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September 14, 1990

Mr. Pergadia, P.E.
Regional Hazardous Waste Remediation Engineer
New York State Department
of Environmental Conservation
21 South Putt Corners Road
New Paltz, New York 12561-1696

Dear Mr. Pergadia,

Enclosed, you will find the revised Monitoring Well Installation Plan and the Health and Safety Plan for your review and approval.

I look forward to your approval of these plans so that Command can expeditiously address these environmental issues. Next Friday, I will follow-up with you on the status of these plans.

If you have any questions on either of these issues, please do not hesitate to contact me at (914) 462-6100, Ext. 325.

Sincerely,

William Pulling

William Pulling
Manager
Safety and Audits

WP:nm
Enc.

cc: Bawa Singh - American Eagle
Gene DeFrancisco - AA
✓Keith Browne - DEC
Steve Brownell - LLL & M

DUTCHESS COUNTY AIRPORT, 263 NEW HACKENSACK ROAD, WAPPINGERS FALLS, NY 12590, (914) 462-6100

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Monitor Well Installation Plan

September, 1990

Command Airways
Wappinger Falls, NY

DAMES & MOORE

MONITOR WELL LOCATION AND INSTALLATION

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FIGURES

MONITOR WELL LOCATION AND INSTALLATION

1.0 INTRODUCTION

Dames & Moore has been retained by Command Airways to conduct an investigation of the subsurface conditions at the Command Airways leased property at Dutchess County Airport in Wappingers Falls, NY (hereafter called the site).

An Underground Storage Tank (UST) which collected waste water from the floor drain in the Command Airway hangar is suspected to have contributed to groundwater and soil contamination at the Site. A soil gas survey has been performed at this location. The results of this survey indicated some potential sources of contamination. This work plan is a revision which addresses comments made by the New York State Department of Environmental Conservation to the original work plan submitted in May, 1990. The report based on the soil gas survey was included as an attachment to the original (May, 1990) monitor well installation plan.

2.0 MONITOR WELL INSTALLATION

Four (4) groundwater monitor wells will be installed to identify shallow and possible deep contamination in the groundwater. One well will be screened in the shallow sand aquifer and three wells will be screened in the deep bedrock aquifer under the site. The proposed locations of the monitor wells are illustrated on Figure 1.

Three bedrock well will be installed. Each bedrock well will be approximately 85 feet in depth. An "as-built" diagram showing a typical bedrock monitoring well is provided as Figure 2.

- One bedrock well will be placed upgradient of the UST to monitor the groundwater entering the site.
- One bedrock well will be placed downgradient of the UST to monitor the groundwater after it has traversed the site and;
- One bedrock well will be placed cross gradient to triangulate with the other wells and provide up or downgradient information should groundwater flow direction be different than expected.

In the shallow sand aquifer at the site, the inferred groundwater flow direction is to the northwest. One shallow well will be located to the west of the UST (Figure 1). The shallow well will allow for the collection of more detailed information where higher levels of contamination may exist. An "as-built" diagram showing a typical shallow monitoring well is provided as Figure 3.

The monitor wells will be drilled and installed through the overburden using hollow stem auger method of at least 4 1/4 inch I.D. Drill cuttings will be monitored and collected on the ground next to each monitor well and covered with a tarp. The cuttings will be drummed if contamination is evident through physical appearance or if organic vapors are detected above background levels by a photo-ionization detector. Based on these guidelines, the decision to drum the cuttings will be made in the field by a Dames & Moore Project Geologist.

During drilling, soil samples will be collected at five foot intervals using standard split spoon sampling techniques in accordance with ASTM Specification D-1586. The soil samples taken will be classified based on the Unified Soils Classification System by the Dames & Moore geologist in the field. Each sample will be field screened using a photo-ionization detector to identify the presence of organic vapors. One sample from each boring will be selected for subsequent laboratory analysis for the Volatile Organic Compounds. One sample from the well screened interval will be analyzed for grain size distribution, Atterberg limits and moisture content.

The bedrock-soil interface will be defined from information in literature or blow counts greater than or equal to 100 blows per six inch advance of the split spoon. When bedrock is encountered a NX bit and core barrel will be used to advance the boring, approximately 10 feet into bedrock. Prior to well installation, the rock portion of the boring will then be enlarged to approximately 3 1/2 inches by spinning the casing into the rock and washing out the borehole with a tricone roller bit.

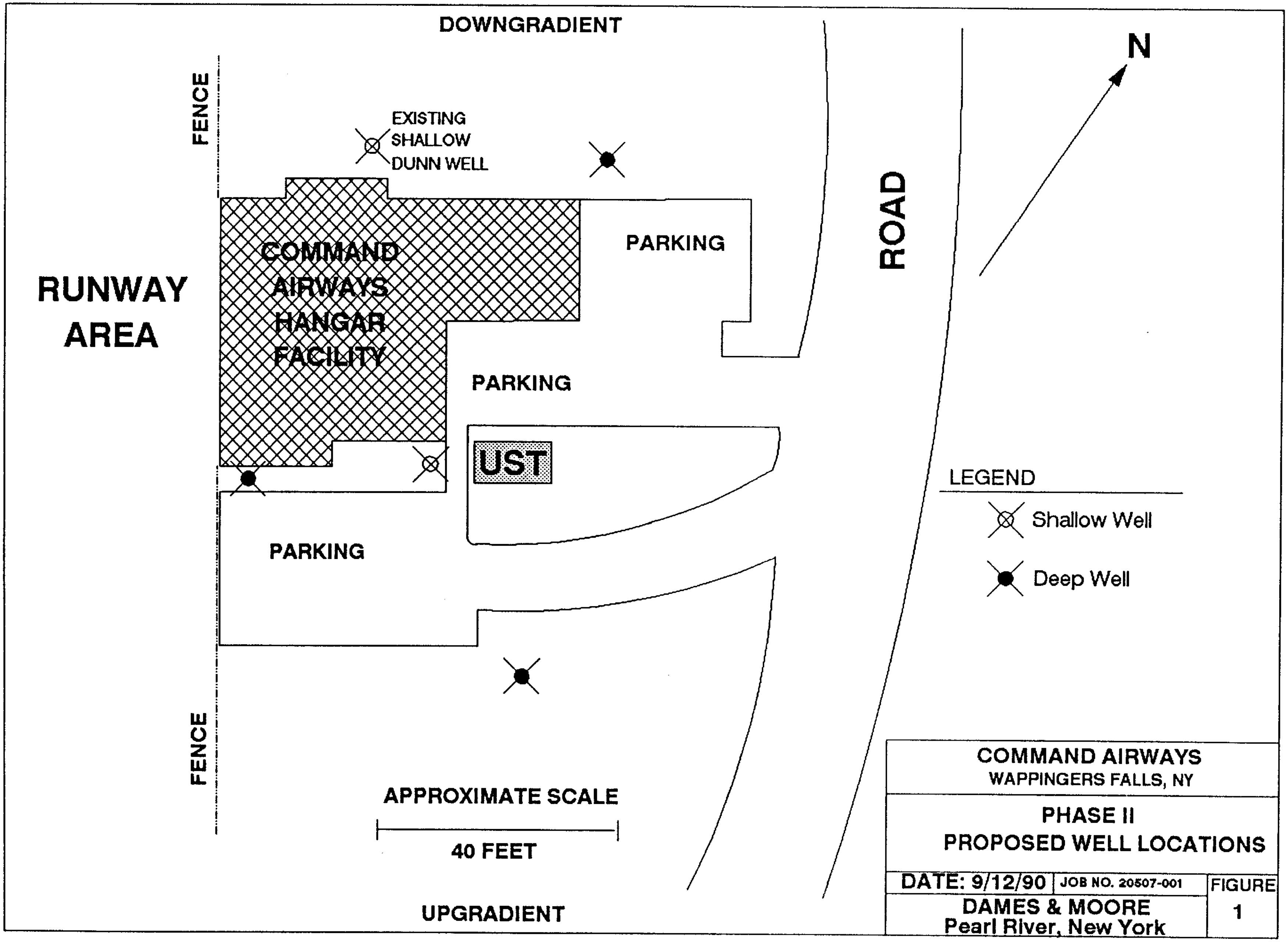
The monitor wells will be constructed according to NYSDEC specifications. The monitor well construction will consist of 4 inch PVC pipe and screen, with 0.010 inch slots in the screened interval. Each section of pipe will be threaded and no glue will be used to join adjacent segments of the pipe. The well screen will be approximately 10 feet in length. The shallow monitor wells installed will be screened at the first water bearing zone encountered and the screen will extend approximately one foot above the water table. The monitor wells installed in the bedrock will be screened from the top of the bedrock to ten feet below. A sand pack will be placed around the screened interval and up to one foot above the top of the screen. Above this, a bentonite pellet seal two feet in length will be placed. A cement-bentonite grout using tremie methods then will be installed to the surface. A protective pipe or curb box will be installed around the monitor well. Each well installation will be described on a boring log and a schematic diagram will be prepared on-site by the field geologist showing the details of the installation.

The drilling equipment will be steam cleaned between the drilling of each monitor well. The split spoons will be decontaminated with a phosphate-free detergent followed by a potable water rinse between samples. After installation of the monitor wells, each well will be developed. Development water will be discharged to the ground in a manner that prevents ponding. Each well volume will be monitored for pH, temperature, specific conductance, and turbidity. When the ground water reaches 50 NTUs turbidity or less, development will be considered to be completed. However, it should be noted that due to natural subsurface soil conditions, 50 NTUs turbidity may not be attainable no matter how long the well is pumped. If so, a modified development procedure will be developed and implemented.

After development, a slug test will be performed on each well and the results of the tests analyzed. Based on the results of these tests, the hydraulic conductivity (permeability) of the monitored units will be calculated. Three (3) rounds of water table measurements will be made over the course of the Phase II investigation to allow for the preparation of accurate water table maps.

Each monitor well and test boring location will be surveyed as to the location and elevation. The surface elevations and elevations of the inner casing of each well will be surveyed to the nearest 0.01 foot by a licensed land surveyor.

A health and safety plan to be implemented during drilling operations has been prepared for use at this site.



