary of Risks:** Toluene is irritating to the eyes, nose, and respiratory tract. Inhalation of high concentrations produces a narcotic effect sometimes leading to coma as well as liver and kidney damage. 93% of inhaled toluene is retained in the body of which 80% is metabolized to benzoic acid, then to hippuric acid and excreted in urine. The remainder is metabolized to *o*-cresol and excreted or exhaled unchanged. Toluene metabolism is inhibited by alcohol ingestion and is synergistic with benzene, asphalt fumes, or chlorinated hydrocarbons (i.e. perchloroethylene). Toluene is readily absorbed through the skin at 14 to 23 mg/cm²/hr. Toluene is absorbed quicker during exercise than at rest and appears to be retained longer in obese versus thin victims; presumably due to its lipid solubility. There is inconsistent data on toluene's ability to damage bone marrow; chronic poisoning has resulted in anemia and leucopenia with biopsy showing bone marrow hypo-plasia. These reports are few and some authorities argue that the effects may have been due to benzene contaminants. Chronic inhalation during pregnancy has been associated with teratogenic effects on the fetus including microcephaly, CNS dysfunction, attentional deficits, developmental delay + language impairment, growth retardation, and physical defects including a small midface, short palpebral fissures, with deep-set eyes, low-set ears, flat nasal bridge with a small nose, micrognathia, and blunt fingertips. There is some evidence that toluene causes an autoimmune illness in which the body produces antibodies that cause inflammation of its own kidney.

Continue on next page

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Section 6. Health Hazard Data

Medical Conditions Aggravated by Long-Term Exposure: Alcoholism and CNS, kidney, skin, or liver disease. **Target Organs:** CNS, liver, kidney, skin. **Primary Entry Routes:** Inhalation, skin contact/absorption. **Acute Effects:** Vapor inhalation causes respiratory tract irritation, fatigue, weakness, confusion, dizziness, headache, dilated pupils, watering eyes, nervousness, insomnia, parasthesis, and vertigo progressing to narcotic coma. Death may result from cardiac arrest due to ventricular fibrillation with catecholamines loss. Liquid splashed in the eye causes conjunctival irritation, transient corneal damage and possible burns. Prolonged skin contact leads to drying and fissured dermatitis. Ingestion causes GI tract irritation and symptoms associated with inhalation. **Chronic Effects:** Symptoms include mucous membrane irritation, headache, vertigo, nausea, appetite loss and alcohol intolerance. Repeated heavy exposure may result in encephalopathies (cerebellar ataxia and cognitive dysfunction), liver enlargement, and kidney dystrophy (wasting away). Symptoms usually appear at workdays end, worsen at weeks end and decrease or disappear over the weekend. **FIRST AID** **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult an ophthalmologist immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting because of danger of aspiration into the lungs. Gastric lavage may be indicated if large amounts are swallowed; potential toxicity needs to be weighed against aspiration risk when deciding for or against gastric lavage. **Note to Physicians:** Monitor cardiac function. If indicated, use epinephrine and other catecholamines carefully, because of the possibility of a lowered myocardial threshold to the arrhythmogenic effects of such substances. Obtain CBC, electrolytes, and urinalysis. Monitor arterial blood gases. If toluene has > 0.02% (200 ppm) benzene, evaluate for potential benzene toxicity. BEI: hippuric acid in urine, sample at shift end (2.5 g/g creatinine); Toluene in venous blood, sample at shift end (1.0 mg/L).

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Cleanup personnel protect against inhalation and skin/eye contact. Use water spray to cool and disperse vapors but it may not prevent ignition in closed spaces. Cellosolve, hycar absorbent materials, and fluorocarbon water can also be used for vapor suppression/containment. Take up small spill with earth, sand, vermiculite, or other absorbent, noncombustible material. Dike far ahead of large spills for later reclamation or disposal. For water spills, (10 ppm or greater) apply activated carbon at 10X the spilled amount and remove trapped material with suction hoses or use mechanical dredges/lifts to remove immobilized masses of pollutants and precipitates. Toluene can undergo fluidized bed incineration at 842 to 1796 °F (450 to 980 °C), rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C), or liquid injection incineration at 1202 to 2912 °F (650 to 1600 °C). Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** Blue gill, LC_{50} = 17 mg/L/24 hr; shrimp (*Crangonfracis coron*), LC_{50} = 4.3 ppm/96 hr; fathead minnow (*Pimephales promelas*), LC_{50} = 36.2 mg/L/96 hr. **Environmental Degradation:** If released to land, toluene evaporates and undergoes microbial degradation. In water, toluene volatilizes and biodegrades with a half-life of days to several weeks. In air, toluene degrades by reaction with photochemically produced hydroxyl radicals. **Disposal:** Treat contaminated water by gravity separation of solids, followed by skimming of surface. Pass through dual media filtration and carbon absorption units (carbon ratio 1 kg to 10 kg soluble material). Return waste water from backwash to gravity separator. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U220
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg)
[* per RCRA, Sec. 3001; CWA, Sec. 311 (b)(4); CWA, Sec. 307 (a)]
Listed as a SARA Toxic Chemical (40 CFR 372.65): Not listed

