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POST ACCIDENT PROCEDURES FOR CHEMICALS AND PROPELLANTS

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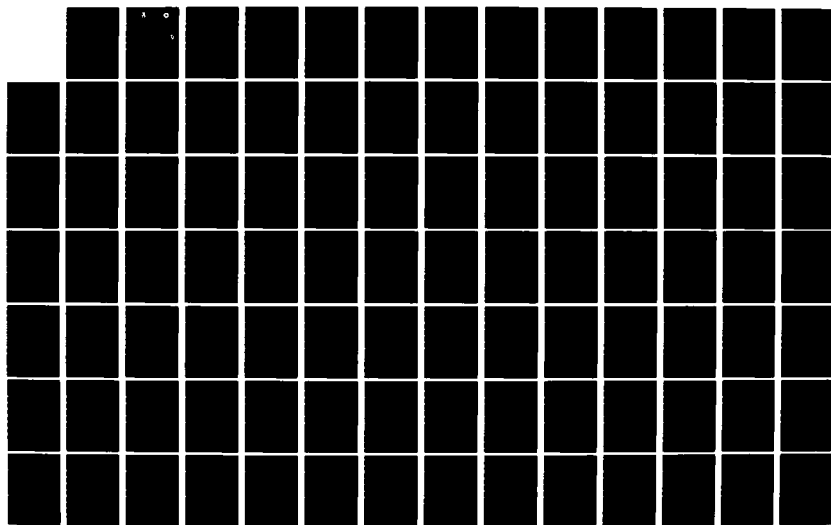
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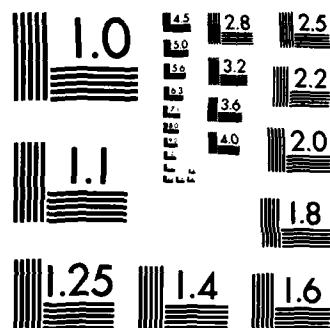
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Report F04611-80-C-0046



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POST ACCIDENT PROCEDURES FOR CHEMICALS AND PROPELLANTS

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Prepared for

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PREFACE

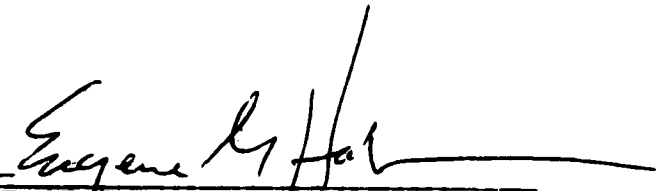
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This technical report has been reviewed and is approved for publication.

FOR THE DIRECTOR


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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report presents production volumes, storage capacities, shipment quantities, containers used for highway and rail shipments, general commodity flow patterns and disposal sites and capabilities for 12 hazardous materials; an overview of emergency response guidelines and resources available to selected industry groups and state and local agencies; a review of the CHRIS, EPA, AAR, and DOT emergency response systems as they specifically apply to the 12 hazardous materials; a review of 16 NTSB investigated rail and highway accidents involving these hazardous materials; a discussion of six spill scenarios, the		

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philosophy behind their development and their applicability to community planning; a discussion of the USCG HACS, Shell R&D Spills, AF statistical/empirical, DDESB Chemical Hazard Slide Rule and an overview of dense gas vapor dispersion models, the assumptions basic to each and their applicability to transportation spills; criteria which are needed for developing improved and innovative guidelines to mitigate hazards associated with response activities at hazardous materials transportation accidents; and a discussion of state-of-the-art means for physically lifting derailed cars and containers.

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LIST OF ACRONYMS

AAR	-	Association of American Railroads
AE	-	Acoustic Emission
AFB	-	Air Force Base
AFCRL	-	Air Force Cambridge Research Laboratories
BE	-	AAR Bureau of Explosives
BLEVE	-	Boiling Liquid Expansion Vapor Explosion
CCC	-	Communications Coordination Center
CFR	-	Code of Federal Regulations
CHEMTREC	-	Chemical Transportation Emergency Center
CHRIS	-	Chemical Hazards Response Information System
CMA	-	Chemical Manufacturers Association
DDESB	-	Department of Defense Explosives Safety Board
DOD	-	U.S. Department of Defense
DOT	-	Department of Transportation
EPA	-	Environmental Protection Agency
HACS	-	USCG Hazard Assessment Computer System
HM	-	Hazardous Material

LIST OF ACRONYMS (cont'd)

IR	-	Infrared
JANNAF	-	Joint Army-Navy-NASA-Air Force
LEC	-	Lower Explosive Limit
LPG	-	Liquefied Petroleum Gas
MMH	-	Monomethylhydrazine
MTB	-	U.S. Materials Transportation Bureau
NIOSH	-	National Institute of Occupational Safety & Health
NRC	-	National Response Center
NTSB	-	National Transportation Safety Board
OHMTADS	-	Oil and Hazardous Material Technical Assistance Data System
OSC	-	On-Scene Coordination
OSHA	-	Occupational Safety and Health Administration
RCRA	-	Resource Conservation and Recovery Act
RMA	-	Rocky Mount Arsenal
SHELL R&D SPILLS	-	Shell Vapor Dispersion Model
SRI	-	Stanford Research Institute

LIST OF ACRONYMS (cont'd)

STCC	-	Standard Transportation Commodity Code
TCC	-	Transportation Commodity Code
TLV	-	Toxic Lethal Valve
UDMH	-	Unsymmetrical Dimethylhydrazine
UN	-	United Nations
USAF	-	United States Air Force
USCG	-	United States Coast Guard
UV	-	Ultraviolet

1. EXECUTIVE SUMMARY

The overall objective of this program is to perform a state-of-the-art assessment to develop technology which will minimize hazards and environmental damage from transportation-related accidents or other spills of certain chemicals and propellants. These are anhydrous ammonia, butadiene, chlorine, ethylene oxide, hydrazine, liquefied hydrogen, liquefied oxygen, monomethylhydrazine, nitrogen tetroxide, propane, unsymmetrical dimethylhydrazine and vinyl chloride.