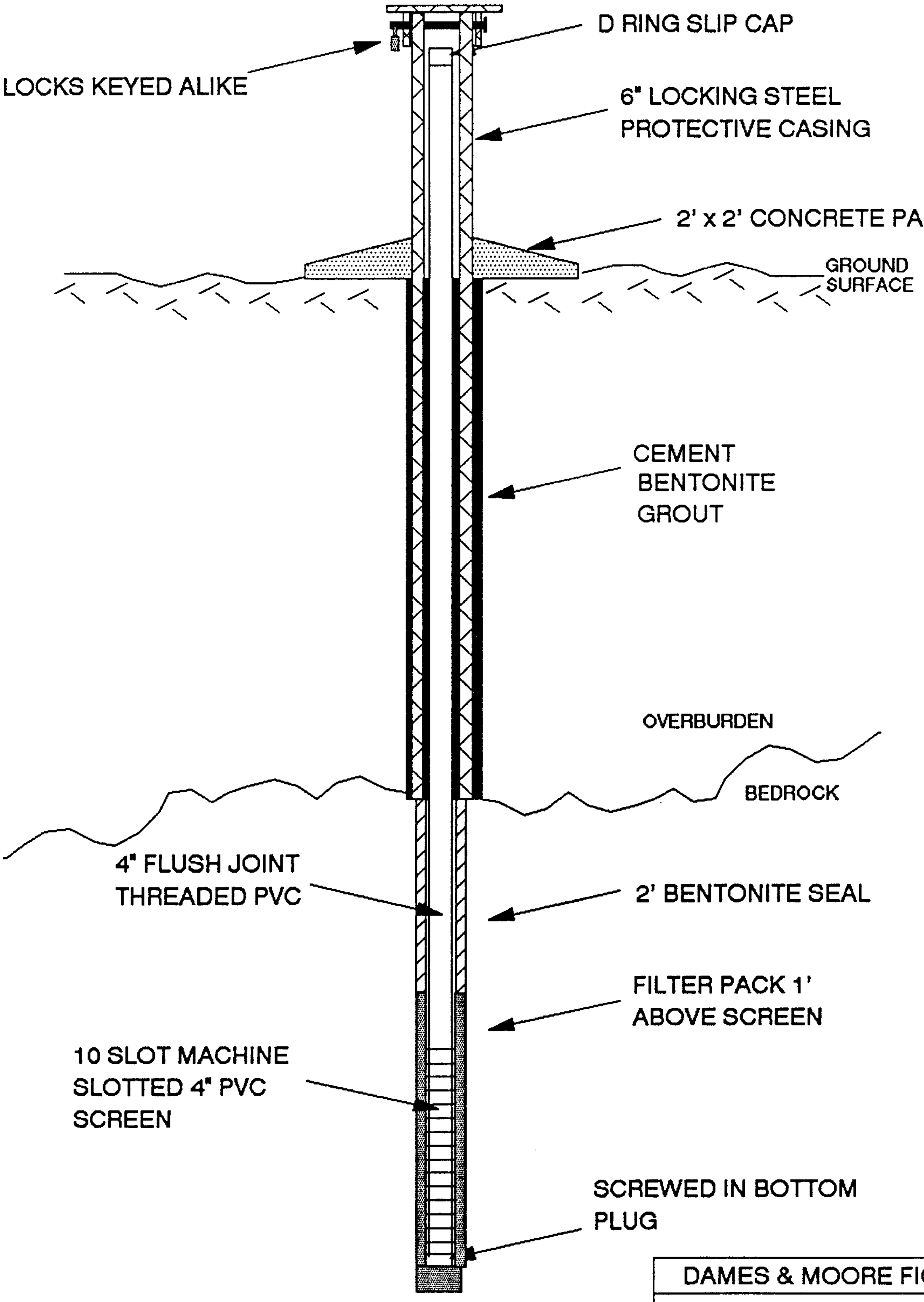
COMMAND AIRWAYS
WAPPINGERS FALLS, NY

PHASE II
PROPOSED WELL LOCATIONS

DATE: 9/12/90 JOB NO. 20507-001

FIGURE 1

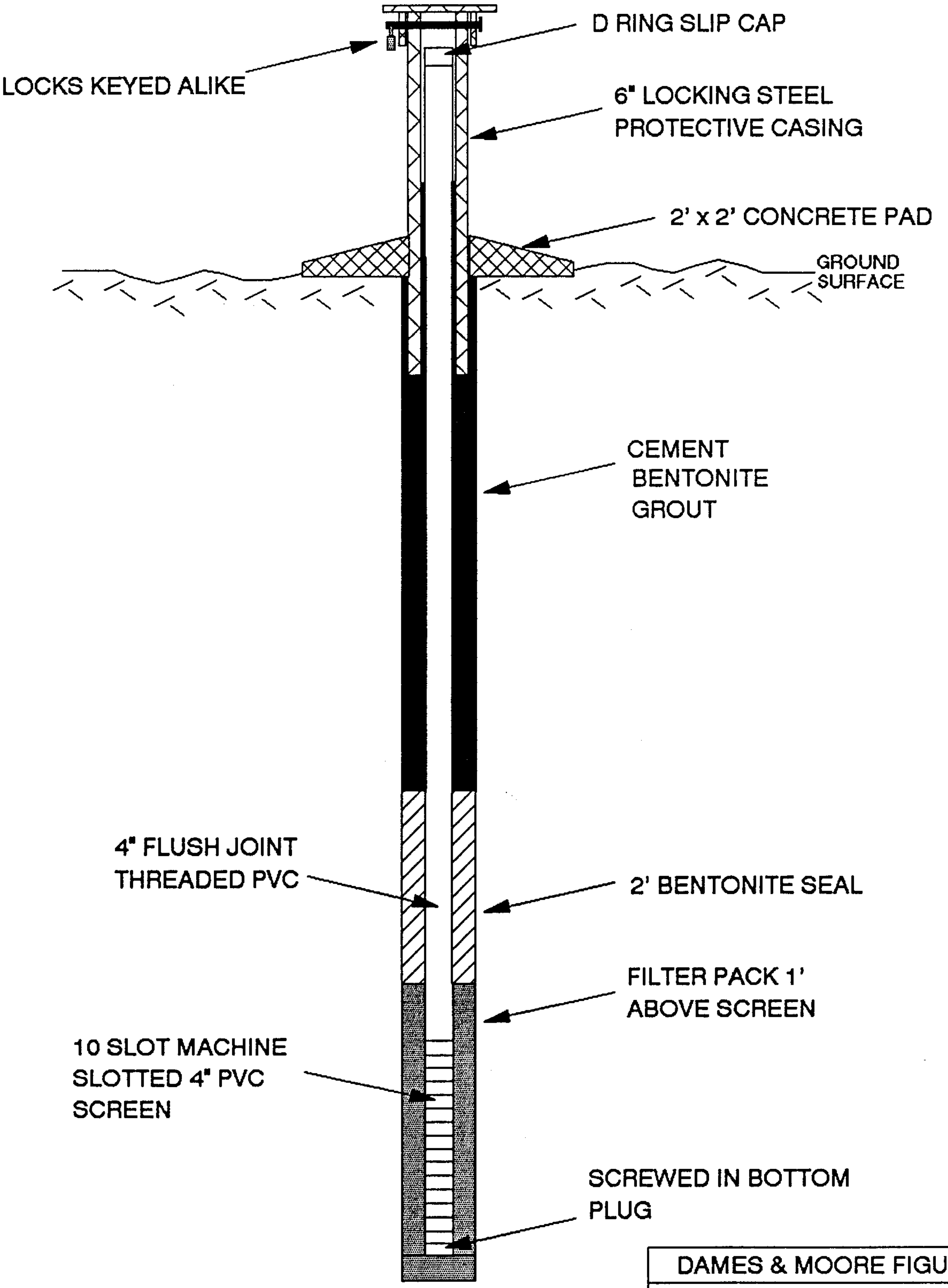
DAMES & MOORE
Pearl River, New York



DAMES & MOORE FIGURE 2

BEDROCK WELL CONSTRUCTION

NOT TO SCALE



DAMES & MOORE FIGURE 3
OVERBURDEN WELL CONSTRUCTION
NOT TO SCALE

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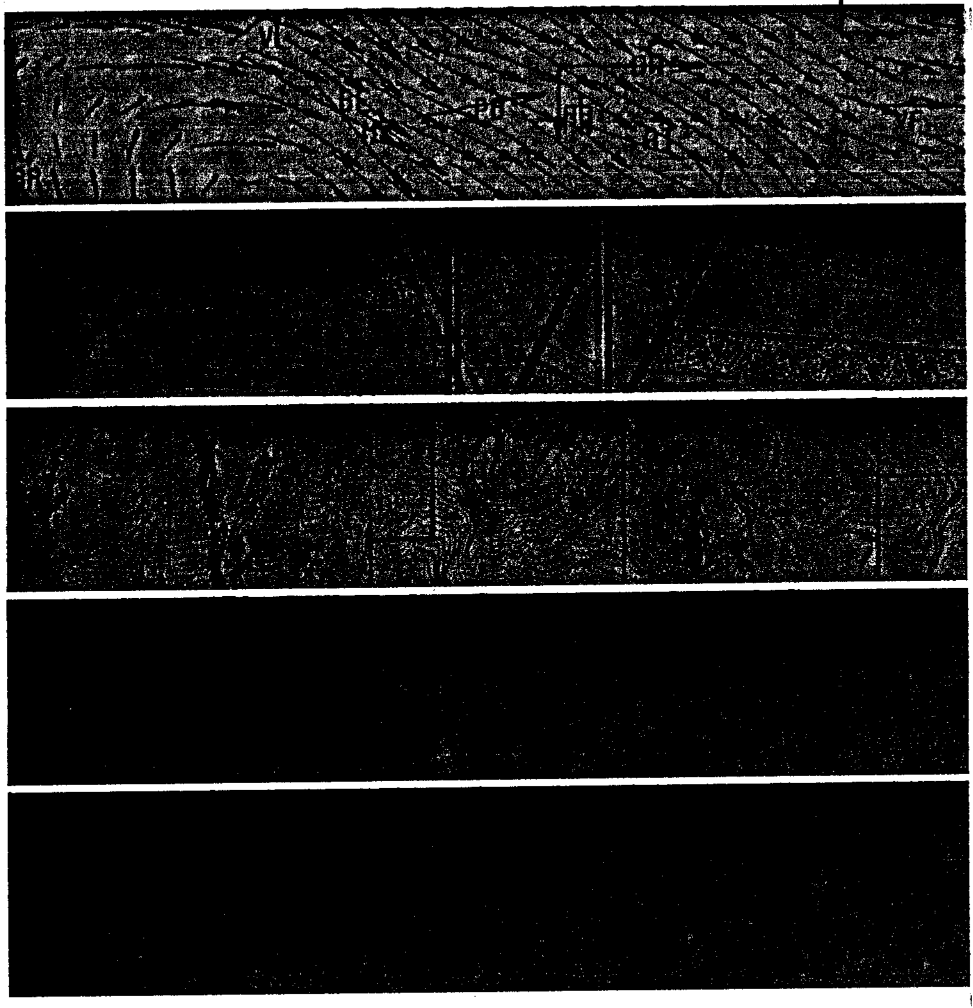
[illegible]



Health and Safety Plan

Prepared for

COMMAND AIRWAYS

August 7, 1990

DAMES & MOORE

DAMES & MOORE
HEALTH & SAFETY PLAN

Project Name:	Command Airways
Project Number:	20507-001
Project Site Location:	Wappingers Falls, New York 12590
Project Manager:	Robert Zimmer
Site Safety Officer:	John Wylock
Plan Reviewer:	Kathryn A. Sova
Preparation Date:	July 20, 1990

APPROVED;

Regional Health & Safety Coordinator

Kathryn A Sova 9/13/90
(Date)

Office Safety Coordinator

John Wylock/gi 9/13/90
(Date)

Managing Principal-In-Charge

Victor M. Bolano/gi 9/13/90
(Date)

Firm-Wide Health & Safety Director
(upon discretion of the FWHSO)

____
(Date)

H&S Plan Approval No.

____

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1.0 PURPOSE

The purpose of this plan is to assign responsibilities, establish personnel protection standards, mandatory safety practices and procedures, and provide for contingencies which may arise while conducting an investigation of the subsurface conditions at the Command Airways leased property at Dutchess County Airport in Wappingers Falls, New York. This plan will be implemented during the drilling and installation of nine (9) monitoring wells and collection of subsurface soil samples at the facility.

2.0 APPLICABILITY

The provisions of this plan are mandatory for all Dames and Moore employees engaged in on-site operations who will have the potential to be exposed to on-site hazardous substances.

Subcontractors shall provide a health and safety plan for their employees covering any exposure to hazardous materials and shall complete all work in accordance with that plan. The subcontractor may choose to use Dames and Moore's Health and Safety Plan as a guide in developing its own plan or may use the Dames & Moore plan. However, the subcontractor shall hold Dames and Moore harmless from, and indemnify it against, all liability in the event of any injury. Dames and Moore reserves the right to review and approve the subcontractor's plan at any time.

Inadequate health and safety precautions on the part of the subcontractor, or the belief that the subcontractor's personnel are or may be exposed to an immediate health hazard, can be the cause for Dames and Moore to suspend the subcontractor's site work and ask the subcontractor's personnel to evacuate the hazard area.

Subcontractors will be responsible for operating in accordance with the Occupational Safety and Health Administration (OSHA) regulations 29 CFR Part 1910.120-Hazardous Waste Operations and Emergency Response. These regulations include the following provisions for employees exposed to hazardous substances: Training as described in 120 (e); medical surveillance as described in 120 (f); and personal protective equipment described in 120 (g).

3.0 SITE DESCRIPTION

3.1 GENERAL INFORMATION

Site: Command Airways
Dutchess County Airport
263 New Hackensack Road
Wappingers Falls, New York 12590

Job No: 20507-001
Objective: Installation of Monitoring Wells
Proposed Date of Investigation: June 20, 1990
Background Review of Site: Complete____ Preliminary X
Documentation/Summary of overall Hazard: Low X Moderate X High ___

3.2 SITE HISTORY

The Command Airways site, also known as American Eagle, a wholly owned subsidiary of AMR, is located in Wappingers Falls, New York. Historical groundwater monitoring data at a neighboring site, an IBM airplane hangar, has shown elevated levels of 1, 1 dichloroethane (DCA) and other Volatile Organic Compounds (VOCs) were present in the ground water beneath the site. Vinyl chloride was detected in only one monitoring well at a concentration of 23 parts per billion. It is, therefore, of concern that VOCs may be present in the ground water beneath the Command site and ultimately impact public health by entering the drinking water wells at the airport.

In Phase I of the site characterization, a soil gas survey was conducted by Dames & Moore on April 16 and 17, 1990, to determine the distribution of contaminants (VOCs). The results of the survey indicate that more than one source of contamination may be present. Potential sources include an underground storage tank, which collects waste water from the floor drain of the Command Airway hangar, and an "off-site" source to the south. Soil gas monitoring indicated elevated readings (greater than 100 ppm) of 1, 1, 1-trichloroethane were present. Toluene was present at concentrations (greater than 1 ppm) to the north at the hangar where a heating oil underground storage tank was once located. This area is currently being remediated using of a vapor extraction system. Concentrations greater than 1 ppm of the compound tetrachloroethylene (PCE) was detected beneath the hangar, extending to the east and south, and in the area of the waste water underground storage tank. Elevated soil gas concentrations of 1, 1-DCA, toluene, and heavy hydrocarbons are present in the southeastern corner of the facility.

3.2.1 Dames & Moore Activities

It is anticipated that Dames & Moore will implement an investigation of subsurface conditions which will include the following elements:

Monitor Well Installation:

- Observation of drilling operations to install nine (9) groundwater monitoring wells.
- Collection of soil samples which will be screened with a Foxboro Organic Vapor Analyzer (OVA) to identify the presence of organic vapors and sent to an appropriately certified laboratory for chemical analysis.
- Observation of monitor well construction.
- Development of monitor wells including monitoring of well discharge for pH, temperature, specific conductance and turbidity.

3.3 FACILITY DESCRIPTION

Possible Waste Types: Liquid X Solid___ Gas___
Waste Characteristics: Ignitable X, Volatile X Toxic X Corrosive____
Site Features: Flat topography, most-areas accessible by parking lot; Above Ground Electrical Wires

Status: Active

3.4 HAZARD EVALUATION

Nine (9) monitoring wells are proposed to be installed on Command Airways leased property in areas where 1,1,1-trichloroethane (greater than 10 ppm), dichloroethane (greater than 10 ppm), toluene (greater than 0.1 ppm), and other volatile organics (greater than 1.0 ppm) are suspected. Monitoring wells to be installed near the east side of the hanger will be located in an area were 1,1,1 (trichloroethane (greater than 0.1 ppm) and tetrachloroethylene (greater than 0.1 ppm) have been found in the soil gasses; and monitoring wells north of the hanger will be located in an area where toluene (greater than 0.1 ppm) has been found in the soil gasses. The exposure limits, symptoms and first-aid treatment for these contaminants are presented in Tables 1 and 2.

The main routes of exposure associated with the volatile organic compounds found at the facility are via inhalation, ingestion, skin absorption and eye contact. Routes of exposure associated with contaminated dusts are via skin contact or inhalation if dry or dusty conditions exist.