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

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses with shatter-resistant glass and side-shields or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 100 ppm, use any chemical cartridge respirator with appropriate organic vapor cartridges, any supplied-air respirator (SAR), or SCBA. For < 200 ppm, use any SAR operated in continuous-flow mode, any SAR or SCBA with a full facepiece, or any air-purifying respirator with a full facepiece having a chin-style, front or back mounted organic vapor canister. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Polyvinyl alcohol with a breakthrough time of > 8 hr, Teflon and Viton are recommended as suitable materials for PPE. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove toluene from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from ignition sources and incompatibles. Outside or detached storage is preferred. If stored inside, use a standard flammable liquids warehouse, room, or cabinet. To prevent static sparks, electrically ground and bond all equipment used with toluene. Do not use open lights in toluene areas. Install Class 1, Group D electrical equipment. Check that toluene is free of or contains < 1% benzene before use. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. **Administrative Controls:** Adopt controls for confined spaces (29 CFR 1910.146) if entering areas of unknown toluene levels (holes, wells, storage tanks). Consider preplacement and periodic medical exams of exposed workers that emphasize the CNS, liver, kidney, and skin. Include hemocytometric and thrombocyte count in cases where benzene is a contaminant of toluene. Monitor air at regular intervals to ensure effective ventilation.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Toluene
DOT Hazard Class: 3
ID No.: UN1294
DOT Packing Group: II
DOT Label: Flammable Liquid
Special Provisions (172.102): T1

Packaging Authorizations
a) Exceptions: 150
b) Non-bulk Packaging: 202
c) Bulk Packaging: 242

Quantity Limitations
a) Passenger Aircraft or Railcar: 5L
b) Cargo Aircraft Only: 60L

Vessel Stowage Requirements
Vessel Stowage: B
Other: --

MSDS Collection References: 26, 73, 100, 101, 103, 124, 126, 127, 132, 140, 148, 153, 159, 163, 164, 167, 169, 171, 174, 175, 176, 180.
Prepared by: M Gannon, BA; Industrial Hygiene Review: PA Roy, CIH, MPH; Medical Review: AC Darlington, MD, MPH

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Material Safety Data Sheets Collection:

Sheet No. 312
Trichloroethylene

Issued: 7/79 Revision: F, 9/92

Section 1. Material Identification

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Trichloroethylene (C_2HCl_3) Description: Derived by treating tetrachloroethane with lime or other alkali in the presence of water, or by thermal decomposition of tetrachloroethane followed by steam distillation. Stabilizers such as epichlorohydrin, isobutanol, carbon tetrachloride, chloroform, benzene, or pentanol-2-triethanolamine are then added. Used as a degreasing solvent in electronics and dry cleaning, a chemical intermediate, a refrigerant and heat-exchange liquid, and a diluent in paint and adhesives; in oil, fat, and wax extraction and in aerospace operations (flushing liquid oxygen). Formerly used as a fumigant (food) and anesthetic (replaced due to its hazardous decomposition in closed-circuit apparatus).
Other Designations: CAS No. 79-01-6; acetylene trichloride; Algylen; Anamenth; Benzinol; Cecolene; Chlorylen; Dow-Tri; ethylene trichloride; Germalgene; Narcogen; Triasol; trichloroethene; TCE; 1,1,3-trichloroethylene.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(75) for a suppliers list.

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

NFPA
2 / 2 / 0 / -

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

Cautions: TCE is irritating and toxic to the central nervous system (CNS). Inhalation of high concentrations have lead to death due to ventricular fibrillation. Chronic exposure may lead to heart, liver, and kidney damage. The liquid is absorbed through the skin. Although it has a relatively low flash point, TCE burns with difficulty.

Section 2. Ingredients and Occupational Exposure Limits

Trichloroethylene, < 100% [contains stabilizers (Sec. 1)].

1991 OSHA PELs
8-hr TWA: 50 ppm (270 mg/m^3)
15-min STEL: 200 ppm (1080 mg/m^3)

1990 IDLH Level
1000 ppm

1990 NIOSH REL
10-hr TWA: 25 ppm (~135 mg/m^3)

1992-93 ACGIH TLVs
TWA: 50 ppm (269 mg/m^3)
STEL: 200 ppm (1070 mg/m^3)

1990 DFG (Germany) MAK
Ceiling: 50 ppm (270 mg/m^3)
Category II: Substances with systemic effects
Half-life: 2 hr to shift length
Peak Exposure Limit: 250 ppm, 30 min average value; 2 peaks/shift

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 160 ppm/83 min caused hallucinations and distorted perceptions.
Human, lymphocyte: 5 mL/L caused DNA inhibition.
Rabbit, skin: 500 mg/24 hr caused severe irritation.
Rabbit, eye: 20 mg/24 hr caused moderate irritation.
Mouse, oral, TD_{Lo}: 455 mg/kg administered intermittently for 78 weeks produced liver tumors.

* See NIOSH, *RTECS* (KX4550000), for additional irritation, mutation, reproductive, tumorigenic and toxicity data.

Section 3. Physical Data

Boiling Point: 189 °F (87 °C)
Freezing Point: -121 °F (-85 °C)
Viscosity: 0.0055 Poise at 77 °F (25 °C)
Molecular Weight: 131.38
Density: 1.4649 at 20/4 °C
Refraction Index: 1.477 at 68 °F (20 °C/D)
Odor Threshold: 82 to 108 ppm (*not an effective warning*)

Vapor Pressure: 58 mm Hg at 68 °F (20 °C); 100 mm Hg at 32 °F (0 °C)
Saturated Vapor Density (Air = 0.075 lbs/ft^3; 1.2 kg/m^3): 0.0956 lbs/ft^3; 1.53 kg/m^3
Water Solubility: Very slightly soluble; 0.1% at 77 °F (25 °C)
Other Solubilities: Highly soluble in organic solvents (alcohol, acetone, ether, carbon tetrachloride, & chloroform) and lipids.
Surface Tension: 29.3 dyne/cm

Appearance and Odor: Clear, colorless (sometimes dyed blue), mobile liquid with a sweet chloroform odor.