In Task 1A, an in-depth literature search was conducted to identify production volumes, storage capacities, shipment quantities, commodity flow patterns, storage quantities, disposal site locations and capabilities, and container types used for highway and rail transport of the above mentioned chemicals and propellants. These information sources were then compiled in an annotated bibliography. Data were obtained from numerous federal, state and local government agencies, trade associations, rail and highway carriers, chemical manufacturers, wreckage removal and cleanup and disposal contractors.

In Task 1B, a preliminary review of sixteen NTSB-investigated rail and highway accidents was conducted and a comparison, pointing up deficiencies, conflicts or agreements between procedures used and existing response systems was made. These accidents involved anhydrous ammonia, butadiene, propane, liquefied oxygen, chlorine and vinyl chloride of the hazardous materials in this study. It must be noted that in many, if not most of the NTSB accidents that were investigated the local emergency response personnel were unaware of and did not have the benefit of hazards mitigation and handling procedures from ANY response system.

In Task 2A, an in-depth analysis of emergency response, hazards mitigation, cleanup and disposal and wreckage removal procedures used at nine (9) selected rail and highway accidents involving anhydrous ammonia, butadiene, chlorine, liquefied oxygen, propane and vinyl chloride of the chemicals and propellants in our study was conducted. One other accident, involving the overturn of a highway tank truck carrying gasoline was also examined. As part of the accident review the actual emergency response and handling procedures used for each material involved in a major rail or highway accident documented by the NTSB are also presented, and a determination of the adequacy and effectiveness of the procedures is made. During this task, the U.S. Coast Guard CHRIS system,^(31,33,34,35) the EPA Hazardous Material Spill Control Manual,⁽³⁶⁾ the AAR Handbook⁽²⁷⁾ and the DOT Response Guidebook⁽³⁰⁾ were also assessed in detail in terms

chemicals and propellants, the applicability to land spills and availability to emergency responders at an accident site. Additionally, selected industry, state and local emergency response procedures and appropriate resources available have been investigated. Procedures assessed include emergency response, hazards mitigation, cleanup and disposal, wreckage removal and product transfer. Available resources deemed important include trained personnel, emergency communications links, personal protective clothing and equipment, wreckage removal equipment and equipment and materials to contain, transfer and cleanup spilled materials.

The rail industry, for the most part, relies heavily on the shipper for hazards information on specific commodities; on the local fire and police departments to respond to fires, carry out evacuations and isolate and secure the site; on the cleanup contractor to cleanup and remove spilled chemicals; and on the wrecking contractor to move wrecked and damaged cars and clear the right-of-way. In a few cases, railroads support in-house emergency response teams for chemical emergencies, however, this expertise resides in the minds of a few experts with few if any written procedures or techniques. The tank truck carriers rely specifically on the shipper for emergency information, as well as specialized driver training and emergency response teams. In very few cases do tank truck carriers have in-house response teams. The main function of the teams they do have is to oversee cleanup and removal of the wrecked tank motor vehicle. Many states and localities are developing emergency response and contingency plans for hazardous chemical emergencies, but this effort is still in its infancy.

In Task 2B, six (6) spill scenarios based on conditions and parameters from actual accident experience were identified. The scenarios provide a broad view of the transportation emergency picture for eventual use in aiding communities with emergency planning through use of vapor dispersion models. A preliminary overview and assessment of vapor dispersion methods with particular emphasis on their availability and applicability to transportation spills on land was conducted. These models include the USCG HACs, Shell R&D SPILLS, AF Empirical/Statistical, DDESB Chemical Hazard Slide Rule and dense gas vapor dispersion models.

Task 3 involved the development of detailed criteria to serve as the basis for the detailed procedures to be developed in Task 4. These procedures will provide for improved hazards mitigation, wreckage removal and cleanup and disposal techniques at hazardous materials transportation emergencies. In Task 3A, the specific criteria for optimum hazards mitigation, wreckage removal and cleanup and disposal methods were developed. They include criteria for on-scene identification of materials; on-scene communications; assessing toxic, flammable and explosive vapor hazards; determining

meteorologic conditions for establishing air dispersion limits; handling leaks; assessing container structural integrity; remote sensing of container temperature and pressure; transfer operations; wreckage removal and cleanup and disposal. A logic sequence for determining optimum operational procedures for the accident scene was also developed along with criteria for developing necessary training aids for emergency response teams.

In Task 3B, various state-of-the-art means of physically lifting rail cars or other containers involved in an accident are discussed and criteria for optimum wreck handling procedures are then developed.

Task 3C involved development and assessment of several formats for a spill handling procedures manual with examples of each. One format was then recommended to become the user's manual developed in Task 4 for the twelve chemicals and propellants.