Drilling and sampling activities at the facility will be conducted while wearing the protective equipment indicated in Table 4. If organic vapors, as measured in the breathing zone by the OVA exceed 5 ppm, personnel engaged in drilling and sampling activities will don respirators. If organic vapors exceed 10 ppm above the ambient background level, personnel will evacuate the area and notify the Project Manager and Health and Safety Officer.

4.0 EMERGENCY INFORMATION

If an emergency develops on-site, the procedures as listed in Appendix A should be utilized. Should the situation require outside support services, the client will be notified along with the appropriate contact from the list which follows:

4.1 EMERGENCY CONTACTS

Contact	Person or Agency	Telephone
Police		(914) 452-0400
Fire		(914) 471-1427
Ambulance	Solper Wilen	(914) 297-3777
Hospital	Vassar Brothers	(914) 358-1000
Poison Control		(914) 353-1000
Client Contact	William Pulling	(914) 462-6100
D&M Project Manager	Robert Zimmer	(914) 735-1200
D&M MPIC/Group Leader	Victor Bolano	(914) 735-1200
Regional H&S Manager	Kathryn A. Sova	(201) 272-8300 (201) 279-6180 (Home)

4.2 LOCATION OF SITE RESOURCE (for emergency use)

Water Supply:	Available on site
Telephone:	Available on site

The exact location of site resources for emergency use will be identified by the Site Safety Officer prior to initiation of on-site activities.

4.3 EMERGENCY ROUTE TO HOSPITAL

From parking lot of airport make a right onto New Hackensack Road. Proceed on New Hackensack Road for approximately 3 miles and make a right onto Route 9 North. Proceed on Route 9 North for approximately 6 miles and take the Columbia Street exit. On Columbia Street, take the first right onto Young Street and continue to Vassar Brothers Hospital.

4.4 ADDITIONAL ARTICLES TO BE TAKEN INTO FIELD

1. First Aid Kit
2. Disposal Eye Wash (1 liter or more)

5.0 MONITORING AND PERSONAL PROTECTION REQUIREMENTS

5.1 MONITORING

Drilling operations may disturb the subsurface soils sufficiently to increase the risk of contaminant exposure through:

1. Dust generated during drilling
2. Contaminated soil/cuttings that are brought to the surface
3. the release of organic vapors into the atmosphere
4. Contaminated groundwater that is brought to the surface

Due to the increased risk of exposure to potentially harmful substances during field explorations, the following procedures will be followed while drilling wells.

1. The drilling rig will be positioned upwind of the borehole whenever possible and the wind direction will be monitored continuously.

2. All personnel within an area designated the Exclusion Zone by the Health and Safety Officer (HSO) will use Level D+ personnel protection. However, if dust generation cannot be controlled and respirators are warranted then an upgrade to level C will occur.

3. Periodically throughout drilling, the HSO shall conduct monitoring for organic vapors and combustible vapors/gases. The worker's breathing zone will be scanned for vapors and both the breathing zone as well as the ground at the borehole will be scanned to detect the presence of combustible vapors/gases. If the OVA indicates levels above 5 ppm, then an upgrade to level C protection will occur.

4. Motor exhausts are to be located at least 5 ft. from the ground surface and directed away from the work activities. The driller will be required to verify that the pipes and seals of the exhaust system are in good working condition.

5. Drill cuttings, recovered drill water and disposable items shall be placed in drums and sealed. All drums will be placed in a designated storage area at the site. The contents of the stored drums will be tested as directed by the on-site HSO, and properly disposed of in a manner consistent with the contents.

5.1.1 Field Equipment

1. Air monitoring equipment used will be an Foxboro Organic Vapor Analyzer (OVA). A MSA Model 2A combustible gas meter will also be used. Each detection device will be carefully wrapped in plastic to prevent contamination of the instruments. (Note: attention must be given to avoid blocking the vents). The plastic and other disposable items will be handled in accordance with the procedures described in Section 6.4.

5.1.2 Monitoring Schedule

5.1.2.1 Instrument Calibration

All applicable instruments shall be calibrated daily. Readings shall be recorded on the Instrument Calibration Check-Out Sheet provided in Appendix F.

5.1.2.2 Background Readings

Before any field activities commence, the background levels of the site will be read and noted on the Air Monitoring Forms a copy of which is provided in Appendix F. Daily background readings shall take place away from areas of potential contamination to obtain accurate results.

Generally, background levels for organic vapors in ambient air read zero. If background readings indicate higher levels of organic vapors than anticipated, the Site Safety Officer will determine the source of the readings prior to initiation of on-site activities. The plan will be amended, as appropriate, to reflect any adjustments necessary as the result of higher than expected background levels.

5.1.2.3 Air Monitoring Frequency

All site readings may be noted on the Air Monitoring Form provided in Appendix F along with the date, time, weather conditions, wind direction and speed, if possible, and location where the background level was recorded.

The following schedule should be followed for air monitoring activities as specified for each activity.

Activity: Drilling and Sampling

Air Monitoring Equipment	Monitoring Frequency
Combustible Gas Indicator (CGI)	Monitor every 15 min/every sample retrieved
Organic Vapor Analyzer (OVA)	Monitor every 15 min/every sample retrieved

5.2 LEVELS OF PROTECTION

A minimum of Level D+ protection is needed to perform work on-site, with the potential upgrade to Level C. The protective equipment to be used is indicated in Table 4.

5.3 RESPIRATORY PROTECTION

5.3.1 Types of Cartridges/Limits of Cartridges

If air purifying respirators are required, a full face respirator with organic vapor cartridges and high efficiency dust and mist filters shall be used.

5.4 WORK LIMITATIONS

In general, field work will be conducted during daylight hours only. At least two personnel will be in the field at all times. The Dames & Moore Project Manager (PM) or Regional Health and Safety Manager (RHSM) must grant special permission for any field activities conducted beyond daylight hours.

All Dames & Moore personnel working in the field will have completed the Dames & Moore Hazardous Material Sites Training Course (or its equivalent). Additionally, all Dames & Moore field personnel will have been declared medically fit for duty and, where respiratory protection is necessary, will have been properly trained, fit tested and declared fit for respiratory use. No drilling shall take place without first investigating the presence of subsurface utility lines or other suspected buried metal objects.

5.5 Field Personnel

The responsibilities of the Project Manager, the on-site Safety Officer and project personnel are listed in Appendix D and must be adhered to at all times.

A work party from Dames and Moore consisting of the following persons will perform the tasks associated with the groundwater investigation (i.e., sampling):

Project Manager: Robert Zimmer
Dames & Moore Site Field Personnel: John Wylock
Site Safety Officer (SSO): John Wylock

5.6 HEAT STRESS/COLD STRESS

If on-site activities are conducted during extreme weather conditions, instructions for minimizing heat stress/cold stress are given in Appendix E.

6.0 DECONTAMINATION PROCEDURES AND SITE WORK AREA ORGANIZATION

6.1 SITE WORK AREA ORGANIZATION

The subsurface investigations are being conducted in a work area where elevated levels of organic compounds are suspected.

If contaminants are brought to the surface during drilling, contamination of the work zone will be confined to the area immediately surrounding the drill rig. The actual limits of the work zone will be established by the HSO based on the air monitoring results.

Airborne contaminants (VOCs) may readily diffuse upon being brought to surface and contaminated groundwater and cuttings will be contained in sealed drums and appropriately stored. If unsafe levels of airborne contaminant levels are detected, the HSO shall determine from air monitoring for the aerial extent of airborne contamination and reestablish as necessary the limits of the Exclusion Zone.

A decontamination area will be established in the Contamination Reduction Zone beyond the Exclusion Zone. All supplies will be available at the site for decontamination purposes if contaminants are encountered.

General Standard safe work practices and those for drilling & sampling operations are given in Appendix B.

6.2 DECONTAMINATING PROCEDURES

Upon exiting the Exclusion Zone, decontamination, if required, will proceed as follows:

1. Boot wash and rinse
2. Outer glove wash and drop
3. Tyvek coverall removal and disposal
4. Respirator removal and drop
5. Cartridge drop and inner glove disposal

Prior to the removal from the Exclusion Zone or advancing to the next cluster location, the drill rig, and augering and sampling equipment shall be decontaminated by steam cleaning.

6.3 DECONTAMINATION EQUIPMENT

The following constitutes a list of supplies and necessary equipment to be provided by the driller for decontamination that will be available and maintained on site:

- 2 galvanized tubs
- wash and rinse water
- long handled wood brush
- water sprayer
- duct tape
- paper towels
- trash bags
- surgical gloves
- hand cleaner
- non-phosphate soap

6.4 CLOSURE OF THE PERSONNEL DECONTAMINATION STATION

All disposable clothing and plastic sheeting used during the operation should be double-bagged and removed to an approved off-site disposal facility. Decon and rinse solution will be contained on site. Re-usable rubber clothing should be dried and prepared for future use. (If gross contamination has occurred, additional decontamination of these items may be required.) Cloth items should be bagged and removed from the site for final cleaning. All wash tubs, pail containers, etc. should be thoroughly washed, rinsed, and dried prior to removal from the site. The command post for the project will be Command Airlines offices, at Dutchess County Airport.

7.0 TASK TEAM RESPONSIBILITIES AND SUBCONTRACTOR COORDINATION

John Wylock will serve as the "on-site" Health and Safety Officer (HSO) for the project. The main responsibility of the HSO will be to monitor on-site activities, and inform all field personnel of the potential hazards associated with site operations. A safety meeting will be held with Dames & Moore and subcontractor personnel before work commences in order to review emergency procedures and other details of the Health and Safety Plan.

8.0 FORMS

The following forms are located in Appendix F.

1. Plan Acceptance Form
2. Plan Feedback Form
3. Contractor/Subcontractor Statement of Compliance
4. Site Briefing Forms
5. Calibration Check Sheet
6. Air Monitoring Form
7. Exposure History Form (to be completed by PM only)
8. Accident Report Form

The Plan Acceptance Form should be filled out by all employees working on the site. The Plan Feedback Form should be filled out by the On-Site Safety Officer and any other on-site employee who wishes to fill one out. The Accident Report Form should be filled out by the Project Manager in the event that an accident occurs.

ALL COMPLETED FORMS SHOULD BE RETURNED TO THE
NYK HEALTH AND SAFETY OFFICER OR
PROJECT MANAGER

TABLE 1

EXPOSURE LIMITS AND RECOGNITION QUALITIES

Compound	Permissible Exposure Limit (ppm)	IDLH Level (ppm)	Odor	Odor Warning Concentration (ppm)	LEL %	IP (ev)
1,1-Dichloroethane (CH_3CHCl_2)	100 (1) 200 (2)	4000	Chloroform-Like	120	6	11.12
Tetrachloroethylene ($CCl_2 = CCl_2$)	25 (1) 50 (2)	Ca	Chloroform-either Like	4.68-50 (106-690)	not combustible	9.32
Toluene ($C_6H_5CH_3$)	100 (1)(2)	2000	Aromatic odor Like Benzene	0.17-40 fatigue (300-400)	1.3	8.82
1,1,1-Trichloroethane ($CHCl_3CH_3$)	350 (1)(2)	500	Sweet, Chloroform Like	20-500	7	11.3
Trichloroethylene $CHCL = CAl_2$	50 (1)(2)	Ca	Sweet, Chloroform Like	21.4-400	11	9.47

IDLH = Immediately Dangerous to Life or Health Level

(1) OSHA Permissible Exposure Limit (Time Weighted Average)

(2) American conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) (8-Hour Time Weighted Average)

Ca = Potential human carcinogen

LEL = Lower Explosive Limit

IP = Ionization Potential

TABLE 2

EFFECTS AND FIRST AID TREATMENT

Compound	Route of Entry	Eye Irritant	Skin Irritant	Symptoms
1,1-Dichloroethane (CH_3CHCl_2)	Inhalation, Ingestion, Skin/Eye Contact	--	Yes	CNS depression, Skin Irritation (dermatitis), drowsiness, unconsciousness, Liver, Kidney damage.
Tetrachloroethylene ($CCl_2 = CCl_2$)	Inhalation, Ingestion, Skin/Eye Contact	Yes	--	Irritation of eyes, nose and throat, dermatitis nausea, flush face, vertigo, dizziness, uncoordination, headache, erythermia, liver.
Toluene ($CaHoCH_3$)	Inhalation, Ingestion, Skin/Eye Contact	--	Yes	Fatigue, weakness, confusion, euphoria, dizziness, headache, dilated pupils, photophobia, dermatitis.
1,1,1-Trichloroethane ($CHCl_3CH_3$)	Inhalation, Ingestion Skin/Eye Contact	Yes	Yes	Irritation of the nose and eyes, CNS depression liver and kidney damage, headache, lassitude, poor equilibrium.
Trichloroethylene $CHCL = CAl_2$	Inhalation, Skin absorption, Ingestion, Skin/Eye contact	Yes	Yes	Irritation of nose and yes, CNS, depression, liver, kidney damage. Headache, vertigo, visual disturbance, tremors, nausea, vomiting, dermatitis, cardiac arrythmias, paresthesia.