Section 4. Fire and Explosion Data

Flash Point: 90 °F (32 °C) CC	Autoignition Temperature: 788 °F (420 °C)	LEL: 8% (25 °C); 12.5% (100 °C)	UEL: 10% (25 °C); 90% (100 °C)

Extinguishing Media: A Class 1C Flammable Liquid. Although it has a flash point of 90 °F, TCE burns with difficulty. For small fires, use dry chemical, carbon dioxide, water spray, or regular foam. For large fires, use water spray, fog, or regular foam. **Unusual Fire or Explosion Hazards:** Vapor/air mixtures may explode when ignited. Container may explode in heat of fire. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides only limited protection against TCE. Apply cooling water to sides of container until well after fire is out. Stay away from ends of tanks. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: TCE slowly decomposes in the presence of light and moisture to form corrosive hydrochloric acid. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Include alkalis (sodium hydroxide), chemically active metals (aluminum, beryllium, lithium, magnesium, sodium, potassium, and titanium), epoxides, and oxidants (nitrogen tetraoxide, perchloric acid). Contact with 1-chloro-2,3-epoxy propane or the mono and di 2,3-epoxypropyl ethers of 1,4-butanediol + 2,2-bis-4(2',3'-epoxypropoxy)-phenylpropane can, in the presence of catalytic quantities of halide ions, cause dehydrochlorination of TCE to explosive dichloroacetylene. **Conditions to Avoid:** Exposure to light, moisture, ignition sources, and incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of TCE (above 300 °C) or exposure to ultraviolet light can produce carbon dioxide (CO_2) and toxic dichloro acetylene (explosive), chlorine, hydrogen chloride, and phosgene gas.

Section 6. Health Hazard Data

Carcinogenicity: The following agencies have rated TCE's carcinogenicity: IARC (Class 3, limited animal evidence & insufficient human data), Germany MAK (Class B, justifiably suspected of having carcinogenic potential), & NIOSH (Class X, carcinogen defined with no further categorization). **Summary of Risks:** TCE vapor is irritating to the eyes, nose, and respiratory tract and inhalation of high concentrations can lead to severe CNS effects such as unconsciousness, ventricular arrythmias, and death due to cardiac arrest. Mild liver dysfunction was also seen at levels high enough to produce CNS effects. Contact with the liquid is irritating to the skin and can lead to dermatitis by defatting the skin. Chronic toxicity is observed in the victims increasing intolerance to alcohol characterized by 'degreasers flush', a transient redness of the face, trunk, and arms. The euphoric effect of TCE has led to craving, and habitual sniffing of its vapors.

Continue on next page

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Section 6. Health Hazard Data, *Continued*

TCE crosses the placental barrier and thus exposes the fetus (any effects are yet unknown). There are increased reports of menstrual disorders in women workers and decreased libido in males at exposures high enough to cause CNS effects. TCE is eliminated unchanged in expired air and as metabolites (trichloroacetic acid & trichloroethanol) in blood and urine. **Medical Conditions Aggravated by Long-Term Exposure:** Disorders of the nervous system, skin, heart, liver, and kidney. **Target Organs:** Respiratory, central & peripheral nervous, and cardiovascular (heart) systems, liver, kidney, and skin. **Primary Entry Routes:** Inhalation, skin and eye contact, and ingestion (rarely). **Acute Effects:** Vapor inhalation can cause eye, nose, and throat irritation, nausea, blurred vision, overexcitement, headache, drunkenness, memory loss, irregular heartbeat (resulting in sudden death), unconsciousness, and death due to cardiac failure. Skin contact with the liquid can cause dryness and cracking and prolonged exposure (generally if the victim is unconscious) can cause blistering. Eye contact can cause irritation and watering, with corneal epithelium injury in some cases. Ingestion of the liquid can cause lip, mouth, and gastrointestinal irritation, irregular heartbeat, nausea and vomiting, diarrhea (possibly blood-stained), drowsiness, and risk of pulmonary edema (fluid in lungs). **Chronic Effects:** Effects may persist for several weeks or months after repeated exposure. Symptoms include giddiness, irritability, headache, digestive disturbances, mental confusion, intolerance to alcohol (degreasers flush), altered color perception, loss or impairment of sense of smell, double vision, and peripheral nervous system function impairment including persistent neuritis, temporary loss of sense of touch, and paralysis of the fingers from direct contact with TCE liquid.

FIRST AID **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. Do not give milk, as its fat content (TCE is lipid soluble) may inhance gastrointestinal absorption of TCE. **Note to Physicians:** TCE elimination seems to be triphasic with half lives at 20 min, 3 hr, and 30 hr. Some success is seen in treating patients with propranolol, atropine, and disulfiram. Monitor urine and blood (lethal level = 3 to 110 µg/mL) metabolites. BEI = 100 mg/g creatinine (trichloroacetic acid) in urine, *sample at end of workweek.* BEI = 4 mg/L (trichloroethanol) in blood, *sample at end of shift at end of the workweek.* These tests are not 100% accurate indicators of exposure; monitor TCE in expired air as a confirmatory test.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off all ignition sources. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable container for later disposal. For large spills, flush to containment area where density stratification will form a bottom TCE layer which can be pumped and containerized. Report any release in excess of 1000 lbs. Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** Bluegill sunfish, LC_{50} = 44,700 µg/L/96 hr; fathead minnow (*Pimephales promelas*), LC_{50} = 40.7 mg/L/96 hr. **Environmental Degradation:** In air, TCE is photooxidized with a half-life of 5 days and reported to form phosgene, dichloroacetyl chloride, and formyl chloride. In water it evaporates rapidly in minutes to hours. TCE rapidly evaporates and may leach since it does not absorb to sediment. **Soil Absorption/Mobility:** TCE has a Log K_{oc} of 2, indicating high soil mobility. **Disposal:** Waste TCE can be poured on dry sand and allowed to vaporize in isolated location, purified by distillation, or returned to supplier. A potential candidate for rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C) with an acid scrubber to remove halo acids. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a RCRA Hazardous Waste (40 CFR 261.33 & 261.31): No. U228 & F002 (*spent solvent*)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 100 lb (45.4 kg) [* per RCRA, Sec. 3001, CWA Sec. 311 (b)(4), & CWA Sec. 307 (a)]