2. INTRODUCTION

The overall objective of this program is to perform a state-of-the-art assessment to develop technology which will minimize hazards and environmental damage from transportation-related accidents or other spills of certain chemicals and propellants.

This report compiles the work accomplished in Tasks one, two and three and is structured into the following sections:

- Section 1 - Executive Summary
- Section 2 - Introduction
- Section 3 - Chemicals and Propellants Production and Transportation Data
- Section 4 - Assessment of Current Methods and Procedures
- Section 5 - Development of Spill Scenarios
- Section 6 - Applicability of Vapor Dispersion Models to Transportation Spills
- Section 7 - Criteria for Developing Procedures for Mitigating Hazards Associated with Response Activities at an Accident
- Section 8 - State-of-the-Art Means For Lifting Derailed Cars and Other Containers
- Section 9 - User's Manual Format
- Appendices A-P

Sections 1 and 2 present highlights and structural overview of the report. Section 3 lists data sources and presents analysis of production volumes, storage capacities, shipment quantities, containers used for highway and rail shipments, general commodity flow patterns and disposal sites and capabilities. Section 4 presents an overview of emergency response procedures and resources available to selected industry groups and state and local agencies; a review of the CHRIS, EPA, AAR and DOT emergency response systems as they specifically apply to the twelve chemicals and propellants; an overview of sixteen NTSB rail and highway accident reports involving these chemicals; and detailed review, identification and analysis of procedures in 10 selected NTSB accident reports. Section 5 presents a discussion of the six spill scenarios, the philosophy behind their development and their adaptability to community planning. Section 6 is a discussion of the USCG HACS, Shell R&D SPILLS, AF statistical/empirical, DDES Chemical Hazard Slide Rule and an overview of dense gas vapor dispersion models, the assumptions basic to each and their applicability to transportation spills. Section 7 discusses criteria which are needed for developing improved and innovative procedures to mitigate hazards associated with response activities at hazardous material transportation emergencies. Section 8 presents state-of-the-art means for physically lifting derailed cars and containers. Section 9 presents discussion of some potential formats for a spill handling procedures manual. Twelve appendices follow: Appendix A contains a sample printout from the OHMTADS

system on anhydrous ammonia and the data fields available through this system; Appendix B presents a list of disposal facilities capable of handling hazardous spill residues from accidents and incidents and appropriate state and regional EPA hazardous waste offices; Appendix C provides transport container specifications from Title 49 of the Code of Federal Regulations applicable to the twelve chemicals and propellants; Appendices D, E, F, and G provide commodity specific information from each of the four emergency response systems reviewed in-depth; Appendix H contains detailed analyses of procedures used on-scene at ten selected accidents investigated by the NTSB in which one or more of the chemicals or propellants were involved; Appendix I is an annotated bibliography which summarizes the current state-of-the-art for emergency response methods, procedures and systems, hazards mitigation and cleanup activities for rail and highway accidents and user transfer operations involving releases of the 12 selected hazardous commodities; Appendix J contains a catalog of organizational activities at a hazardous materials transportation emergency; Appendix K are details of NTSB-investigated accidents related to wreck-clearing operations; Appendix L discusses innovative means for assessing tank car structural integrity; Appendix M presents an outline for the contents of each volume of a projected five volume spill handling procedures manual; Appendix N contains examples of two different types of commodity-specific procedures manuals; Appendix O illustrates the possible contents of a sample organizational guide series response procedures manual; and Appendix P is a glossary of terms used in this report.

3. CHEMICALS AND PROPELLANTS PRODUCTION AND TRANSPORTATION DATA

3.1 DATA SOURCES

An extensive literature search has been conducted and a data base compiled including production volume, storage capacities, shipping quantities, disposal facilities, general commodity flow patterns, transportation mode and shipping containers for the twelve chemicals and propellants in this project. Data from several Federal and State agencies as well as some industrial organizations, trade associations and academic institutions have been collected, compiled and reviewed. A list of the sources contacted includes the following:

Federal

- Bureau of Census
- Council on Environmental Quality (CEQ)
- Department of Defense (DOD)
 - United States Air Force (USAF)
- Department of Energy (DOE)
 - Office of Environment
- Department of Interior (DOI)
 - Water Resources Scientific Information Center
- Department of Labor (DOL)
 - Occupational Safety and Health Administration (OSHA)
- Department of Transportation (DOT)
 - Federal Railroad Administration (FRA)
 - National Response Center (NRC - U.S. Coast Guard)
 - Transportation Systems Center (TSC)
 - Materials Transportation Bureau (MTB)
- Department of Health and Human Resources
 - National Institute of Occupational Safety and Health (NIOSH)
- Environmental Protection Agency (EPA)
- Federal Emergency Management Administration (FEMA)
- Interstate Commerce Commission (ICC)
- National Aeronautics and Space Administration (NASA)
- National Transportation Safety Board (NTSB)

State

- California Highway Patrol
- Commonwealth of Pennsylvania, Department of Transportation
- Commonwealth of Virginia, State Office of Emergency & Energy Services
- Maryland State Police
- Montgomery County, Maryland, Department of Fire & Rescue Services
- State of South Dakota, Division of Highways

Private Sector

Trade Associations

- Association of American Railroads (AAR)
- Chemical Manufacturers Association (CMA)
- CHEMTREC
- National LP-Gas Association
- The Fertilizer Institute
- The Chlorine Institute