General First-Aid Treatment	(A first-aid kit will be kept in the site vehicle)
Eye	Irrigate immediately (A portable eye-wash unit will be kept in the site vehicle).
Skin	Soap Wash Promptly
Inhalation	Move to Fresh Air
Ingestion	Get Medical Attention

TABLE 3

HAZARD MONITORING METHOD, ACTION LEVELS, AND PROTECTIVE MEASURES

Hazard	Method	Monitoring Action Level	Protective Measures
Toxic Vapors	OVA	<5 ppm	Level D+ Continue working, equipment required (see Table 4)
	OVA	5-10 ppm	Level C Don full-face respirator with organic vaporcartridge/ high efficiency dust and mist filters
	OVA	>10 ppm	Stop work, evacuate area; notify Project Manager
Explosive	CGI		
		0-10% LEL	Continue working
		10-25% LEL	Continue working with continuous monitoring
		>25% LEL	EVACUATE the area EXPLOSION HAZARD*

* If encountered in a boring or monitoring well, purge boring or well with notrogen until safe limits (less than 10% LEL) are achieved, if > 25% LEL persists, abandon boring or well evacuate areas.

Definitions

OVA - Organic Vapor Analyzer
CGI - Combustible Gas Indicator
LEL - Lower Explosion Limit

TABLE 4

PROTECTIVE EQUIPMENT REQUIRED FOR ON-SITE ACTIVITIES

Activity/Location	Protective Equipment
Drilling and Sampling	• Hard hat • Safety goggles* • Gloves (PVC) with inner latex gloves • Steel toed rubber boots • Tyvek coveralls • Full-face respirator with organic vapor cartridge/high efficiency dust and mist filter **

* When not wearing respiratory protection

** If OVA>5 ppm or dusting conditions exist

APPENDIX A

APPENDIX A

CHEMICAL HAZARD EVALUATION

(Material Safety Data Sheets

AMERICAN
INDUSTRIAL
HYGIENE
ASSOCIATION

HYGIENIC GUIDE SERIES

1,1-DICHLOROETHANE

(Ethylidene Chloride; 1,1-Ethylidene Dichloride)
Chemical Abstracts Service No. 75-34-3
CH_3-$CHCl_2$

Significant Physical Properties[1]

1,1-Dichloroethane is a colorless liquid with a chloroform-like odor

Molecular weight:	98.97
Flash point:	14°C (57°F) Tag Open Cup 12°C (53.6°F) Closed Cup
Autoignition temperature:	493°C (919°F)
Explosive limits:	5.6 - 11.4% by volume, in air
Specific gravity:	1.174 (20/4°C)
Solubility:	0.5 g/100 mL water @ 20°C; soluble in ethanol, ethyl ether
Melting point:	-96.7°C (-142°F)
Boiling point:	57.3°C (135°F)
At 25°C and 760 mm Hg:	Saturated air contains 30.8% 1,1-dichloroethane, by volume. Relative density of saturated air = 1.743 (air = 1.0) 1 ppm = 4.05 mg/m³ 1 mg/M³ = 0.247 ppm

I. Hygienic Standards

A. WORKDAY EXPOSURE CONCENTRATIONS: (8 hours, Time Weighted Average):

1. *Threshold Limit Value (TLV)®:* 200 ppm[2,3]
2. *OSHA Permissible Exposure Level:* 100 ppm[4]

B. SHORT-TERM EXPOSURE CONCENTRATIONS: The ACGIH STEL is 250 ppm or 1010 mg/M³.[2,3]

C. ATMOSPHERIC CONCENTRATION IMMEDIATELY HAZARDOUS TO LIFE: Unknown for humans but estimated at 4000 ppm.[5,6]

II. Toxic Properties

A. INHALATION: There have been no reported cases of human overexposure to 1,1-dichloroethane. Although early animal studies reported that the material was "similar to carbon tetrachloride" in toxicity,[7] the only published information on chronic inhalation studies, with rats and dogs, indicates that 1,1-dichloroethane is considerably less toxic than carbon tetrachloride.[8] The most important effect observed was chronic poisoning, affecting primarily the liver. However, recent detailed, chronic studies indicate that 1,1-dichloroethane has little capacity for causing liver damage, being similar to methylene chloride and 1,1,1-trichloroethane in this respect.[9,10] Rats survived eight hours of exposure at 4000 ppm but died after eight hours at 16000 ppm.[8] Rats exposed to 64000 ppm died within ten minutes.[9] The minimum lethal concentration for mice, following 24-hr exposure, was reportedly about 17500 ppm.[11] Unpublished data indicate that rats survived 30 minutes of exposure to 32000 ppm

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The Committee wishes to acknowledge Ronald D. Schaible for the preparation of this guide.

but died after 2.5 hours.(9) Rats, guinea pigs, rabbits, and dogs were exposed to either 500 or 1000 ppm for seven hours per day, five days per week, for six months. Gross and microscopic pathological and hematological studies showed no evidence of changes attributable to the exposure. The most consistent findings in animals exposed to higher concentrations (8000 to 64000 ppm) for periods up to seven hours were definite pathological changes in the kidneys and liver (and lungs at the higher concentrations). 1,1-Dichloroethane has been tested for carcinogenicity in laboratory animals. The initial test results were inconclusive; low survival rates complicated the interpretation of the bioassay results. However, NIOSH has recommended that 1,1-dichloroethane be closely monitored for carcinogenic effects in humans and/or laboratory animals. 1,1-Dichloroethane should be treated in the workplace with caution because of its relation to four other chloroethanes shown to be carcinogenic in laboratory animals.(12)

B. SKIN CONTACT: Undiluted 1,1-dichloroethane repeatedly applied to either the intact or abraded skin of rabbits caused slight to moderate hyperemia (*i.e.*, an excessive accumulation of blood; congestion) followed by a slight edema (*i.e.*, swelling) and very slight necrosis after the sixth of ten daily applications.(9) Twenty-one days after the final application, the skin had essentially returned to normal. Although there is evidence that the material can be absorbed through the skin,(13) it is apparently not absorbed in amounts sufficient to produce systemic injury.

C. EYE CONTACT: When the undiluted material was placed in the eyes of rabbits, there was immediate, moderate conjunctival irritation and partial swelling which subsided within a week.(9)

D. INGESTION: The acute oral LD_{50} value for rats is reportedly 14.1 g/kg; the minimum lethal dose for dogs is 2.5 g/kg.(14) Although the metabolism has not been investigated, 1,1-dichloroethane could be expected to yield acetic acid.(15)

In summary, only very limited evaluation is possible. Attention is drawn to the small amount of animal data and lack of data on endocrine and gonadal effects and on fertility. There is limited evidence that it is not teratogenic in rats. Attention is drawn to the complete absence of data on humans.(16)

III. Industrial Hygiene Practice

A. INDUSTRIAL USES: 1,1-dichloroethane is used as a chemical intermediate, an industrial solvent, and in fumigants, perfumes, lacquers, thermoplastics and medicines.

B. EVALUATION OF EXPOSURES:

1. *Sensory Recognition:* Although the material has a distinctive, recognizable odor at the TLV, it is not unpleasant and is easily tolerated. A low odor threshold of 455.5 mg/M^3 and a high odor threshold of 810 mg/M^3 has been reported.(17) Odor may not be a satisfactory warning of excess chronic exposure.(1)

2. *Air Sampling and Analysis:*

   a. Direct Field Methods: In the absence of other interfering materials, concentrations of 1,1-dichloroethane in air can be determined with a properly calibrated Davis Halide Meter,(18) combustible gas indicator (dual range model), flame ionization meter, appropriate detector tube or portable infrared spectrometer. Photoionization detectors equipped with probes having an energy of 11.7 electron volts may also be used. Photoionization detectors will not detect a compound if the probe has a lower energy than the compound's ionization potential.(19)

   b. Laboratory Methods: NIOSH Method 1003 uses activated charcoal with analysis by vapor phase chromatography.(20) Specific identification and quantitation of concentrations in air can also be accomplished by collecting air samples in FEP-Teflon®, Tedlar or Mylar bags(21) with subsequent analysis by infrared spectrophotometry,(22,23) vapor phase chromatography(22,24) or mass spectroscopy.(25)

3. *Clinical Monitoring:* Volatile halogenated hydrocarbons can be identified and measured in blood samples by either infrared spectrophotometry or vapor phase chromatography.(26,27) However, the nature and extent of metabolism at 1,1-dichloroethane has not been established. The analysis of expired breath, using infrared or gas chromatographic techniques, may be used in the evaluation of exposures.(27,28) However, neither blood nor breath concentrations have been correlated to toxic effects and thus have limited use in evaluating exposure consequence.

C. HAZARDS AND THEIR RECOMMENDED CONTROL:

1. *Inhalation:* Because of its high vapor pressure, anesthetic and/or lethal con-

centrations of [illegible]ichloroethane can be attained rea[illegible] at room temperature, particularly in the event of massive spills in poorly ventilated areas. Good industrial hygiene practices, including the use of local exhaust ventilation, are required to maintain atmospheric concentrations of this material below the recommended TLV of 200 ppm.

Engineering control of the environment is the best industrial hygiene practice. Personal respiratory protection should be considered a secondary means of protecting the worker. Where engineering control is not possible, personal protective devices must be used. If gross inhalation exposure is likely, as during tank cleaning or cleanup of spills in areas having poor ventilation, an airline respirator equipped with an emergency escape cylinder or a self-contained breathing apparatus equipped with full face mask should be worn. Only respiratory protective equipment which is appropriate for the exposure should be used.

Respiratory Protection for 1,1-Dichloroethane[29]

Concentration or Condition	Minimum Respiratory Protection
100-1000 ppm	Any chemical cartridge respirator with an organic vapor cartridge(s) Any supplied-air respirator Any self-contained breathing apparatus
4000 ppm or less	A full facepiece gas mask with a chin-style or a front- or back-mounted organic vapor canister Any supplied-air respirator with a full facepiece, helmet or hood Any self-contained breathing apparatus with a full facepiece
Greater than 4000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in a pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure demand or other positive pressure mode
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure demand or other positive pressure mode
Escape	Any gas mask providing protection against organic vapors Any escape self-contained breathing apparatus

2. *Skin Contact:* Although 1,1-dichloroethane is not readily absorbed through the skin in amounts sufficient to produce systemic injury, prolonged or repeated skin contact can produce a slight erythema and should thus be avoided.(9,13) Viton is the protective clothing material of choice.(30) Contaminated clothing should be removed immediately and not re-worn until they have been decontaminated.
3. *Eye Contact:* Chemical workers' goggles and/or faceshield should be worn during operations where there is a possibility of direct eye contact with the material.
4. *Ingestion:* Although intentional swallowing of substantial amounts of 1,1-dichloroethane would likely produce serious systemic effects, ingestion incidental to industrial handling is not considered to be a practical problem.
5. *Fire and Explosion:* 1,1-dichloroethane is a flammable liquid with a low flash point and relatively high vapor pressure. Explosive atmospheres are attained readily in the event of massive spills of the material in areas having inadequate ventilation. Decomposition products may include phosgene, hydrogen chloride and dichloroacetylene.(12) NFPA Ratings: Health = 2, Flammability =3, Reactivity = 0.(31)

IV. Medical Information

A. FIRST AID PROCEDURES:

1. *Inhalation exposure:* Rescuers must use appropriate respiratory protection equipment during rescue operations. If a person inhales excessive amounts of 1,1-dichloroethane, move the victim to an uncontaminated atmosphere at once; apply artificial respiration if needed.
2. *Skin Exposure:* If skin contact has occurred, remove contaminated clothing and wash the exposed area with soap and plenty of water.

3. *Eye Contact:* If eye con[illegible] has occurred, irrigate with copious amounts of water for at least 15 minutes.

4. *Ingestion:* In case of ingestion, seek medical attention promptly.(29)

B. MEDICAL MANAGEMENT: As stated in the previous edition of this Hygienic Guide, administer gastric lavage, followed by saline catharsis and use of demulcents if ingested. Do not make an unconscious person vomit. Treat symptomatically. Particular attention should be paid to cardiac rhythm in cases of overexposure resulting in anesthesia. Oxygen therapy is indicated. Use of epinephrine, or other vasopressor drugs, is contraindicated. Pre-placement physical examinations are recommended to prevent persons with histories of liver or kidney disease from being placed on jobs which involve potential overexposure to this material. Periodic re-examination should be made with particular emphasis on liver and kidney function tests.(29)

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AMERICAN
INDUSTRIAL
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HYGIENIC GUIDE SERIES

TOLUENE
(Toluol, Methyl benzene, Phenyl methane, $C_6H_5CH_3$)
CAS No. 108-88-3

Significant Physical Properties

Toluene is a noncorrosive, colorless flammable liquid with an aromatic hydrocarbon-like odor.

Molecular weight:	92.13
Melting point:	-95 °C
Boiling point:	110.6 °C
Flash point (closed cup):	4.4 °C
Autoignition temperature:	552 °C
Flammable limits:	1.2 to 7.0 (% by volume in air)
Vapor pressure:	28 mm Hg at 25 °C
Specific gravity:	0.866 (water = 1)
Vapor density:	3.14 (air = 1)
Solubility:	Insoluble in water; soluble in acetone; miscible with alcohol, ether, and benzene.
At 25 °C and 760 mm Hg:	1 ppm = 3.75 mg/m^3 1 mg/m^3 = 0.267 ppm

I. Hygienic Standards

A. WORKDAY EXPOSURE CONCENTRATIONS: One hundred parts toluene per million parts of air by volume (375 mg/m^3) is the Threshold Limit Value.(1) The Permissible Exposure Limit adopted by OSHA is 200 ppm.(2) Special attention must be given to the potential contribution this exposure by the cutaneous route. Other recommendations are USSR (1967) 14 ppm; Czechoslovakia (1969) 50 ppm; West Germany (1974) 200 ppm; Sweden (1975) 100 ppm; East Germany (1973) 50 ppm.(3)

B. SHORT-TERM EXPOSURE CONCENTRATIONS: The recommended short term exposure limit is 150 ppm for a period up to 15 minutes. There should be no more than four excursions per day with at least sixty minutes between each excursion.(1)

C. CEILING CONCENTRATIONS: A ceiling concentration of 200 ppm is recommended by NIOSH.(4) OSHA has set a ceiling concentration at 300 ppm and a maximum peak concentration of 500 ppm permitted for a period up to 10 minutes per eight-hour shift.(2)

D. IMMEDIATE LETHAL CONCENTRATIONS: Unknown for humans. NIOSH reports 2000 ppm as the concentration that is immediately dangerous to life and health.(3) 8000-12 000 ppm rapidly fatal to mice.(5)

II. Toxic Properties

The major problem of toluene vapor toxicity is its narcotic effect on workers and its irritation to the eyes, skin, and respiratory tract. It is generally supported that earlier studies which attributed myelotoxicity to toluene were biased because of the presence of significant quantities of benzene in industrial toluene.(4,6)

A. INHALATION: Inhalation of toluene may cause central nervous system depression. The effects of controlled exposure of human subjects to essentially benzene-free toluene for eight-hour periods have been reported:

The Committee wishes to acknowledge the assistance of Sondra Barber Akins in the preparation of this Hygienic Guide.