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

Section 8. Special Protection Data

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

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in steel drums, in a cool, dry, well-ventilated area away from sunlight, heat, ignition sources, and incompatibles (Sec. 5). Store large quantities in galvanized iron, black iron, or steel containers; small amounts in dark (amber) colored glass bottles. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Design processes so that the operator is not directly exposed to the solvent or its vapor. Do not use open electric heaters, high-temperature processes, arc-welding or open flames in TCE atmospheres. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers with emphasis on skin, respiratory, cardiac, central and peripheral nervous systems, and liver and kidney function. Employ air and biological monitoring (BEIs). Instruct employees on safe handling of TCE.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Trichloroethylene
DOT Hazard Class: 6.1
ID No.: UN1710
DOT Packing Group: III
DOT Label: Keep Away From Food
DOT Special Provisions (172.102): N36, T1

Packaging Authorizations
a) Exceptions: 173.153
b) Non-bulk Packaging: 173.203
c) Bulk Packaging: 173.241

Quantity Limitations
a) Passenger Aircraft or Railcar: 60L
b) Cargo Aircraft Only: 220L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: 40

MSDS Collection References: 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 149, 153, 159, 163, 164, 167, 168, 171, 174, 175, 176, 180.
Prepared by: M Gannon, BA; Industrial Hygiene Review: D Wilson, CIH; Medical Review: AC Darlington, MD

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IDENTIFIERS

CHEMTOX RECORD 2116 LAST UPDATE OF THIS RECORD: 03/04/91
NAME: TRINITROTOLUENE
SYNONYMS: TNT; alpha-TNT; TOLIT; TOLITE; TRINITROTOLUENE; sym-TRINITROTOLUENE; 2,4,6-TRINITROTOLUENE; TRINITROTOLUENE, WET (DOT); sym-TRINITROTOLUOL; TRITOL; TROTYL; TROTYL OIL; TOLUENE, 2,4,6-TRINITRO,-(WET); SYM-TRINITROTOLUENE
CAS: 118-96-7 RTECS: XU0180000
FORMULA: C7H5N3O6 MOL WT: 227
WLN: WNR B1 CNW ENW
CHEMICAL CLASS: Nitro compound

See other identifiers listed below under Regulations.

PROPERTIES

PHYSICAL DESCRIPTION: COLORLESS TO PALE YELLOW, ODORLESS SOLID
BOILING POINT: 513.15 K 240 C 464 F
MELTING POINT: 354.27 K 81.1 C 178 F
FLASH POINT: EXPLODES EXPLODES EXPLODES
AUTO IGNITION: NA
VAPOR PRESSURE: (185 F): 0.05 MM
UEL: NA
LEL: NA
VAPOR DENSITY: No data
SPECIFIC GRAVITY:
DENSITY: g/cc or 0 lb/gal
WATER SOLUBILITY: 0.013%

INCOMPATIBILITIES: STRONG OXIDIZERS, AMMONIA, STRONG ALKALIES, OXIDIZABLE MATERIALS

REACTIVITY WITH WATER: No data on water reactivity
REACTIVITY WITH COMMON MATERIALS: No data
STABILITY DURING TRANSPORT: No Data
NEUTRALIZING AGENTS: No data
POLYMERIZATION POSSIBILITIES: No data

TOXIC FIRE GASES: None reported other than possible unburned vapors
ODOR DETECTED AT (ppm): Unknown
ODOR DESCRIPTION: Unknown SOURCE: Unspecified
100 % ODOR DETECTION: No data

REGULATIONS

DOT HAZARD CLASS: Flammable solid
DOT GUIDE: 33
DOT ID NUMBER: UN1356
DOT SHIPPING NAME: TRINITROTOLUENE, WET; HIGH EXPLOSIVE
STCC NUMBER: 4917160

CLEAN AIR ACT: Not covered
EPA WASTE NUMBER:
CERCLA REF:
RQ DESIGNATION: Not listed
SARA TPQ VALUE: Not listed
SARA Sect. 312 categories:
Fire hazard: flammable.
Acute toxicity: adverse effect to target organs.
Chronic toxicity: adverse effect to target organ after long period of exposure.

UNITED STATED POSTAL SERVICE MAILABILITY:
Hazard class: Not given
Mailability: Nonmailable
Max per parcel: 0

NFPA CODES:
HEALTH HAZARD (BLUE): (2) Hazardous to health. Area may be entered with self-contained breathing apparatus.
FLAMMABILITY (RED) : (4) This material forms readily ignitable mixtures in air.
REACTIVITY (YELLOW): (4) Capable of detonation or explosive decomposition at normal temperatures.
SPECIAL : Unspecified

TOXICITY DATA

TARGET ORGANS: BLOOD, LIVER, EYES, CVS, CNS, KIDNEYS, SKIN.
SYMPTOMS: LIVER DAMAGE; JAUN, CYAN, SNEEZ, COUGH, SORE THROAT, PERI NEUR, MUSC PAIN]KIDNEY DAMAGE;CARD;CATARACT;DERM;LEUCYT; ANEMIA
Source: NIOSHP

CONC IDLH: Unknown

NIOSH REL:

'TLV.CALC' LINE 27. [B10] Variable has not been assigned a value. Zero used.
'TLV.CALC' LINE 27. [B10] Variable has not been assigned a value. Zero used.
'TLV.CALC' LINE 28. [B10] Variable has not been assigned a value. Zero used.
'TLV.CALC' LINE 28. [B10] Variable has not been assigned a value. Zero used.
ACGIH TLV: TLV =0.5 mg/M3*STEL =0 ppm*STEL =0 mg/M3*SKIN
ACGIH STEL: Not specified

OSHA PEL: Transitional Limits:
PEL =1.5mg/M3(SKIN)
Final Rule Limits:
TWA =0.5 mg/M3(SKIN)

CARCINOGEN?: STATUS:

CARCINOGEN LISTS:
IARC: Not listed
MAK: A compound which is justifiably suspected of having carcinogenic potential.
NIOSH: Not listed
NTP: Not listed
ACGIH: Not listed
OSHA: Not listed

HUMAN TOXICITY DATA: (Source: NIOSH RTECS)
ori-hmn LDLo:28 gm/kg34ZIAG -,610,69
BEHAVIORAL
Hallucinations, distorted perceptions
LUNGS, THORAX, OR RESPIRATION
Cyanosis
GASTROINTESTINAL
Other changes

LD50 value: ori-rat LD50:795 mg/kg

OTHER SPECIES TOXICITY DATA: (Source: NIOSH RTECS 1990)

ori-rat LD50:795 mg/kg
ori-mus LD50:660 mg/kg
ori-cat LDLo:1850 mg/kg
scu-cat LDLo:200 mg/kg
ori-rbt LDLo:500 mg/kg
scu-rbt LDLo:500 mg/kg

Reproductive toxicity (1990 RTECS):
This chemical is a mammalian reproductive toxin.

PROTECTION AND FIRST AID

PROTECTION SUGGESTED
FROM THE CHRIS MANUAL:

NIOSH POCKET GUIDE TO CHEMICAL HAZARDS

** WEAR APPROPRIATE EQUIPMENT TO PREVENT:
Reasonable probability of skin contact.

** WEAR EYE PROTECTION TO PREVENT:
Reasonable probability of eye contact.

** EXPOSED PERSONNEL SHOULD WASH:
Promptly when skin becomes contaminated and at the end of each work shift.

** WORK CLOTHING SHOULD BE CHANGED DAILY:
If there is any reasonable possibility that the clothing may be contaminated

** REMOVE CLOTHING:
Promptly remove non-impervious clothing that becomes contaminated.

** REFERENCE: NIOSH

RECOMMENDED RESPIRATION PROTECTION Source: NIOSH POCKET GUIDE (85-114)
ACGIH (TRINITROTOLUENE)
5.0 mg/M3: Any supplied-air respirator. * Substance reported to cause eye irritation or damage may require eye protection. / Any self-contained breathing apparatus. * Substance reported to cause eye irritation or damage may require eye protection.
12.5 mg/M3: Any supplied-air respirator operated in a continuous flow mode. * Substance reported to cause eye irritation or damage may require eye protection.
25 mg/M3: Any supplied-air respirator with a full facepiece. / Any self-contained breathing apparatus with a full facepiece.
1000 mg/M3: Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode.
EMERGENCY OR PLANNED ENTRY IN UNKNOWN CONCENTRATIONS OR IDLH CONDITIONS.:
Any self-contained breathing apparatus with full facepiece and operated in a pressure-demand or other positive pressure mode. / Any supplied-air respirator with a full facepiece and operated in pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
ESCAPE: Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister having a high-efficiency particulate filter. / Any appropriate escape-type self-contained breathing apparatus.

FIRST AID (NIOSH):
EYE:
IRR IMMED
SKIN:
SOAP WASH PROMPTLY
INHALATION:
ART RESP
INGESTION:
WATER, VOMIT

INITIAL INCIDENT RESPONSE

US Department of Transportation Guide to Hazardous Materials Transport Information - Publication DOT 5800.5 (1990).
DOT SHIPPING NAME: TRINITROTOLUENE, WET; HIGH EXPLOSIVE
DOT ID NUMBER: UN1356

* POTENTIAL HAZARDS *

*FIRE OR EXPLOSION

Flammable/combustiblematerial; may be ignited by heat sparks, or flames.
Dried out material may explode if exposed to heat, flame or shock; keep material wet with water or treat it as an explosive (Guide 46).
Runoff to sewer may create fire or explosion hazard.

*HEALTH HAZARDS

Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

* EMERGENCY ACTION *

Keep unecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
CALL CHEMTREC AT 1-800-424-9300 FOR EMERGENCY ASSISTANCE. If water pollution occurs, notify the appropriate authorities.

*FIRE

Tire Fires: Flood with water; if no water is available, use dry chemical or dirt. (CAUTION) Tire fires may start again.
Do not move cargo or vehicle if cargo has been exposed to heat.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

*SPILL OR LEAK

Shut of ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
Small Spills: Flush area with flooding amounts of water.
Large Spills: Wet down with water and dike for later disposal.

*FIRST AID

Move victim to fresh air; call emergency medical care.
In case of contact with material, immediatelyflush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

Genium Publishing Corporation
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Material Safety Data Sheets Collection:

Sheet No. 708
Vinylidene Chloride

Issued: 4/90

Section 1. Material Identification 31

Vinylidene Chloride Description: Prepared from ethylene chloride. Also prepared from vinyl chloride by successive chlorination and dehydrochlorination steps. Used primarily as a co-monomer in producing vinylidene copolymers (Saran®, Velon®) for films and coatings. Also used in producing methyl chloroform, vinyl chloride resins, plastics, chloracetyl chloride; in adhesives; as a component of synthetic fibers; a chemical intermediate in vinylidene fluoride synthesis; and for 1,1,1-trichloroethane. A common constituent in our environment, measurable quantities of vinylidene chloride are found in poorly ventilated areas with a high concentration of plastics. It is a notable contaminant in recycled air environments such as nuclear submarines and spacecraft.
Other Designations: CAS No. 0075-35-4; $C_2H_2Cl_2$; 1,1-DCE; 1,1-dichloroethene; *asym*-dichloroethylene; VDC; vinylidene dichloride.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.
Comment: At temperatures above 32 °F/0 °C and especially in the presence of oxygen or other suitable catalysts, vinylidene chloride polymerizes to a plastic. Therefore, commercial products may contain small proportions of inhibitors to preserve the monomer.