Industrial

- Olin Corporation
- Stanford Research Institute
- Vertac, Inc.
- Union Carbide Corporation
- Cleanup/Disposal Contractors
 - IT Corporation
 - OH Materials
- Rail
 - Southern Railway
 - Family Lines
 - Union Pacific
 - Burlington Northern
 - Norfolk & Western
- Tank Manufacturers
 - Union Tank Car
 - Heil Company
- Wreckage Removal Contractors
 - Iaringhausen
 - Hulcher

Academic

- University of Indiana
- OHMTADS

3.2 PRODUCTION QUANTITIES

Many levels and types of data have been obtained, some of which have proven less commodity specific than anticipated. The following sections indicate the data obtained, an assessment of its sufficiency and indications of where data elements are missing, why they are missing, and whether they are obtainable.

3.2.1 Physical/Chemical Data

Physical/chemical data were obtained on each of the twelve commodities from a variety of sources such as chemical dictionaries, handbooks and manuals; individual data cards and storage and handling guides from CMA and individual manufacturers and shippers; a computerized commodity specific data base called OHMTADS (See Appendix A for a list of data fields and a sample printout for anhydrous ammonia); publications such as NIOSH bulletins and criteria documents,⁽⁵⁶⁻⁵⁹⁾ the OSHA Chemical Safety Manual,⁽¹⁴¹⁾ the NIOSH Toxic Substances List⁽³⁷⁾ and many more as

indicated in Appendix I, Annotated Bibliography. Other pertinent data such as thermal and chemical reactivity, synergistic/antagonistic effects with other materials, toxicity, exposure and environmental effects were also compiled from the above as well as from the data provided in several of the emergency response systems studied (see Appendices D, E, F, G). Since the data are already documented, they will not be further reproduced here.

3.2.2 Production Volume

Data on annual production volume for the twelve chemicals and propellants were compiled from the Census of Manufacturing, the National LP-Gas Association,⁽⁶²⁾ the 1979 SRI Directory of Chemical Producers in the U.S., individual chemical producers, Chemical Marketing Reporter's Chemical Profiles, Chemical and Engineering News-Key Chemicals, and the NIOSH Criteria Documents on hydrazines, ethylene oxide, vinyl chloride and chlorine.

The data are presented for each commodity (where available) in terms of location of production sites, annual production on a state-by-state basis, and total U.S. annual production.

3.2.2.1 Anhydrous Ammonia

Table 3-1 lists producers, production sites and capacities for anhydrous ammonia. The total annual U.S. production capacity is 18,719,000 metric tons. Figure 3-1 shows annual production capacity by state. Production is highest in the Midwest and Southwest regions of the U.S. Ammonia is usually derived from natural gas but can also be derived from coal. The major end uses of ammonia include fertilizers (80%); plastics, resins and fibers (10%); and explosives (5%).

3.2.2.2 Butadiene

Table 3-2 lists producers, production sites and capacities for butadiene. The total annual U.S. production capacity is 2,111,000 metric tons. Figure 3-2 shows annual production capacity is centered in two states, Louisiana and Texas. This is because butadiene is derived from dehydrogenation of butenes or butane, which is associated with petroleum refinery activities. The major end uses of butadiene include manufacture of styrene-butadiene rubber (44%); polybutadiene (19%); other chemicals (11%); neoprene (7%); styrene-butadiene latex (7%); ABS resins (6%); nitrile rubber (3%); miscellaneous, including exports (3%).

TABLE 3-1. PRODUCERS AND PRODUCTION CAPACITY OF ANHYDROUS AMMONIA

<u>Producer</u>	<u>Production Sites</u>	<u>Annual Capacity (Thousands of Metric Tons)</u>
Air Products & Chems., Inc.	New Orleans, La.	204
Allied Chem. Corp.	Pensacola, Fla.	68
Agricultural Div.	Geismar, La.	308
	Helena, Ark.	170
	Omaha, Neb.	181
Fibers Div.	Hopewell, Va.	318
American Cyanamid Co.		
Indust. Chems. Div.	New Orleans, La.	549
Apache Powder Co.	Benson, Ariz.	13
Baker Indust. Corp.	Conda Idaho	86
Borden Inc.		
Borden Chem. Div.		
Petrochems.	Geismar, La.	272
Car-ten	Columbus, Miss.	60
CF Indst., Inc.		
Chattanooga Nitrogen Complex	Tynar, Tenn.	123
Donaldsonville Nitrogen Complex	Donaldsonville, La.	1478
Fremont Nitrogen Complex	Fremont, Neb.	37
North Carolina Nitrogen Complex	Tunis, N.C.	154
Olean Nitrogen Complex	Olean, N.Y.	78
Terre Haute Nitrogen Complex	Terre Haute, Ind.	132
Coastal States Gas Corp.		
Colorado Interstate Corp., subsidi., Wycon Chem. Co., subsid.	Chayenne, Wyo.	126
Columbia Nitrogen Corp.	Augusta, Ga.	450
Cominco American Inc.	Borger, Tex.	363
Diamond Shamrock Corp.		
Oil and Gas Unit	Sunray, Tex.	145
Dow Chem. U.S.A.	Freeport, Tex.	104
E. I. du Pont de Nemours & Co., Inc.		
Elastomer Chems. Dept.	Beaumont, Tex.	309
Plastic Products and Resins Dept.	Victoria, Tex.	91
El Paso Natural Gas Co.		
El Paso Products Co., subsidi.	Odessa, Tex.	106
Farmland Indust., Inc.	Dodge City, Ks.	209
	Enid, Okla.	862
	Fort Dodge, Iowa	195
	Hastings, Neb.	143
	Lawrence, Ks.	345
	Pollock, La.	431
First Mississippi Corp.		
Ampro, subsid.	Donaldsonville, La.	-
FIRSTMISS INC., subsid.	Fort Madison, Ia.	290
FMC Corp.		
Indust. Chem. Group	South Charleston, W. Va.	20
Gardiner Big River Inc.		
Gardiner Inc., subsid.		
U.S. Phosphoric Products	Tampa, Fla.	121
Georgia-Pacific Corp.		
Chem. Div.	Plaquemine, La.	172
Getty Oil Co.		
Hawkeye Chem. Co., subsid.	Clinton, Iowa	123
Goodpasture, Inc.	Dimmitt, Tex.	55
W R. Grace & Co.		
Agricultural Chems. Group	Memphis, Tenn.	308
Green Valley Chem. Corp.	Creston, Iowa	32
Gulf + Western Indust., Inc.		
The New Jersey Zinc Co., div.	Palmerton, Pa.	33