Moderate fatigue and slight headache were experienced at 100 ppm. Additional symptoms of impaired coordination, reduced light accommodation and nausea followed by after effects of restless sleep and confusion were experienced at 200 ppm exposures. Higher concentrations led to more severe manifestation of the above symptoms, insomnia, and skin paresthesia. Lack of self control, extreme fatigue, confusion and staggering gait were significant after three hours exposure at 600 ppm and 800 ppm.(4) Acute accidental exposure at 10,000 to 30,000 ppm (waist to floor level) resulted in loss of consciousness, with complete recovery after two months. Permanent encephalopathy has been reported from severe chronic exposure resulting from toluene sniffing, and reversible liver injury has also been attributed to habitual toluene use.(4) Effects of occupational exposure to toluene vapors at 100 ppm to 1100 ppm from periods of two weeks to five years were mild intoxication, enlarged livers, enlarged red blood cells, mild depression of erythrocyte level, enlarged lymphocytes, and elevation of hemoglobin level.(4)

B. SKIN CONTACT: Repeated and prolonged skin contact with liquid toluene may cause drying, fissuring, and dermatitis. Immersing hands and arms in liquid toluene can result in slow skin absorption. Reported experimental rates of toluene absorption through the skin of hands and forearms of workers range from 14 to 23 mg/sq cm/hour.(4) Percutaneous absorption of toluene vapor is not expected to be an industrial problem.

C. EYE CONTACT: Transient irritation may result from exposing the eyes to liquid toluene. Workers accidentally splashed with toluene experienced corneal damage and conjunctival irritation with complete recovery within 48 hours. Mild, transitory eye irritation was experienced by workers exposed to toluene vapors at 200 ppm.(4)

D. INGESTION: No accounts of industrial poisoning resulting from ingestion of toluene were found in the literature. It is reported that leukemia patients administered toluene when it was believed to be an effective treatment, tolerated daily oral doses of ten grams of toluene in olive oil for three weeks without complaints or clinical evidence of side effects.(4)

III. Industrial Hygiene Practice

A. INDUSTRIAL USES AND OCCURRENCE. Toluene was formerly derived solely from coal tar. The major source of toluene today is petroleum and petrochemical processes including catalytic reforming. Toluene is used in the production of benzene and other aromatic compounds, saccharin, dyes, photographic chemicals, and pharmaceuticals. It is found in aviation and motor gasoline and in solvents for paints and coatings. Highly purified toluene containing less than 0.01% benzene is used for commercial purposes; however, commercial grade toluene contained up to 15% benzene years ago. The 90/120 grade may contain as much as 25% benzene.(4)

B. EVALUATION OF EXPOSURE

1. *Sensory Recognition:* Toluene is recognized by its benzene-like odor and may be perceptible at concentrations of 2 to 5 ppm.(7) Sensory recognition is an unreliable evaluation method because of variation of odor threshold among individuals and olefactory fatigue.

2. *Air Sampling and Analysis:* The NIOSH validated compliance method for the determination of toluene vapor in air employs adsorption on charcoal followed by desorption with carbon disulfide (CS_2) and gas chromatographic analysis. Air is pulled through a charcoal tube using a pump with flow rate known to ± 5%. Air moisture decreases the efficiency of toluene adsorption. With a 0.20 L/min sampling rate the method yielded a 0.052 coefficient of variation in the toluene concentration range 145.5 - 582 ppm.(8) A known toluene concentration of 200 ppm sampled at 0.1 L/min yielded a systematic error of 7.4% and precision of 4.5%.(4) Passive dosimeters consisting of charcoal covered by a diffusion membrane are available for organic vapor evaluation. Portable combustible gas meters, flame ionization meters, variable path infrared analyzers and gas chromatographs are acceptable for field use if they are properly calibrated.(4) Bottle and bag grab air samples may be collected and analyzed by gas chromatography or infrared spectrophotometry. Colorimetric detector tubes (reliability to 25 to 35%) are available for approximating toluene concentrations. Long duration colorimetric detector tubes useable with low flow pumps have been recently made available.

3. *Clinical Monitoring:* Clinical monitoring of body fluids may be helpful in evaluating occupational exposure to toluene when used as a supplement to air sampling. A number of studies have correlated urinary hippuric acid levels with occupational exposure to toluene.(4,9,10) A level of 5 g/L hippuric acid in the urine of workers exposed to toluene has

been recommended to correlate with a time-weighted average of 200 ppm toluene in air.(4) The more acceptable procedures for quantitative determination of urinary hippuric acid employ colorimetry, ultraviolet spectrophotometry and fluorometry as analytical methods.(4) Short-comings of this exposure correlation method result from the effect of dietary habits, individual metabolism kinetics and alternate metabolic pathways on urinary hippuric acid levels.(10) Clinical studies have also shown excessive levels of benzoic acid and cresols in the urine of workers exposed to toluene.(4,11) Toluene levels in the blood have been correlated with toluene exposure.(9,12) Earlier literature reported a figure of 2.4 mg toluene per liter of blood to correspond to an exposure of 100 ppm toluene in the environmental atmosphere.(12) Blood analysis has not been used extensively in industrial hygiene for measuring exposure.(10) Experimental studies have correlated the concentrations of a few organic solvent vapors in exhaled air, analyzed by gas chromatography, with inhalation exposure. No accounts of application of the technique to toluene monitoring were found in the literature. However there is some optimism about future application of this technique to organic chemicals. Expected advantages of exhaled air analysis over urine and blood analysis include the probable absence of metabolic effects on the determination, rapid appearance of the chemical in the exhaled breath, and the possibility of rapidly extracting successive breath samples.(10)

C. HAZARDS AND THEIR RECOMMENDED CONTROL

1. *Inhalation:* Engineering controls such as local exhaust ventilation and process isolation should be installed where necessary to keep concentrations of toluene vapor at acceptable levels. While engineering controls are pending and during nonroutine and emergency conditions when toluene levels are unacceptable, NIOSH/MSHA approved respiratory protection must be used. The NIOSH/MSHA recommendation for respiratory protection against toluene vapor concentrations up to 500 ppm is any chemical cartridge respirator with organic vapor cartridge(s), any supplied air respirator, or any self-contained breathing apparatus.(12) However at concentrations below 500 ppm which may result in significant eye irritation to some individuals, full facepiece cartridge respirators, hooded or full-facepiece supplied air respirators and full facepiece self-contained breathing apparatus may be warranted. The NIOSH OSHA minimum recommended protection at 1000 ppm toluene vapor is a full facepiece chemical cartridge respirator with organic vapor cartridge(s). For concentrations up to 2000 ppm, the toluene vapor concentration immediately dangerous to life and health, the recommended respiratory protection includes any of the following: (a) gas mask with chin-style or front - or back - mounted organic vapor canister; (b) any supplied air respirator with full facepiece helmet or hood; (c) any full facepiece self-contained breathing apparatus. For concentrations exceeding 2000 ppm and during entry and escape from unknown concentrations the recommendation is a full facepiece self-contained breathing apparatus operated in positive pressure mode or a full facepiece supplied air respirator equipped with auxilliary self-contained breathing apparatus operated in a positive pressure mode. When there is a potential toluene inhalation exposure while fire fighting, the minimum respiratory protection requirement is a full facepiece self-contained breathing apparatus operated in a positive pressure mode.(13)
2. *Skin Contact:* Drench showers and cleansing facilities must be available in areas where there is potential skin exposure to toluene. Impervious footwear, clothing and gloves must be worn during operations which require continued exposure to liquid toluene. Viton is rated as an excellent protective material. Toluene-wetted clothing which is not impervious should be removed immediately.
3. *Eye Contact:* Eye wash fountains should be provided for emergency use. Shatter resistant eye glasses with side shields or equivalent protection should be worn when there is danger of toluene splash.(4)
4. *Ingestion:* The risk of accidental ingestion is reduced by keeping food and drink outside of areas where toluene is used.
5. *Other Important Hazards:* Toluene can pose a fire hazard when exposed to heat, flame, or oxidizers. Smoking materials must be prohibited from the work area and toluene wetted clothing kept away from heaters, flames, or spark-producing equipment. Make available appropriate fire extinguishers (foam,

- carbon diox[illegible] dry chemical and Halon) Carbon monoxide gas evolves during combustion. A potential explosion hazard exists when toluene is reacted with sulfuric • nitric acid (H_2SO_4 • HNO_3), dinitrogen tetroxide (N_2O_4), and silver perchlorate ($AgClO_4$).(11)

IV. Medical Information

A. FIRST AID PROCEDURES: In case of eye contact, irrigate the eyes with copious amounts of water. If liquid toluene contacts the skin, remove wetted clothing and use drench showers. If toluene is ingested, dilute by administering water or milk if the victim is conscious and not having convulsions. Discontinue dilution if the victim becomes nauseous. Get medical assistance. (Only upon a physician's advice and instruction should activated charcoal be administered or vomiting induced after ingestion of toluene.) If the victim loses consciousness from inhalation or ingestion of toluene, keep the airway open. Administer artificial respiration or cardiopulmonary resuscitation if indicated. Call an emergency squad as soon as possible.(15)

B. MEDICAL MANAGEMENT: Differentiate symptoms from other causes of confused state such as hypoglycemia, hyperglycemia and cerebrovascular accident, transient ischemic episodes, head injury, postepileptic confusion, hysteria, heat stroke, drug abuse, toxic encephalopathy, meningitis, or encephalitis. Blood glucose, rectal temperature and neurologic tests are recommended if signs of central nervous system depression occur.(16) Comprehensive preplacement and periodic medical examinations are recommended for workers subject to toluene exposure. Direct examination with emphasis on central nervous system, liver, and kidney. Complete blood count and urinalysis are recommended.(4)

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Material Safety Data Sheet

From Genium's Reference Collecti[illegible]
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No.

PE[illegible]HLOROETHYLENE
(Revision D)
Issued: November 1978
Revised: August 1988

SECTION 1. MATERIAL IDENTIFICATION

26

Material Name: PERCHLOROETHYLENE

Description (Origin/Uses): Used in commercial dry cleaning and metal-degreasing operations; used to a lesser extent in home products and in veterinary anthelmintics (worming).

Other Designations: Ethylene Tetrachloride; Tetrachloroethylene; C_2Cl_4; CAS No. 0127-18-4

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

0	
2	0
-	

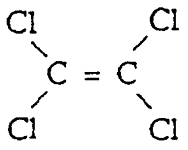
NFPA

HMIS	
H	1
F	0
R	1
PPG*	
*See sect. 8	

R	1
I	3
S	2
K	0

SECTION 2. INGREDIENTS AND HAZARDS

SECTION 2. INGREDIENTS AND HAZARDS	%	EXPOSURE LIMITS
Perchloroethylene, CAS No. 0127-18-4	Ca 100	**OSHA PEL** 8-Hr TWA: 100 ppm Ceiling: 200 ppm Maximum Peak above the Ceiling: 300 ppm for 5 min. in any 3 Hrs **ACGIH TLVs, 1987-88** TLV-TWA: 50 ppm, 340 mg/m³ TLV-STEL: 200 ppm, 1340 mg/m³ **Toxicity Data*** Human, Inhalation, TC_{Lo}: 96 ppm/7 Hrs



*See NIOSH, *RTECS* (No. KX3850000), for additional data with references to reproductive, irritative, tumorigenic, and mutagenic effects.

SECTION 3. PHYSICAL DATA

Boiling Point: 250°F (121°C)
Specific Gravity (H_2O = 1): 1.623
% Volatile by Volume: 100

Water Solubility (%): Insoluble
Molecular Weight: 166 Grams/Mole
Vapor Pressure: 19 Torrs at 77°F (25°C)
Vapor Density (Air = 1): 5.83

Appearance and Odor: A clear, colorless liquid; ethereal odor.

SECTION 4. FIRE AND EXPLOSION DATA

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

Extinguishing Media: *Perchloroethylene does not burn. Use extinguishing agents that will put out the surrounding fire.

Unusual Fire or Explosion Hazards: Perchloroethylene vapor is heavier than air and it collects in low-lying areas such as sumps, wells, and underground piping systems. Enter these low-lying areas with appropriate caution.

Special Fire-fighting Procedures: Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Use care in selecting safety equipment (see sect. 5, Conditons to Avoid).

SECTION 5. REACTIVITY DATA

Perchloroethylene is stable in closed containers during routine operations. It does not undergo hazardous polymerization.

Chemical Incompatibilities: Hazardous chemical reactions involving perchloroethylene and barium, beryllium, or lithium are reported in Genium reference 84, page 491M-208.