R 3
I 4
S 2
K 4

NFPA

HMIS
H 2
F 4
R 2
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Vinylidene chloride, ca 100%

OSHA PEL
8-hr TWA: 1 ppm, 4 mg/m³

ACGIH TLVs, 1989-90
TLV-TWA: 5 ppm, 20 mg/m³
TLV-STEL: 20 ppm, 79 mg/m³

NIOSH REL, 1987
None established

Toxicity Data*
Mouse, skin, TD_{Lo}: 4840 mg/kg has tumorigenic effects on skin, appendages, lungs, thorax, and respiration
Rat, inhalation, LC_{50}: 6350 ppm/4 hr
Human, inhalation, TC_{Lo}: 25 ppm produces changes in behavior (general anesthetic), the liver, kidney, ureter, and bladder

* See NIOSH, *RTECS* (YZ8061000), for additional mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 89.1 °F/31.7 °C at 760 mm Hg
Melting Point: -188.5 °F/-122.5 °C
Vapor Pressure: 591 mm Hg at 77 °F/25 °C
Vapor Density (Air = 1): 3.4
Molecular Weight: 96.94 g/mol
Specific Gravity (H_2O = 1 at 39 °F/4 °C): 1.2129 at 68 °F/20 °C
Water Solubility: Sparingly soluble (0.04 % wt/vol in water at 68 °F/20 °C)

Appearance and Odor: Colorless, volatile liquid with a mild, sweet odor that resembles chloroform. Most persons can detect vinylidene chloride at 1000 ppm, but others can detect it at less than 500 ppm. Neither odor is adequate to warn of excessive exposure.

Section 4. Fire and Explosion Data

Flash Point: -19 °F/-28 °C	Autoignition Temperature: 1058 °F/570 °C	LEL: 5.6% v/v	UEL: 11.4% v/v

Extinguishing Media: Use dry chemical, alcohol foam, or carbon dioxide. Use water to cool fire-exposed containers..
Unusual Fire or Explosion Hazards: Vinylidene chloride is a very flammable and volatile liquid with a burning rate of 2.7 mm/min. This material is a very dangerous fire hazard and moderately explosive when exposed to heat or flame. It may explode spontaneously since the vapor forms explosive mixtures with air. At elevated temperatures, polymerization may take place and containers may rupture.
Special Fire-fighting Procedures: Since vinylidene chloride may be poisonous if inhaled or absorbed through the skin, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode with a fully encapsulating suit. Keep unnecessary people away from the hazard area. Vapors may travel to an ignition source and flash back. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Vinylidene chloride is self-reactive. If stored between -40 °F/-40 °C and 77 °F/25 °C in air without an inhibitor, this material rapidly absorbs oxygen and forms a violently explosive peroxide. The heat of polymerization is -185 cal/g (inhibited). When unstable, vinylidene chloride decomposes into chlorine, hydrogen chloride, phosgene, and formaldehyde. Hazardous polymerization can occur if exposed to sunlight, air, copper, aluminum, or heat.
Chemical Incompatibilities: This material reacts violently with chlorosulfonic acid, nitric acid, and oleum; and vigorously with oxidizing materials.
Hazardous Products of Decomposition: Thermal oxidative decomposition of vinylidene chloride can produce highly toxic fumes of chlorine (Cl_2) and hydrogen chloride (HCl).

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Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists vinylidene chloride as a carcinogen, although the ACGIH suggests it is a suspected carcinogen. Various animal studies suggest a high rate of cancer in species-specific testing; application to humans does not appear valid.
Summary of Risks: Vinylidene chloride is an irritant to the skin, eyes, and mucous membranes, although any inhibitor in vinylidene chloride may partly cause the irritation. VDC is narcotic at concentrations greater than 4000 ppm, and has caused liver and kidney injury in experimental animals. Solutions containing the inhibitor MEHQ (monomethyl ether of hydroquinone) may cause leucoderma (white skin) and serious eye injury.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Skin, eyes, central nervous system, liver, and kidneys.
Primary Entry Routes: Inhalation.
Acute Effects: Inhalation of VDC causes narcosis and respiratory irritation. Concentrations of 4000 ppm lead to symptoms of drunkenness and eventually unconsciousness if the exposure continues. In monkey studies, exposure to 200 ppm caused acute liver injury with a mechanism similar to carbon tetrachloride. Animal studies indicate acute kidney changes in high-level exposures. Eye contact may cause conjunctivitis, transient corneal injury, and iritis. VDC also causes skin and mucous membrane irritation.
Chronic Effects: With chronic inhalation, vinylidene chloride may cause hepatic and renal dysfunction. In monkey studies, long-term inhalation at a 48-ppm level caused liver and kidney damage and death.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have a *conscious* person drink 1 to 2 glasses of water, then induce repeated vomiting until vomit is clear.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Solutions containing increased MEHQ concentrations are caustic and should not be removed by emesis. There is no specific treatment for VDC intoxication, but if significant amounts have been ingested, monitor the patient for liver and kidney failure.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice a vinylidene chloride spill control and countermeasure plan (SCCP).* Notify safety personnel, evacuate all unnecessary personnel from hazard area, remove all heat and ignition sources, and ventilate area. Cleanup personnel should protect against inhalation and skin and eye contact. For lab spills, absorb the spill with paper towels and place in a hood to allow liquid to evaporate. For large spills, absorb bulk spill with cement powder, fly ash, sawdust, or commercial sorbents. Place waste in appropriate disposal containers. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 5000 lb (2270 kg) [* per Clean Water Act, Sec. 31 (b)(4), Sec. 307(a); per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