TABLE 3-1. PRODUCERS AND PRODUCTION CAPACITY OF
ANHYDROUS AMMONIA (continued)

<u>Producer</u>	<u>Production Sites</u>	<u>Annual Capacity (Thousands of Metric Tons)</u>
Hercules Inc.	Louisiana, Mo.	63
International Minerals & Chem. Corp.		
IMC Chem. Group	Sterlington, La.	431
Jupiter Chems., Inc.	Lake Charles, La.	113
Kaiser Aluminum & Chem. Corp.		
Kaiser Agricultural Chems. Div.	Savannah, Ga.	90
Mississippi Chem. Corp.	Pascagoula, Miss.	170
	Yazoo City, Miss.	318
Monsanto Co.		
Monsanto Agricultural Products Co.	Luling, La.	796
N-Ren Corp.		
Cherokee Nitrogen Div.	Pryor, Okla.	75
St. Paul Ammonia Products Div.	East Dubuque, Ill.	204
N-Ren Southwest, Inc., subsidi.	Carlsbad, N.M.	60
Occidental Petroleum Corp.		
Hooker Chem. Corp., subsidi.		
Hooker Chems. and Plastics Corp., subsidi.		
Electrochemical and Specialty Chems Div.	Tacoma, Wash.	24
Occidental Chem. Co., subsidi.		
Jefferson Lake Sulphur Co., div.	Plainview, Tex.	51
	Taft, La.	82
Oklahoma Nitrogen Co.	Woodward, Okla.	372
Olin Corp.		
Olin Chems. Group	Lake Charles, La.	432
Pennwalt Corp.		
Inorganic Chem. Div.	Portland, Ore.	7
Phillips Pacific Chem. Co.	Finley, Wash.	136
Phillips Petroleum Co.		
Fertilizer Div.	Beatrice, Neb.	190
PPG Indust., Inc.		
Chems. Group		
Chem. Division-U.S.	Natrum, W.Va.	30
Reichhold Chems., Inc.	St. Helens, Ore.	77
Simplot Co.		
Minerals and Chem. Div.	Pocatello, Idaho	85
Standard Oil Co. of Calif.		
Chevron Chem. Co., subsidi.		
Ortho Fertilizer Div.	Fort Madison, Iowa	86
Chevron U.S.A. Inc., subsidi.	El Segundo, Calif.	5
	Richmond, Calif.	9
Standard Oil Co. (Ky.) subsidi.	Pascagoula, Miss.	431
Standard Oil Co. (Indiana)		
Amoco Oil Co., subsidi.	Texas City, Tex.	433
The Standard Oil Co. (Ohio)		
Vistron Corp., subsidi.		
Chems. Dept.	Lima, Ohio	426
Tennessee Valley Authority	Muscle Shoals, Ala.	62
Terra Chems. Internat'l. Inc.	Port Neal, Iowa	185
Triad Chem.	Donaldsonville, La.	318
Tyler Corp.		
Atlas Powder Co., subsidi.	Joplin, Mo.	117

TABLE 3-1. PRODUCERS AND PRODUCTION CAPACITY OF
ANHYDROUS AMMONIA (continued)

<u>Producer</u>	<u>Production Sites</u>	<u>Annual Capacity (Thousands of Metric Tons)</u>
Union Oil Co. of Calif. Union Chems. Div.	Brea, Calif. Kenai, Alas.	254 943
United States Steel Corp. USS Agri-Chemicals Div.	Cherokee, Ala. Clairton, Pa. Geneva, Utah Ventura, Calif.	159 370 63 51
USA Petrochem Corp. Valley Nitrogen Producers, Inc.	El Centro, Calif.	163
Vulcan Materials Co. Chems Div.	Wichita, Ks.	32
The Williams Companies Agrico Chem. Co., subsid.	Blytheville, Ark. Donaldsonville, La. Verdigris, Okla.	308 372 862
TOTAL		18,719

NOTE: Data represents estimates of effective annual capacities.