Conditions to Avoid: Prevent contact with incompatible chemicals. Avoid exposure to direct sunlight. Monitor the stabilizer level in the perchloroethylene product; get specifications from your supplier for the proper inhibitor levels. This material forms hydrochloric acid (HCl) if the inhibitor level becomes too low. Do not mix perchloroethylene with caustic soda or potash. This material may degrade or attack rubber and some plastics and coatings, so select protective gear and handling equipment carefully.

Hazardous Products of Decomposition: Although perchloroethylene itself does not burn, it can be very hazardous in fires because of thermooxidative degradation at high temperatures to very toxic phosgene and corrosive hydrogen chloride. Electric arcs and perchloroethylene vapor may also produce these products of hazardous decomposition.

SECTION 6. HEALTH HAZARD INFORMATION

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

Summary of Risks: Perchloroethylene affects the central nervous system (CNS), causing incoordination, headache, vertigo, light narcosis, dizziness, unconsciousness, and even death. All of these can occur as the level and duration of exposure continues.

Medical Conditions Aggravated by Long-Term Exposure: None reported. **Target Organs:** CNS, eyes, skin.
Primary Entry: Inhalation, skin. **Acute Effects:** Irritation of the skin, eyes, and upper respiratory tract (URT); CNS effects.
Chronic Effects: None reported.

FIRST AID
Eyes: Immediately flush eyes, including under the eyelids, gently but thoroughly with plenty of running water for at least 15 minutes.
Skin: Immediately wash the affected area with soap and water.
Inhalation: Remove the exposed person to fresh air; restore and/or support his or her breathing as needed.
Ingestion: Never give anything by mouth to someone who is unconscious or convulsing. Do not induce vomiting.

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, provide ventilation, and eliminate all sources of ignition immediately. Cleanup personnel need protection against contact with and inhalation of vapor (see sect. 8). Contain large spills and collect waste or absorb it with an inert material such as sand, earth, or vermiculite. Use nonsparking tools to place waste liquid or absorbent into closable containers for disposal. Keep waste out of sewers, watersheds, and waterways. **Waste Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations
Air Contaminant (29 CFR 1910.1000 Subpart Z)
EPA Designations (40 CFR 302.4)
RCRA Hazardous Waste, No. U210
CERCLA Hazardous Substance, Reportable Quantity: 1 lb (0.454 kg), per Clean Water Act (CWA), section 307 (a) and Resource Conservation and Recovery Act (RCRA), section 3001

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing of perchloroethylene solution may occur, wear a full face shield/splash guard. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Consult the *NIOSH Pocket Guide to Chemical Hazards* for general recommendations on respirator protection. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine use (e.g., cleaning reactor vessels or storage tanks); wear an SCBA with a full facepiece operated in the pressure-demand or positive-pressure mode. Warning: Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, and gauntlets, etc., to prevent prolonged or repeated skin contact with perchloroethylene. Suggested material includes polyvinyl alcohol, polyethylene, or neoprene. Leather shoes are also appropriate.
Ventilation: Install and operate general and local ventilation systems that are powerful enough to maintain airborne levels of perchloroethylene dust below the OSHA PEL standard cited in section 2. **Safety Stations:** Make eyewash stations, washing facilities, and safety showers available in areas of use and handling. **Contaminated Equipment:** Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them. Do *not* wear contact lenses in any work area. Remove contaminated clothing and launder it before wearing it again; clean this material from shoes and equipment.
Comments: Practice good personal hygiene; always wash thoroughly after using this material. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do *not* eat, drink, or smoke in any work area. Avoid inhaling perchloroethylene vapor. Select safety equipment carefully (see sect. 5, Conditions to Avoid).

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store perchloroethylene in a cool, dry, well-ventilated area away from barium, beryllium, and lithium.

Special Handling/Storage: Protect containers from physical damage. Fit all holding tanks with an air-drying venting system that prevents moist air from entering the tank and allows for perchloroethylene vapor expansion and contraction; airtight storage facilities are not recommended. Aluminum is not recommended for storage facilities.

Transportation Data (49 CFR 172.101-2)
DOT Shipping Name: Tetrachloroethylene
DOT ID No. UN1897
DOT Label: None
DOT Hazard Class: ORM-A
IMO Label: Saint Andrew's Cross (X)*
IMO Class: 6.1
*Harmful-Stow away from Foodstuffs (Materials of IMO Class 6.1, Packaging Group III).

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

Prepared by PJ Igoe, BS
Industrial Hygiene Review: DJ Wilson, CIH
Medical Review: MJ Hardies, MD

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HYGIENIC GUIDE SERIES

1,1,1-Trichloroethane

CH_3CCl_3

Significant Physical Properties

1,1,1-Trichloroethane is a volatile, colorless liquid with an aromatic "chloroform-like" odor. The industrial odor threshold is approximately 100 ppm.

Molecular Weight:	133.42
Specific Gravity:	1.3366 (25°/4°C)
Boiling Point:	74.07°C (760 mm Hg)
Vapor Pressure:	125 mm Hg (25°C)
Solubility:	Insoluble in water, but miscible with alcohol, ether and most organic solvents.
At 25°C and 760 mm Hg:	
1 ppm of vapor:	$0.545\ mg/m^3$
$1\ mg/m^3$ of vapor:	0.183 ppm
Saturated air concentration:	16.5%
Relative density of vapor:	4.6 (Air = 1.0)
Relative density of saturated air:	1.6 (Air = 1.0)

I. Hygienic Standards

A. ACCEPTABLE MAXIMUM ATMOSPHERIC CONCENTRATION (8 HOURS) IN PARTS OF VAPOR PER MILLION PARTS OF AIR BY VOLUME (ppm):

1. 400 ppm(1)
2. 350 ppm(2)

B. ACCEPTABLE CEILING CONCENTRATION IN PARTS OF VAPOR PER MILLION PARTS OF AIR BY VOLUME (ppm):

1. 500 ppm(1)

C. ACCEPTABLE MAXIMUM PEAK:

1. 800 ppm by volume for a duration of not more than five minutes if encountered not more than once in two hours during an 8 hour work day.(1)
2. 440 ppm is recommended as a short term exposure limit for 15 minutes by the ACGIH.(2)

D. IMMEDIATE LETHAL CONCENTRATION:

1. An accidental exposure to 2500 ppm of 1,1,1-trichloroethane for five minutes or less would not be expected to cause incapacitation which would prevent escape or cause irreversible injury.

II. Toxic Properties

A. HEALTH: Moderate for acute exposure, but chronic exposures to concentrations that are without acute effects are unlikely to produce injury. 1,1,1-Trichloroethane is readily absorbed and excreted through the lungs.(3) In acute exposure the most important toxic action is a functional depression of the central nervous system leading ultimately to respiratory failure. The inhalation of 1,1,1-trichloroethane can make the mammalian heart abnormally reactive to epinephrine resulting in cardiac arrythmia.(4) Acute exposure to anesthetized dogs results in a dose dependent, biphasic decline in arterial pressure.(5) Animals exposed repeatedly to high concentrations exhibited some

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The Committee wishes to acknowledge the assistance of Donald E. Rapp in the preparation of this Hygienic Guide.

reversible changes in liver histology, but they were not the severe effects associated with carbon tetrachloride. Chronic exposures to 1000 ppm resulted in moderate fatty degeneration of the liver but no liver necrosis or kidney injury. Growth depression occurred at 650 ppm. No effects were seen from repeated 7-hour daily exposures to 500 ppm. A 24 month inhalation study on rats at 875 ppm and 1750 ppm did not indicate carcinogenic activity.(6) Humans exposed to a vapor concentration of 450 ppm did not show decreased psychophysiological functions (perception, reaction test, manual dexterity).(7) In controlled human exposures to 500 ppm no effects other than slight, transient eye irritation were noted, but at 1,000 ppm and above, mild eye irritation was experienced by all subjects, and some became dizzy.(8,9) As with most solvents, dermatitis might result from repeated skin contact, but 1,1,1-trichloroethane is only poorly absorbed through the skin. Eye contact may result in pain and discomfort, but no impairment of vision is likely.

B. FIRE: 1,1,1-Trichloroethane has no flash point when tested by standard ASTM procedures for the TAG Closed or Cleveland Open Cup Tests. Some inhibited 1,1,1-trichloroethanes have been found to have explosive limits of 6.7% - 17.2% in air, but a high energy source is required to cause ignition and, if the ignition source is removed, the vapor will not continue to burn.(8) When inhibited products are evaporated to a small volume the residue may flash. Thermal decomposition products are very irritating and may be quite toxic, but voluntary overexposure to such materials (largely hydrogen chloride)(10) is not likely. Flammable properties of the commercially available solvent depends to a large extent upon the type and amount of the inhibitors.

C. SHORT EXPOSURE TOLERANCE: Beginning anesthetic effects, including incoordination, appear in some human subjects exposed to concentrations of 800 to 1,000 ppm. They occur quickly in humans at concentrations of 2,000 ppm or higher. Exposures to concentrations in excess of 30,000 (3% by volume) may be lethal in five to six minutes.(11)

D. ATMOSPHERIC CONCENTRATION IMMEDIATELY HAZARDOUS TO LIFE: 30,000 ppm (3% by volume) based on animal experiments.(9,11)

III. Industrial Hygiene Practice

A. INDUSTRIAL USES AND OCCURRENCES:

1,1,1-Trichloroethane is used as a solvent and as a vapor degreasing and cold cleaning agent.

B. EVALUATION OF EXPOSURE:

1. *Sensory Recognition:* The industrial odor threshold varies widely among individuals. Response can range from barely detectable to definitely apparent to the unacclimated. It appears to be approximately 100 ppm. It is slight, but not unpleasant at about 350 ppm, and considered strong and unpleasant at about 1,500 ppm.(12)

2. *Air Sampling and Analysis:*

   a. *Instrumentation:* Instruments based on the Beilstein test, such as the halide meter(13) and halide leak detector, may be calibrated for 1,1,1-trichloroethane. Instruments employing measurement of the conductivity of water which has absorbed the combustion products of this material are available, and those using hydrogen flame ionization, while almost completely non-specific, can probably be used. Gas chromatographic, infrared, and mass spectrographic methods can be used, especially when absolute identification is necessary.

   b. *Chemical Analysis:* Direct combustion followed by absorption in a basic, reducing solution and determination of the halide ion has been used successfully,(14) as has adsorption in silica gel followed by thermal desorption and combustion.(15) The method of Fahy(16) using isopropyl alcohol to desorb from silica gel, followed by alkaline hydrolysis, is said to be applicable.(17) A modified Fujiwara reaction may be used.(18) Detector tubes by various manufacturers can be used, but each batch should be separately calibrated before use.

C. HAZARDS AND THEIR RECOMMENDED CONTROL:

1. *Inhalation:* This is the primary hazard. Control should be to 350 ppm on an 8 hour time-weighted average basis.

2. *Skin Contact:* Minor irritation may occur as a result of prolonged or frequent exposure if confined to the skin, irritation and/or a burn may result. Suitable protective gloves should be worn to prevent liquid contact with solvent. Gloves made of

poly[illegible]alcohol or Neoprene may be appropriate.

3. *Eye Contact:* Mild irritation may result through contact, but essentially no corneal injury. Safety glasses, or their equivalent, should be worn if contact is likely.
4. *Ingestion:* Low toxicity. Based on animal data, it is estimated from one-half to one pint for a 150 pound person. All containers should be properly labeled.
5. *Aluminum Reaction:* Non-inhibited 1,1,1-trichloroethane should not be used in contact with aluminum because of its reactivity with this metal.
6. *Thermal Decomposition:* Halogenated solvents should not be used where their vapors (in concentrations of a few ppm or more) will come into contact with very hot surfaces (such as near a welding operation) because toxic decomposition products, such as chlorine and hydrogen chloride, may be formed. In such cases, local exhaust ventilation will be necessary.

IV. Medical Information

A. ROUTE OF EXPOSURE AND FIRST AID:

1. *Inhalation:* Remove to fresh air. If breathing has stopped, give artificial respiration. Mouth to Mouth is the most effective method. Keep warm and quiet. Obtain help at once.
2. *Skin Contact:* Remove any soaked clothing. Flush skin with running water.
3. *Eye Contact:* Flush eyes thoroughly with plenty of water.
4. *Ingestion:* No specific antidote known. Do not induce vomiting. Obtain medical assistance promptly.

B. MEDICAL MANAGEMENT:

1. *Specific Medical Procedures:* Treat symptomatically; watch the cardiac rhythm in any case of anesthesia. Oxygen therapy may be used, but epinephrine is contraindicated. Some indication of the extent of exposure may be obtained from an analysis of exhaled air. If heart has stopped, closed chest cardiac massage may be [illegible]. Urinary urobilinogen may be of interest as a liver function test following acute excessive exposures. Recovery from a non-fatal acute episode can be expected to be complete and prompt.

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1. American National Standards Institute: (ANSI), Z37.26-1970, New York (1970).
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6. Dow Chemical Company Interim Report.
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HYGIENIC GUIDE SERIES

TRICHLOROETHYLENE [79-01-6]
(1,1,2-Trichloroethylene, Tri, TCE, Acetylene Trichloride)
CCl_2CHCl

Significant Physical Properties

Trichloroethylene is a nonflammable, colorless liquid with a sweet odor that is typical of many chlorinated solvents.

Molecular weight:	131.40
Melting point:	-73°C
Boiling point:	87.1°C at 760 mm Hg
Vapor pressure:	mm Hg: 100.00 / 74.3 / 10.0 / 1.0 °C: 31.5 / 25.0 / -11.8 / -42.9
At 25°C and 760 mm Hg:	Saturated air contains 9.78% by volume of trichloroethylene Relative density of saturated air = 1.34 (air = 1.0) 1 ppm = 5.38 mg/m^3 1 mg/m^3 = 0.186 ppm
Flash point:	None by standard methods
Autoignition temperature:	463°C
Explosive limits:	8.0 - 10.0% at 25°C*
Specific gravity:	1.465 20/4°C**
Solubility:	0.1 part per 100 parts H_2O at 25°C; miscible with alcohol, ether, many hydrocarbons, and oils
Incompatabilities:	Strong caustics; aluminum (when acidic), chemically active metals

*Note as temperature rises the flammable range widens (e.g., 7.0-43% at 100°C).