Section 8. Special Protection Data

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

Section 9. Special Precautions and Comments

Storage Requirements: Store vinylidene chloride in tanks with nickel, glass, or baked phenolic linings at 14 °F/-10 °C in the absence of light, air, water, and other polymerization initiators under a nitrogen blanket (at 10-psi pressure and an oxygen content less than 100 ppm). Outside or detached storage is preferable. If stored inside, store in a standard flammable liquids storage cabinet separate from oxidizing materials and incompatible materials (Sec. 5).
Engineering Controls: VDC requires special handling, precautions, and employee training. Do not handle VDC without adequate ventilation and personal protective gear. Limit exposures to vinylidene chloride by improving housekeeping procedures. Keep VDC away from all heat and ignition sources. All engineering systems should be of maximum explosion-proof design, electrically grounded, and bonded.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Vinylidene chloride, inhibited
DOT Hazard Class: Flammable liquid
ID No.: UN1303
DOT Label: Flammable liquid
DOT Packaging Requirements: 173.119
DOT Packaging Exceptions: 173.118

IMO Shipping Name: Vinylidene chloride, inhibited
IMO Hazard Class: 3.1
IMO Label: Flammable liquid
IMDG Packaging Group: I
ID No.: UN1303

MSDS Collection References: 7, 26, 38, 53, 73, 84, 85, 87, 89, 100, 103, 124, 126, 127, 129, 134, 136
Prepared by: MJ Allison, BS; Industrial Hygiene Review: DJ Wilson, CIH; Medical Review: W Silverman, MD M8

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Final

Investigation Derived Waste Management Plan
Remedial Investigation and Feasibility Study
Pesticide Disposal Site (Site 5)
Preliminary Assessment/Site Investigation
Building W-316 PCB Waste Work Area (Site 21)

Norfolk Naval Base
Norfolk, Virginia

Contract Task Order 0003

August 15, 1996

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by

CH2M HILL

Federal Group, Ltd.
Herndon, Virginia

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Introduction

The Remedial Investigation/Feasibility Study (RI/FS) of the Pesticide Disposal Site (Site 5) and Preliminary Site Assessment/Site Investigation (PA/SI) of the Building 316, PCB Waste Work Area (Site 21) at the Naval Base, Norfolk (NNB) will produce investigation-derived soil and water wastes. Generation of these wastes will subsequently require waste management and disposal in a manner that eliminates potential hazards to the public. This management plan documents methodologies and procedures that CH2M HILL field personnel will implement to handle, manage and dispose of all investigation-derived wastes.

The investigation-derived wastes (IDW) to be generated during the RI/FS and PA/SI field investigations include:

- Soil cuttings generated during soil borings and monitoring-well installation and accumulated wash-cuttings at the decontamination pad.
- Groundwater pumped during monitoring-well development, and purged well volumes extracted during groundwater sampling.
- Personal Protective Equipment (PPE), such as nitrile gloves and tyvek, used during all phases of the investigation, and expendables used during sampling, such as tubing and sample containers.

This IDWMP describes proposed waste handling procedures for soil and groundwater. Disposal practices for personal protective equipment (PPE) and other general IDW considerations are also documented.

Proposed Waste Handling

This section documents the proposed waste handling procedures for soil and groundwater to be followed during the Site 5 RI/FS and Site 21 PA/SI.

Soils

Cuttings generated during monitoring-well installation or soil boring advancement with a drill rig will be placed back into the borehole that was the source of the soil. All additional (waste) soil cuttings from the RI/FS and PA/SI field investigations will be contained in 55-gallon drums, which will be sealed and labeled. In addition, soil cuttings that accumulate in the decontamination pad from the washing of drilling equipment will be placed in drums, sealed and labeled.

At the conclusion of the drilling event, the drums filled with soil cuttings will be stockpiled within the boundary of each site at a location designated by Navy personnel pending the analytical results of the TCLP sampling of the drum contents.

At the end of the RI/FS and PA/SI field investigation activities, composited soil samples will be collected from drums filled with soil cuttings and submitted for full TCLP analyses.

After receipt of the TCLP sampling results, CH2M HILL will formulate a preliminary assessment of any potential hazards posed by the IDW, and submit waste management recommendations to the Navy, and if requested by the Navy, to the EPA. If the analytical soil and groundwater results are low, and if TCLP results are below the TCLP limits listed in 40 CFR 261.24, as amended, CH2M HILL will recommend that the stockpiled soils be dispersed near the boring from which they were removed. If the boring location is in an area with asphalt or concrete surfaces, the soil cuttings will be dispersed within the same site but at a location with a soil surface designated by Navy personnel.