Source: 1979 Directory of Chemical Producers

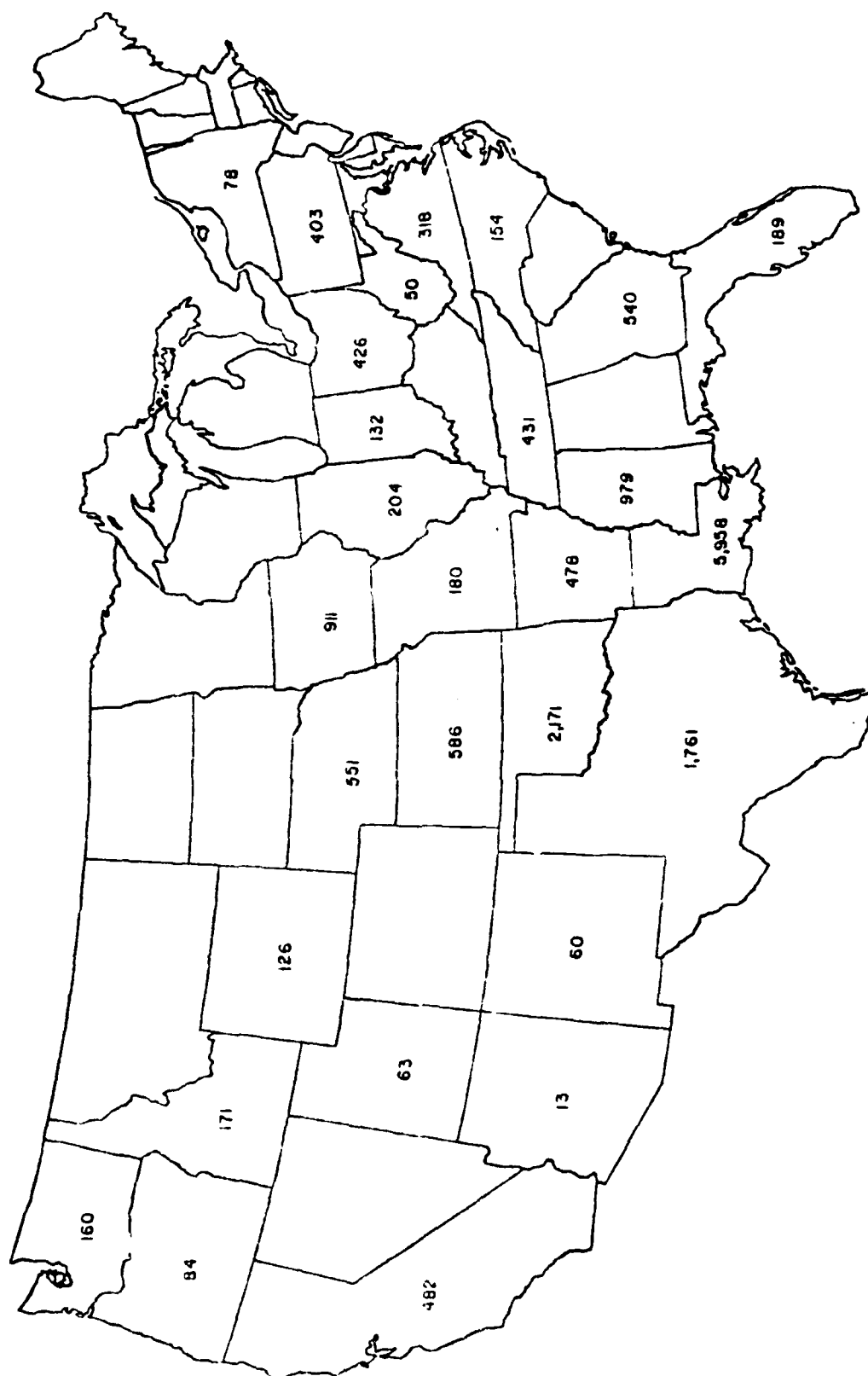


FIGURE 3-1: ANHYDROUS AMMONIA PRODUCTION-THOUSANDS OF METRIC TONS/YEAR
U.S. TOTAL: 18,719

TABLE 3-2. PRODUCTION SITES AND CAPACITY FOR BUTADIENE

<u>Producer</u>	<u>Production Sites</u> ¹	<u>Annual Capacity</u> ² (Thousands of Metric Tons)
Amoco	Chocolate Bayou, TX	81.6
ARCO	Channel View, TX	272.1
Copolymer	Baton Rouge, LA	72.6
Dow	Freesport, TX	38.5
El Paso	Odessa, TX	90.7
Exxon	Baton Rouge, LA	145.1
Exxon	Baytown, TX	113.4
Firestone	Orange, TX	108.8
Mobil	Beaumont, TX	22.7
Monsanto	Chocolate Bayou, TX	45.4
Neches Butane	Port Neches, TX	362.8
Petro-Tex	Houston, TX	340.1
Phillips	Borger, TX	140.6
Shell	Deer Park, TX	226.7
Union Carbide	Seadrift, TX	20.4
Union Carbide	Texas City, TX	29.5
TOTAL		2,111.0

¹Production capabilities vary significantly depending on the butadiene content of petroleum feedstock streams.