**The ratio of the density of trichloroethylene at 20°C to that of water at 4°C.

I. Hygienic Standards

A. WORKDAY EXPOSURE CONCENTRATIONS:

1. American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV)* is 50 parts per million (ppm) by volume, or 270 mg/m^3, for an 8-hr time-weighted average (TWA) exposure.[1]
2. American National Standards Institute (ANSI) recommends a 100 ppm (540 mg/m^3) TWA exposure limit for an 8-hr workday.[2]
3. Occupational Safety and Health Administration (OSHA) adopts an 8-hr TWA permissible exposure limit of 100 ppm (540 mg/m^3).
4. National Institute for Occupational Safety and Health (NIOSH) recommends a 100 ppm TWA exposure limit for an 8-hr workday.[3]

B. SHORT-TERM EXPOSURE CONCENTRATIONS:

1. ACGIH recommends a 15 min TWA exposure limit of 200 ppm (1080 mg/m^3).[1]

The Committee wishes to acknowledge Ching K. Chen, Ph.D., PE, CIH for the preparation of this guide.

2. ANSI recommends a limit of 300 ppm (1620 mg/m^3) for not more than 5 min in any 2-hr period for an 8-hr workday.(2)
3. OSHA establishes a limit of 300 ppm for not more than 5 min in any 2-hr period for an 8-hr shift.

C. CEILING CONCENTRATION:

1. NIOSH recommends a ceiling exposure limit of 150 ppm for a 15-min sampling time and a peak exposure limit of 300. ppm.(3)
2. ANSI recommends an exposure limit of 200 ppm.(2)
3. OSHA adopts a ceiling limit of 200 ppm.

D. IMMEDIATE LETHAL CONCENTRATION:

1000 ppm (5380 mg/m^3) is considered to be the level immediately dangerous to life or health (IDLH), a maximum level from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects.(4)

II. Toxic Properties

The primary toxic effect of exposure to trichloroethylene vapor is one of central nervous system depression. Acute exposure may cause visual disturbances, mental confusion, fatigue, headache, nausea and vomiting. Liquid trichloroethylene may irritate the skin and eyes. In bioassay studies, trichloroethylene introduced by gavage has been found to cause liver cancer in mice.

A. INHALATION: Exposure of rats and mice to trichloroethylene at concentrations in excess of 3000 ppm resulted in immediate narcosis or death after 1 or 6 hours exposure.(3) In acute human exposures, central nervous system depression is the predominant physiological response. In fact, trichloroethylene was once used as an anesthetic.(5) The characteristics of central nervous system depression from overexposure to trichloroethylene include headache, dizziness, vertigo, tremors, nausea and vomiting, sleepiness or drowsiness, fatigue, light headedness, intoxication, unconsciousness and death in some cases.(6-8) Headache, drowsiness and mild eye irritation were reported by human subjects who were exposed to 160 ppm for 83 minutes or 200 ppm for 7 hours.(9) Neurologic changes may result from prolonged overexposure;(10) such exposures may also cause injury to the liver, but the liver injury is likely to be minor or not present at all.(11,12) As with other chlorinated hydrocarbons, trichloroethylene exposure can produce ventricular arrhythmias. Although this effect is not common, cases of sudden death after severe overexposure to trichloroethylene have been reported, possibly caused by ventricular arrhythmias.(6,16) The combination of high trichloroethylene exposure and the consumption of alcoholic beverages has been known to produce erythema (known as "degreasers flush"). Deliberate inhalation of trichloroethylene vapor, often reported as addiction, has resulted in injury and death.(17)

B. SKIN CONTACT: Trichloroethylene has a defatting action on the skin and dermatitis may result from repeated contact with the liquid or with high concentrations of the vapor. It is not absorbed through the skin in acutely toxic amounts, but some absorption can occur.(9,18)

C. EYE CONTACT: Trichloroethylene is irritating to the eyes. If promptly washed away, it is not expected to cause permanent injury.(17)

D. INGESTION: Trichloroethylene is absorbed readily from the gastrointestinal tract leading to respiratory failure or cardiac arrest causing death. Depending on the dose, signs and symptoms of toxicity may be delayed for several hours.(19) The LD$_{50}$ for the rat given a single oral dose of trichloroethylene is about 4.9 gram per kilogram of body weight (gm/kg).(20)

E. CARCINOGENICITY: The National Cancer Institute reported that trichloroethylene is a potent liver carcinogen in mice based on its bioassay involving rats and mice.(21) In this study, the test animals were intubated with trichloroethylene daily for 18 months with an observation period of 3 to 6 months following treatment. Rats were given doses of 500 or 1000 mg/kg and mice were given 900 to 2400 mg/kg, five times per week. Hepatocellular carcinomas were not seen in rats but were seen in 30.6 percent of mice given the lower dose and 43.2 percent of mice given the higher dose. Only 2.5 percent of control mice developed such carcinomas, though the strain of mice used often has a 40% background incidence for such carcinomas. In an inhalation study, rats, mice and Syrian hamsters were exposed 6 hr/day, 5 days/week for 18 month to up to 500 ppm of pure trichloroethylene; no conclusive evidence of carcinogenic potential was found.(17) There has been no published report linking trichloroethylene and cancer in humans.

III. Industrial Hygiene Practices

A. INDUSTRIAL USES AND OCCURRENCE

Trichloroethylene is used primarily (90% of total U.S. consumption) as a solvent in vapor degreasing operations of metal fabricating industries, such as automotive, aircraft and aerospace industries. Approximately 5% of the [illegible] consumption of trichloroethylene is used as a drycleaning solvent for fabrics or as an extractive solvent of foods and medicines. The remaining 5% is used in a variety of operations which use trichloroethylene as a solvent or chemical intermediate. NIOSH has estimated that there are 200 000 workers exposed to trichloroethylene in the United States.(6)

B. EVALUATION OF EXPOSURE:

1. *Sensory Recognition:* Trichloroethylene has a sweet "chlorinated hydrocarbon" odor which is barely perceptible at 60 to 100 ppm.(2) The odor is not unpleasant at 250 ppm. Transient, mild eye irritation occurs at 160 ppm, and lightheadedness occurs between 350 and 400 ppm. Prolonged exposures to concentrations between 200 and 500 ppm cause a mild irritation of the respiratory tract. Repeated prolonged exposures at 200 ppm cause a feeling of fatigue and sleepiness.(9)

2. *Air Sampling and Analysis:* Means of collecting trichloroethylene in air include use of an evacuated gas sampling container, plastic bags, solid adsorbents such as silica gel or activated charcoal, and impingers containing an appropriate absorptive organic liquid. Use of activated charcoal offers the greatest efficiency and ease of collection of trichloroethylene vapors and is recommended in method S 336 by NIOSH.(22) Gas chromatography offers the greatest specificity and sensitivity of the various methods of analysis and is the method specified in S 336. With this method, the collected sample is desorbed with carbon disulfide and analyzed by gas chromatography with a flame ionization detector. The method was validated over a range of 519 to 2176 mg/m^3 (100 to 400 ppm) with a 3 liter air sample; though the probable useful range of detection is reported to be 108 to 3225 mg/m^3 (20 to 600 ppm).

3. *Clinical Monitoring:* Studies show that from 51 to 70% of the inhaled trichloroethylene vapors are retained by the body. Animal studies show the greatest trichloroethylene concentration in the fat, followed by the lungs, spleen, liver and the least in the brain and kidney. The retained trichloroethylene is metabolized to monochloroacetic acid, trichloroethanol and trichloroacetic acid.(23-25) The monochloroacetic acid excretion is maximal at the end of exposure; the trichloroethanol excretion is maximal within 24 hrs after exposure; the trichloroacetic acid excretion [illegible] maximum within 2 to 3 days after exposure. Trichloroethylene has been detected in the expired air for several hours following exposure.(26) Although studies show that biological monitoring can be used as an index of exposure, the monitoring test cannot be used to determine the exposure concentration because of the dependency upon several factors (e.g., retention percentage in the body, metabolism rates and routes, duration of exposure, fluctuations in concentration during exposure, time interval between end of exposure and the test, the accumulative effect from repeated exposures, and sex of the subject).

C. HAZARDS AND THEIR RECOMMENDED CONTROL.

1. *Inhalation:* Since the main route of hazardous overexposure to trichloroethylene is by the inhalation of vapor, local exhaust ventilation and enclosure of process equipment are usually required. Control should be verified by periodic air analyses. Vapor degreasing tanks should not be used without heat and vapor condensation controls. Instructions for commercial cleaners and degreasers should be rigidly followed. If the liquid or even a few ppm of the vapor are exposed to high temperatures (e.g., welding) toxic decomposition products (largely hydrogen chloride, but including phosgene and others) may be formed.(27)

2. *Skin Contact:* Gross skin contact should be prevented. Clothing wet with trichloroethylene should be removed and not worn until completely decontaminated. Use polyvinyl alcohol gloves for protection of hands against direct contact.

3. *Eye Contact:* Chemical splash goggles should be worn if the possibility of contact exists.

4. *Ingestion:* While swallowing substantial quantities of trichloroethylene could cause serious effects, this is not considered to be a problem in normal industrial handling.

5. *Fire and/or Explosion:* High concentrations of trichloroethylene vapor exposed to an energetic source of ignition (welding is a good example) may propagate flame and/or explode. Equipment containing (or that has contained) trichloroethylene should be thoroughly dried and ventilated before being exposed to an ignition source.

6. *Respirator Selection Guide:*

Concentration Condition	Minimum Respiratory Protection
250 ppm or less	Half-mask organic vapor cartridge respirator
1000 ppm or less	Full-facepiece organic vapor cartridge respirator
Greater than 1000 ppm (IDLH Level)	Supplied air respirator with full facepiece
Escape	Self-contained breathing apparatus with full facepiece operated in pressure-demand mode.

IV. Medical Information

A. FIRST AID PROCEDURE: Remove the victim to an uncontaminated atmosphere immediately and apply artificial respiration if indicated. Remove contaminated clothing and do not allow it to be reworn until it is thoroughly decontaminated. If eyes come in contact with the substance, they should be flushed with large amounts of water.

B. MEDICAL MANAGEMENT: Treat symptomatically, watch the cardiac rhythm in any case of anesthesia produced by trichloroethylene. Oxygen therapy may be used, but vasopressor drugs such as epinephrine are contraindicated. Severely overexposed personnel should be hospitalized for observation and supportive therapy. Persons suffering from cardiac, lung, liver and/or kidney disease and/or alcoholism should not be employed on jobs where there may be substantial exposure to trichloroethylene.

V. References

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APPENDIX B

STANDARD SAFE WORK PRACTICES

STANDARD SAFE WORK PRACTICES

1. GENERAL

1. Eating, drinking, chewing gum or tobacco and smoking are prohibited in the contaminated or potentially contaminated area or where the possibility for the transfer of contamination exists.

2. Avoid contact with potentially contaminated substances. Do not walk through puddles, pools, mud, etc. Avoid, whenever possible, kneeling on the ground, leaning or sitting on equipment or ground. Do not place monitoring equipment on potentially contaminated surface (i.e. ground, etc.).

3. Prevent, to the extent possible, spillage. In the event that a spillage occurs, contain liquid, if possible.

4. Prevent splashing of contaminated materials.

5. All field crew members shall make use of their sense (all senses) to alert them to potentially dangerous situations in which they should not become involved (i.e. presence of strong, irritating or nauseating odors).

6. Field crew members shall be familiar with the physical characteristics of investigations, including:

   - Wind direction in relation to the ground zero area;
   - Accessibility to associates, equipment, vehicles;
   - Communications;
   - Hot zone (areas of known or suspected contamination);
   - Site access;
   - Nearest water sources.

7. The number of personnel and equipment in the contaminated area should be minimized, but only to the extent consistent with workforce requirements of safe site operation.

8. All wastes generated during D&M and/or subcontractor activities at the site will be disposed of as directed by the PM.

2. DRILLING AND SAMPLING PROCEDURES

For all drilling and sampling activities, the following standard safety procedures shall be employed:

1. All drilling and sampling equipment shall be cleaned before proceeding to the site.

2. At the drilling or sampling site, sampling equipment shall be cleaned after each use.

3. Work in "cleaner" areas should be conducted first where practical.

4. The minimum number of personnel necessary to achieve the objectives shall be within 25 feet of the drilling or sampling activity.

5. If emergency and back-up subcontracted personnel are at the site, they should remain 25 feet from the drilling or sampling activity, where practical.

6. Exclusion zones will be established within designated hot lines. Delineation of a hot line will reflect the interface between areas at or below a perdetemined threshold contaminant concentation, based on available data including the results of monitoring and chemical analyses, information from site personnel regarding historical site activities, and general observations. This determination will be made by the PM in conjunction with the OSSO and site personnel.

APPENDIX C

CONTACTS AND PROCEDURES

CONTACTS AND PROCEDURES

1. CONTACTS

Should any situation of unplanned occurrence require outside or support services, the appropriate contacts should be made. The list of appropriate contacts is listed in Section 4 of the Health and Safety Plan.

2. PROCEDURES

In the event that an emergency develops on-site, the procedures delineated herein are to be immediately followed. Emergency conditions are considered to exist if:

- o Any member of the field crew is involved in an accident or experiences any adverse effects or symptoms of exposure while on-site; or
- o A condition is discovered that suggests the existence of a situation more hazardous than anticipated.