If the composite soil samples from the drums contain contaminant concentrations above TCLP limits, the drummed soils cuttings will be considered hazardous. These wastes will be manifested, handled as hazardous waste, and shipped to a regulated hazardous waste landfill, treated, or stockpiled as appropriate and as directed by the Navy. The proposed steps for accumulating and handling IDW soil are as follows:

1. Shovel cuttings from all borings directly into the hole from which the soil was derived until the borehole filled.
2. Shovel the remaining cuttings into 55-gallon drums.
3. Stockpile all drums in areas designated by the Navy.
4. Collect composite TCLP samples from the drums.
5. Send TCLP samples to approved off-site laboratory.
6. Secure notification from the Navy that the wastes are not listed by 40 CFR 261.
7. Stockpile the drums at Site 5 and Site 21 during the 30-day TCLP analysis period.
8. Receive TCLP and general analytical results from the laboratory and write a memorandum recommending to the Navy whether to handle the wastes as hazardous or discard in place. Both TCLP results and the applicable certification from the Navy will be considered in the recommendations.
9. Continue to stockpile drums until instructions from the Navy are received.
10. Remobilize to Norfolk Naval Base to spread cuttings from all locations that a nonhazardous.
11. Transport empty drums to an area designated by the Navy for disposal.
12. If some wastes test hazardous or should otherwise be considered hazardous wastes, segregate these drums and stockpile at a location specified by Navy personnel, pending decision on handling.
13. CH2M HILL and Navy negotiate contract modification for handling hazardous IDW soils. The wastes must be handled and disposed of in 90 days.
14. CH2M HILL arranges and carries out handling and disposal of hazardous wastes according to the Navy's instructions. The activity will be responsible for signing all manifests.

Groundwater

Groundwater as an investigation-derived waste will be produced during two field activities, (1) monitoring-well development and (2) groundwater purging and sampling.

The groundwater that is to be contained will be pumped and stored in 55-gallon steel drums, which will be sealed and labeled.

At the conclusion of the RI/FS and PA/SI field investigation, the drums containing groundwater will be stockpiled within the boundary of each site at a location designated by Navy personnel pending the analytical results of soil and groundwater sampling, and TCLP sampling of the drums. At the end of the RI/FS and PA/SI field activities, composited water samples will be collected from drums filled with groundwater and submitted for full TCLP analyses.

After receipt of the TCLP sampling results, CH2M HILL will formulate a preliminary assessment of any potential hazards posed by the IDW, and submit waste management recommendations to the Navy, and if requested by the Navy, to the EPA. If the analytical soil and groundwater results are low, and if TCLP results are below the TCLP limits listed in 40 CFR 261.24, as amended, CH2M HILL will recommend that the groundwater be discharged to the industrial wastewater treatment facility. If the composite groundwater samples from the drums contain contaminant concentrations above TCLP limits, the drummed groundwater will be considered hazardous. These wastes will be manifested, handled as hazardous waste, and shipped to a regulated hazardous waste landfill, treated, or stockpiled as appropriate and as directed by the Navy.

The proposed steps for accumulating and handling IDW groundwater are as follows:

1. Development water from each of the newly installed monitoring wells will be pumped into 55-gallon drums.

2. Groundwater purged from the two newly installed monitoring wells during the groundwater sampling activities will also be pumped into 55-gallon drums.

3. Secure notification from the Navy that the wastes are not listed, as specified in 40 CFR 261.

4. Receive TCLP results from the laboratory and write a memorandum to the Navy recommending whether to handle the groundwater as hazardous or to instruct a subcontractor to dispose of the water.

5. If groundwater is hazardous according to TCLP results or other criteria, CH2M HILL CH2M HILL and Navy will need to negotiate a contract modification for handling hazardous IDW groundwater. The waste, by law, must be handled and disposed of in 90 days.

6. CH2M HILL coordinates with subcontractor for the handling and disposal of hazardous groundwater according to regulations. The activity will be responsible for signing all manifests.

Personal Protective Equipment and Expendables

The personal protective equipment worn by CH2M HILL field personnel and CH2M HILL's subcontractors will be placed in 55-gallon steel drums and labeled appropriately. Examples of PPE to be contained include: nitrile gloves, tyvek, and rubber boots. In addition, any expendable items that were contaminated during sampling will be contained in drums, such as in-line water filters, C-flex tubing, and paper towels.

Personal protective equipment and sampling expendables will be placed in marked bags and discarded in dumpsters if the TCLP results indicate no toxicity hazard. If TCLP results indicate that soils or groundwater are hazardous, the PPE will be handled with the soil.

General Considerations

General considerations pertinent to the generation and handling of IDW are documented below. These include the minimization of waste volume, drum labeling and storage, and disposal and manifesting protocol

Minimizing the Volume of IDW

To minimize the volume of IDW soil generated during drilling and soil boring, the boreholes will be backfilled with the cuttings that were extracted from the borehole during the drilling process. Excess soil shall be drummed as IDW.

To minimize the volume of groundwater to be handled, the minimum volume of water will be purged from the monitoring wells to stabilize the pH, conductivity, and temperature of the discharged water.

Labeling

Every 55-gallon drums containing investigation-derived wastes will be labeled with the following information: the type of IDW (groundwater, soil, or PPE), the date the drum was filled and sealed, and a brief warning not to handle the drum or its contents without permission from the Naval Facilities Engineering Services Command. An example of the information included on each drum is:

Investigation Derived Wastes
Purge Water from Site 5 - MW1
4-8-96
Do Not Handle - Analysis Pending
Ms. Dianne Bailey

Storing IDW

The drums that contain IDW will be stockpiled within the boundary of the site on which they were generated at a location designated by Navy personnel, pending the receipt of RCRA characterization results. For planning purposes, it is necessary that IDW only be stored on base for 60 days in order to comply with the 90-day accumulation time.

Disposal and Manifesting

After the receipt of test results, CH2M HILL will formulate a preliminary assessment of any potential hazards posed by the IDW, and submit waste management recommendations to the Navy. If the test results indicate that the IDW is not hazardous, CH2M HILL will recommend that the water and soils be disposed of to the industrial wastewater treatment plant and the PPE be disposed of in a trash dumpster for disposal with other nonhazardous trash generated at the base. Otherwise, the water, soils, and PPE will be manifested, handled, treated, and disposed of as a hazardous waste by a subcontractor yet to be identified. The Navy will be responsible for signing all manifests.

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