²Source: Chemical Profile, March 17, 1980

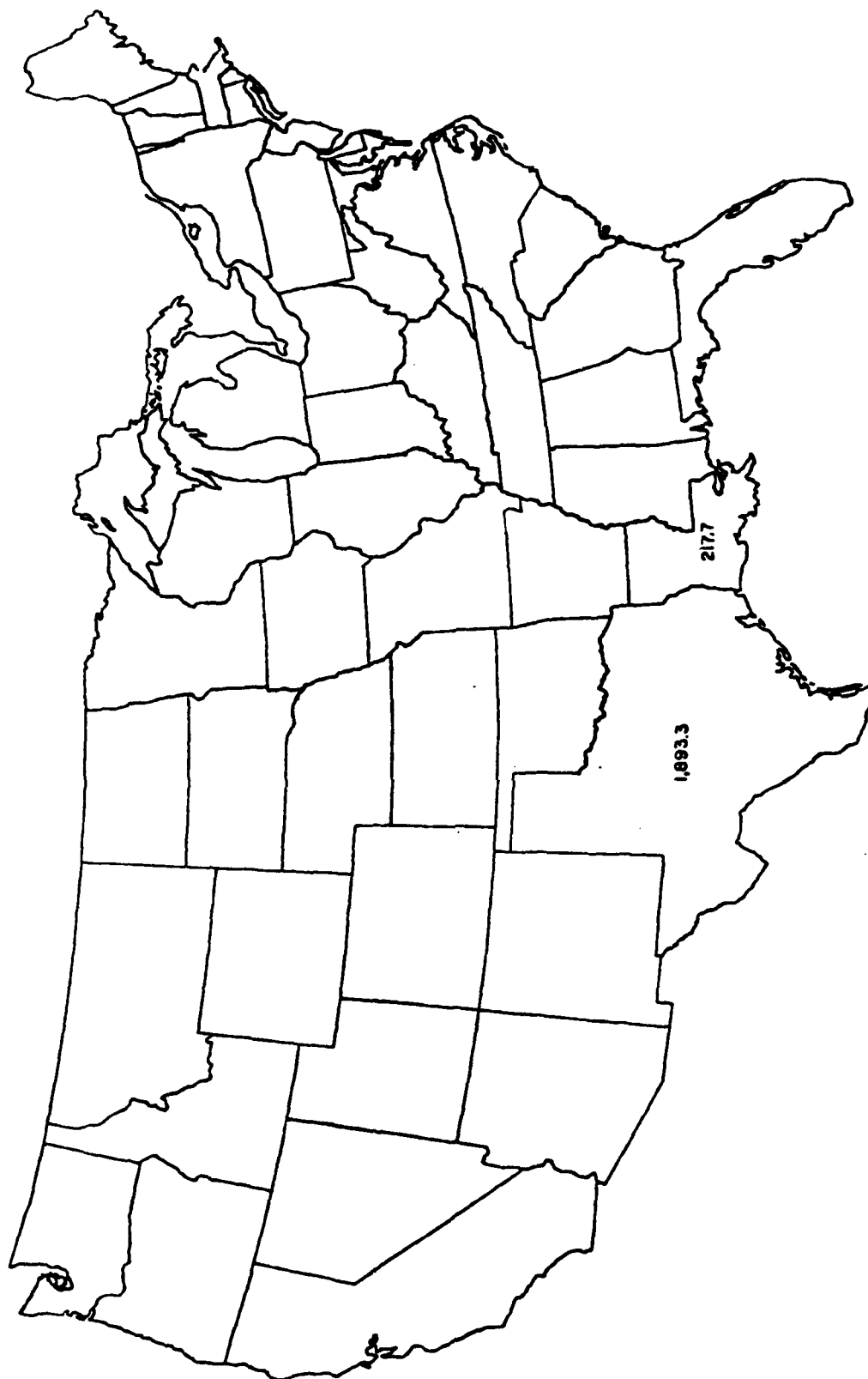


FIGURE 3-2. BUTADIENE PRODUCTION-THOUSANDS OF METRIC TONS/YEAR
U.S. TOTAL: 2,111

3.2.2.3 Chlorine

Table 3-3 lists producers, production sites and capacities for chlorine. The total annual U.S. production capacity is 13,001,000 metric tons. Figure 3-3 shows annual production capacity by state. Approximately 62 percent of chlorine production is centered in Louisiana and Texas. The major production methods are electrolysis of sodium chlorine brine in diaphragm or mercury cathode cells, and fused salt electrolysis of sodium or magnesium chloride. The major uses of chlorine include production of plastics, mostly PVC (20%); pulp and paper processing (13%); chlorinated methanes (13%); inorganic chemicals (11%); organic chemicals (31%); water treatment (6%); and miscellaneous (6%).

3.2.2.4 Ethylene Oxide

Table 3-4 lists producers, production sites and capacities for ethylene oxide. The total annual U.S. production capacity is 2,259,000 metric tons. Figure 3-4 shows annual production capacity by state with Louisiana and Texas accounting for 91 percent of the total. The major uses of ethylene oxide include production of ethylene glycol (60%); surfactants (11%); ethanolamines (7%); glycol ethers (7%); and other (16%).