The following emergency procedures should be followed:

A. Personnel on-site should use the "buddy system" (pairs). Buddies should pre-arrange hand signals or other means of emergency signals for communication in case of lack of radios or radio breakdown (see the following item).

  - o Hand gripping throat: out of air, can't breathe.
  - o Grip partner's wrist or place both hands around waist: leave area immediately, no debate.
  - o Hands on top of head: need assistance.
  - o Thumbs up: okay, I'm alright, I understand.

o -Thumbs down: no, negative.

B. Site work area entrance and exit routes should be planned, and emergency escape routes delineated by the OSSO.

C. Visual contact should be maintained between "pairs" on-site with the team remaining in close proximity in order to assist each other in case of emergencies.

D. In the event that any member of the field crew experiences any adverse effects of symptoms of exposure while on-site, the entire field crew should immediately halt work and act according to the instructions provided by the OSSO.

E. Wind indicators visible to all on-site personnel should be provided by the PM to indicate possible routes for upwind escape.

F. The discovery of any condition that would suggest the existence of a situation more hazardous than anticipated should results in the evacuation of the field team and re-evaluation of the hazard and the level of protection required.

G. In the event that an accident occurs, the PM is to complete an Accident Report Form for submittal to the Office Safety Coordinator (OSC), who will forward a copy to the RHSM and the FWHSD. The OSC should assure that the follow-up action is taken to correct the situation that caused the accident.

H. In the event that an accident occurs, the PM is to complete an Accident Report Form for submittal to the MPIC of the office, with a copy to the health and safety program office. the MPIC should assure that follow-up action is taken to correct the situation that caused the accident.

APPENDIX D

RESPONSIBILITIES

RESPONSIBILITIES

1. PROJECT MANAGER

The Project Manager (PM) shall direct on-site investigations and operational efforts. The PM, assisted by the On-Site Safety Officer (OSSO), has primary responsibility for:

1. Making certain that appropriate personnel protective equipment and monitoring equipment is available and properly utilized by all on-site personnel;

2. Making certain that personnel receive this plan and are aware of the provisions of this plan, are instructed in the work practices necessary to ensure safety, and are familiar with planned procedures for dealing with emergencies;

3. Making certain all field personnel have had the Dames & Moore Core Health and Safety Training Course or its equivalent;

4. Making certain that personnel are aware of the potential hazards associated with site operations;

5. Monitoring the safety performance of all personnel to ensure that the required work practices are employed;

6. Correcting any work practices or conditions that may result in injury or exposure to hazardous substances;

7. Preparing any accident/incident reports (see attached Accident Report Form) and routine job exposure records;

8. Assuring the completion of Plan Acceptance and Feedback Forms attached hereto.

2. ON-SITE SAFETY OFFICER

The On-Site Safety Officer (OSSO) shall:

1. Implement project Health & Safety Plans and report to the Site Safety Coordinator and the PM for action if any deviations from the anticipated conditions described in the plan and has the authorization to stop work at any time;

2. Calibrate all monitoring equipment (except radiation detection equipment) on a daily basis and record results on the attached sheets; (See Section 7.0 - Daily Instrument Calibration Check Sheet and Daily Radiation Instrument Operability Check Sheet.)

3. Making certain that all monitoring equipment is operating correctly according to manufacturers instructions and provide maintenance if it is not;

4. Confirm that personnel working on-site have the proper medical surveillance program and Health & Safety training which qualifies them to work at a hazardous waste site. Also be responsible for identifying all WMS site personnel with special medical problems (i.e. allergies).

3. PROJECT PERSONNEL

Project personnel involved in on-site investigations and operations are responsible for:

1. Taking all reasonable precautions to prevent injury to themselves and to their fellow employees;

2. Performing only those tasks that they believe they can do safely, and immediately reporting any accidents and/or unsafe conditions to the OSSO;

3. Notifying the PM and OSSO of any special medical problems (i.e. allergies) and making certain that all on-site personnel are aware of any such problems.

APPENDIX E

HEAT STRESS/COLD STRESS

HEAT STRESS/COLD STRESS

HEAT STRESS

If site work is to be conducted during the summer or in other hot environments, heat stress is a concern in the health and safety of personnel. For workers wearing permeable clothing, follow recommendations for monitoring requirements and suggested work/rest schedules in the current American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values for Heat Stress. For workers wearing semipermeable or impermeable clothing, the ACGIH standard cannot be used. For these situations, workers should be monitored when the temperature in the work area is above 70°F (21°C).

To monitor the worker, measure:

- Heart rate. Count the radial pulse during a 30-second period as early as possible in the rest period.

  If the heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle by one-third and keep the rest period the same.

  If the heart rate still exceeds 110 beats per minute at the next rest period, shorten the following work cycle by one-third.

- Oral temperature. Use a clinical thermometer (3 minutes under the tongue) or similar device to measure the oral temperature at the end of the work period (before drinking).

  If oral temperature exceeds 99.6°F (37.6°C), shorten the next work cycle by one-third without changing the rest period.

100.6°F (38.

o Body water loss, if possible. Measure [illegible] accurate to ±0.25 lb at the beginning and [illegible] to see if enough fluids are being taken [illegible] Weights should be taken while the [illegible] clothing or, ideally, is nude. The body [illegible] exceed 1.5 percent total body weight loss [illegible]

Initially, the frequency of physiological [illegible] the air temperature adjusted for solar radiation [illegible] (see following Table). The length of [illegible] physical work (see following Table). The length of [illegible] be governed by the frequency of the required physiological [illegible]

SUGGESTED FREQUENCY OF PHYSIOLOGICAL MONITORING FOR FIT AND ACCLIMATIZED WORKERS

ADJUSTED TEMPERATURE(1)	NORMAL WORK ENSEMBLE	IMPERMEABLE ENSEMBLE
90°F (32.2°C) or above	After each 45-min of work	After each 15 min of work
87.5°-90°F (30.8°-32.2°C)	After each 60 min of work	After each 30 min of work
82.5°-87.5°F (28.1°-30.8°C)	After each 90 min of work	After each 60 min of work
77.5°-82.5°F (25.3°-28.1°C)	After each 120 min of work	After each 90 min of work
72.5°-77.5°F (22.5°-25.3°C)	After each 150 min of work	After each 120 min of work

(1) Calculate the adjusted air temperature (ta adj) by using this equation: ta adj °F = ta °F + (13 x % sunshine). Measure air temperature (ta) with a standard mercury-in-glass thermometer, with the bulb shielded from radiant heat. Estimate percent sunshine by judging what percent time the sun is not covered by clouds that are thick enough to produce a shadow. (100 percent sunshine = no cloud cover and a sharp, distinct shadow; 0 percent sunshine = no shadows.)

If workers are not monitored for heat stress, work activities in hot environments can result in dehydration, heat exhaustion, heat stress or even heat stroke.

Signs and Symptoms of Heat Stress

- **Heat rash** may result from continuous exposure to heat or humid air.

- **Heat cramps** are caused by heavy sweating with inadequate electrolyte replacement. Signs and symptoms include:
  - -- muscle spasms
  - -- pain in the hands, feet and abdomen.

- **Heat exhaustion** occurs from increased stress on various body organs including inadequate blood circulation due to cardiovascular insufficiently or dehydration. Signs and symptoms include:
  - -- pale, cool, moist skin
  - -- heavy sweating
  - -- dizziness
  - -- nausea
  - -- fainting

- **Heat stroke** is the most serious form of heat stress. Temperature regulation fails and the body temperature rises to critical levels. Immediate action must be taken to cool the body before serious injury and death occur. Competent medical help must be obtained. Signs and symptoms are:
  - -- red, hot, usually dry skin
  - -- lack of or reduced perspiration
  - -- nausea
  - -- dizziness and confusion
  - -- strong, rapid pulse
  - -- coma

COLD STRESS

Frost Bite

Frostbite is an injury resulting from exposure to cold. The extremities of the body (fingers, toes) are most often affected. The signs of Frostbite are:

- Skin turns white or grayish-yellow.

- Pain is sometimes felt early, but subsides later. Often there is no pain.

- The affected part feels intensely cold and numb.

Hypothermia

If site work is to be conducted during the winter, cold stress is a concern in the health and safety of the personnel. Additional insulated clothing will be provided to field personnel. Of special note for cold stress on this site is the wearing of tyvek suits. Disposable clothing does not breath; therefore, perspiration is not provided with a means of evaporation. During strenuous physical activity, an employee's clothes can become wet. Wet clothes combined with cold temperatures can lead to hypothermia. If the air temperature is less than $40^{o}F$ and an employee becomes wet, the employee must change to dry clothes. The on-site heated trailer facility or a personnel vehicle may be utilized as a change area.

Hypothermia is characterized by shivering, numbness, drowsiness, muscular weakness and a low internal body temperature when the body feels warm externally. This can lead to unconsciousness and death.

In either case (frostbite or hypothermia), seek immediate medical attention.

To prevent these effects from occurring, persons working in cold environments should wear adequate clothing and reduce the time spent in the cold area.

APPENDIX F

FORMS

PLAN ACCEPTANCE FORM

PROJECT HEALTH AND SAFETY PLAN

INSTRUCTIONS: This form is to be completed by each person to work on the subject project work site and returned to the Office Safety Coordinator.

Job No.:__________________________

Client/
Project:____

Date:____________________________

I represent that I have read and understand the contents of the above referenced Health & Safety Plan and agree to perform my work in accordance with it.

____
Signed

____
Print Name

____
Company/Office

____
Date

PLAN FEEDBACK FORM

Job Number: ____________________

Job Name: ____________________

Date: ____________________

Problems with plan requirements:

Unexpected situations encountered:

Recommendations for future revisions:

Contractor/Subcontractor
Statement of Compliance

This is to confirm that the employees listed below are qualified by virtue of training and experience to engage in field activities at ______________________________
Name of Site

in connection with the Contract/Subcontract Agreement between Dames & Moore and ______________________________, dated ______________, 19__________.
Company Name

Further, all said employees have been determined to be properly trained and medically fit to perform those field activities prescribed by said contract and to utilize the respiratory protective equipment necessary to perform the job safely in accordance with Title 29 of the Code of Federal Regulations, Parts 1910 and 1926 and any other Federal, State or local requirements applicable.

Employee Names

1. ______________________________	6. ______________________________
2. ______________________________	7. ______________________________
3. ______________________________	8. ______________________________
4. ______________________________	9. ______________________________
5. ______________________________	10. ______________________________

____
Authorized Subcontractor
Representative

____
Printed Name

ON-SITE SAFETY MEETING

Project

Date Time Job No.

Address

Specific Location

Type of Work

SAFETY TOPICS PRESENTED

Protective Clothing/Equipment

Chemical Hazards

Emergency Procedures

Hospital/Clinic Phone

Hospital Address

Special Equipment

Other

ATTENDEES

Name Printed	Signature

Meeting Conducted By: Name Printed Signature

Site Safety Officer Team Leader

DAILY INSTRUMENT CALIBRATION CHECK SHEET

INSTRUMENT: ______________________________

SERIAL # ______________________________

DATE	PURE AIR Y/N	CALIBRATION GAS (PPM)	BATTERY CHECK (GOOD/BAD)	CALIBRATED BY	REMARKS

AIR MONITORING

GENERAL INFORMATION

Name(s): ______________________

Date: ______________________

Time: ______________________

Project: ______________________

Job No: ______________________

Background Level: ______________

Weather Conditions: ______________
____
____

Estimated Wind Direction: ______________________________

Estimated Wind Speed (i.e., calm, moderate, strong, etc): ______________________

Estimated Air Temperature and % Relative Humidity: ______________________

Location Where Background Level Was Obtained: ______________________

EQUIPMENT SETTINGS

HNU

Range: ______________________

Span Pot: ______________________

Calibration GAs: ______________

EXPLOSIMETER

Alarm Trigger-%LEL : ______________

Alarm Trigger-%02 : ______________

Calibration GAs: ______________

FIELD ACTIVITIES

Field Activities Conducted: ______________________________________

____

		EXPLOSIMETER			
TIME	HNU	%LEL	%02	DRAGER TUBE	RADIATION METER
	Equivalent			ppm-constituent	

PROJECT EXPOSURE HISTORY FORM
(To Be Completed by Project Manager)

JOB NAME: ____________________

JOB NUMBER: ____________________

DATES FROM/TO: ____________________

D&M PERSONNEL ON SITE:

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________

SUSPECTED CONTAMINANTS	VERIFIED CONTAMINANTS AND AIRBORNE CONCENTRATION THEREOF

ACCIDENT REPORT FORM

SUPERVISOR'S REPORT OF ACCIDENT	DO NOT USE FOR MOTOR VEHICLE OR AIRCRAFT ACCIDENTS

TO	FROM TELEPHONE (include area code)

NAME OF INJURED OR ILL EMPLOYEE

DATE OF ACCIDENT	TIME OF ACCIDENT	EXACT LOCATION OF ACCIDENT

NARRATIVE DESCRIPTION OF ACCIDENT

NATURE OF ILLNESS OR INJURY AND PART OF BODY INVOLVED

LOST TIME
YES ☐ NO ☐

PROBABLE DISABILITY (Check One)

FATAL ☐	LOST WORK DAY WITH ___ DAYS AWAY FROM WORK ☐	LOST WORK DAY WITH ___ DAYS OF RESTRICTED ACTIVITY ☐	NO LOST WORK DAY ☐	FIRST AID ONLY ☐

CORRECTIVE ACTION TAKEN BY REPORTING UNIT

CORRECTIVE ACTION WHICH REMAINS TO BE TAKEN (by whom and by when)

NAME OF SUPERVISOR	TITLE
SIGNATURE	DATE