3.2.2.5 Hydrazine, Anhydrous; Monomethylhydrazine (MMH); Unsymmetrical Dimethylhydrazine (UDMH)

Table 3-5 lists producers, production sites and capacities, where available, for hydrazine, MMH and UDMH. The total annual U.S. production capacity for each is:

Hydrazine ³	17,200 metric tons
MMH ⁴	200 metric tons
UDMH ⁵	600 metric tons

Figure 3-5 shows annual production on a state-by-state basis for hydrazine. MMH is produced only by Olin Corporation under contract to the Air Force and site specific information was not available.⁶ UDMH is produced by CTC organics in Atlanta, GA. The major uses of hydrazine include production of agricultural chemicals (35%); water treatment (10%); miscellaneous (10%). The primary use of MMH is as a rocket fuel with small amounts used in organic

³Chemical Week, Sept. 12, 1979

⁴USAF Directorate Of Energy Management

⁵Ibid

⁶Personal conversation with Lou Faloochi, Olin Chemicals, Inc., New Haven, CT.

TABLE 3-3. PRODUCTION SITES AND CAPACITY FOR CHLORINE

<u>Producer</u>	<u>Production Sites</u>	<u>Annual Capacity (Thousands of Metric Tons)</u>
Allied Chemical Corporation	Acme, N.C.	54
Indust. Chems. Div.	Brunswick, Ga.	49
	Moundsville, W.Va.	87
	Syracuse (Solvay), N.Y.	87
Aluminum Co. of America	Point Comfort, Tex.	153
American Magnesium Company	Snyder, Tex.	24
BASF Wyandotte Corp.		
Indust. Chems. Group Inorganics Division	Geismar, La.	325
	Port Edwards, Wisc.	67
	Wyandotte, Mich.	121
Brunswick Pulp & Paper Company		
Brunswick Chem Co. Division	Brunswick, Ga.	27
Champion Internat'l Corp. Champion Papers Division - Chems. & Associated Products	Canton, N.C.	26
	Pasadena, Tex.	20
Diamond Shamrock Corp. - Indust. Chems. & Plastics Unit - Electro Chems. Division	Deer Park, Tex.	365
	Delaware City, Del.	139
	La Porte, Tex.	403
	Mobile, Ala.	38
	Muscle Shoals, Ala.	142
Dow Chem. U.S.A.	Freeport, Tex.	2222
	Midland, Mich.	257
	Oyster Creek, Tex.	317
	Pittsburg, Calif.	227
	Plaquemine, La.	1043
E.I. du Pont de Nemours & Co. Inc. Chems. Dyes and Pigments Dept.	Memphis, Tenn.	30
	Niagara Falls, N.Y.	56
Petrochems. Dept.		
Freon Products Div.	Corpus Christi, Tex.	196
		327
Ethyl Corp.	Baton Rouge, La.	123
	Pasadena, Tex.	36
FMC Corp.		
Indust. Chem. Gp.	South Charleston, W. Va.	265
Gen. Electric Co. Plastics Business Division	Mount Vernon, Ind.	50
Georgia-Pacific Corp. Chem. Div.	Bellingham, Wash.	83
	Plaquemine, La.	284
The BFGoodrich Co.		
PFGoodrich Chem. Div	Clabert City, Ky.	110
Hercules, Inc.	Hopewell, Va.	28
ICI Americas, Inc. Petrochems. Div.	Baton Route, La.	156

TABLE 3-3. PRODUCTION SITES AND CAPACITY FOR CHLORINE
(continued)

<u>Producer</u>	<u>Production Sites</u>	<u>Annual Capacity (Thousands of Metric Tons)</u>
International Minerals & Chemical Corporation IMC Chem. Group Electrochemicals Div.	Ashtabula, Ohio *Niagara Falls, N.Y. Orrington, Me.	30 n.a. 72
Kaiser Aluminum & Chem. Corp. - Kaiser Chems. Division	Gramercy, La.	186
Linden Chlorine Products, Inc.	Linden, N.J.	131
Goody Chemical Corp. Inorganic Chems. Div.	Cedar Bayou, Tex.	82
Monsanto Co. Monsanto Chem. Inter- mediates Company	Sauget, Ill.	40
N. L. Indust., Inc. Magnesium Division	Rowley, Utah	18
Occidental Petroleum Corp. Hooker Chem. Corp. subsidiary Hooker Chems & Plastics Corp. subsidi. Electrochemical & Specialty Chems. Div.	Montague, Mich. Niagara Falls, N.Y. Tacoma, Wash. Taft, La.	74 317 137 502
Olin Corporation Olin Chems. Group	Augusta, Ga. Charleston, Tenn. McIntosh, Ala. Niagara Falls, N.Y.	100 227 454 80
Pennwalt Corp. Inorganic Chems. Div.	Calvert City, Ky. Portland, Ore. Tacoma, Wash. Wyandotte, Mich.	109 105 66 91
PPG Industries, Inc. Chemical Group Chem. Division-U.S.	Barberton, Ohio Lake Charles, La. Natrium, W. Va.	100 778 265
Pull Company	Ashtabula, Ohio	63
Shell Chemical Company	Deer Park, Tex.	70
Stauffer Chemical Co. Industrial Chem. Div.	Henderson, Nev. Le Moyne, Ala. St. Gabriel, La.	116 50 150
Vertac, Inc. Vulcan Materials Co. Chemical Division	Vicksburg, Miss. Denver City, Tex. Geismar, La. Wichita, Kans.	30 12 196 165
Weyerhaeuser Company	Longview, Wash.	127
TOTAL		13,001

*Joint Venture with Occidental Petroleum Corporation, Hooker Chemical Corporation, subsidiary.

NOTE: Several pulp and paper companies not listed are believed to have some captive production. Much of the above capacity is produced for captive use only.

SOURCE: SRI 1979 Directory of Chemical Producers

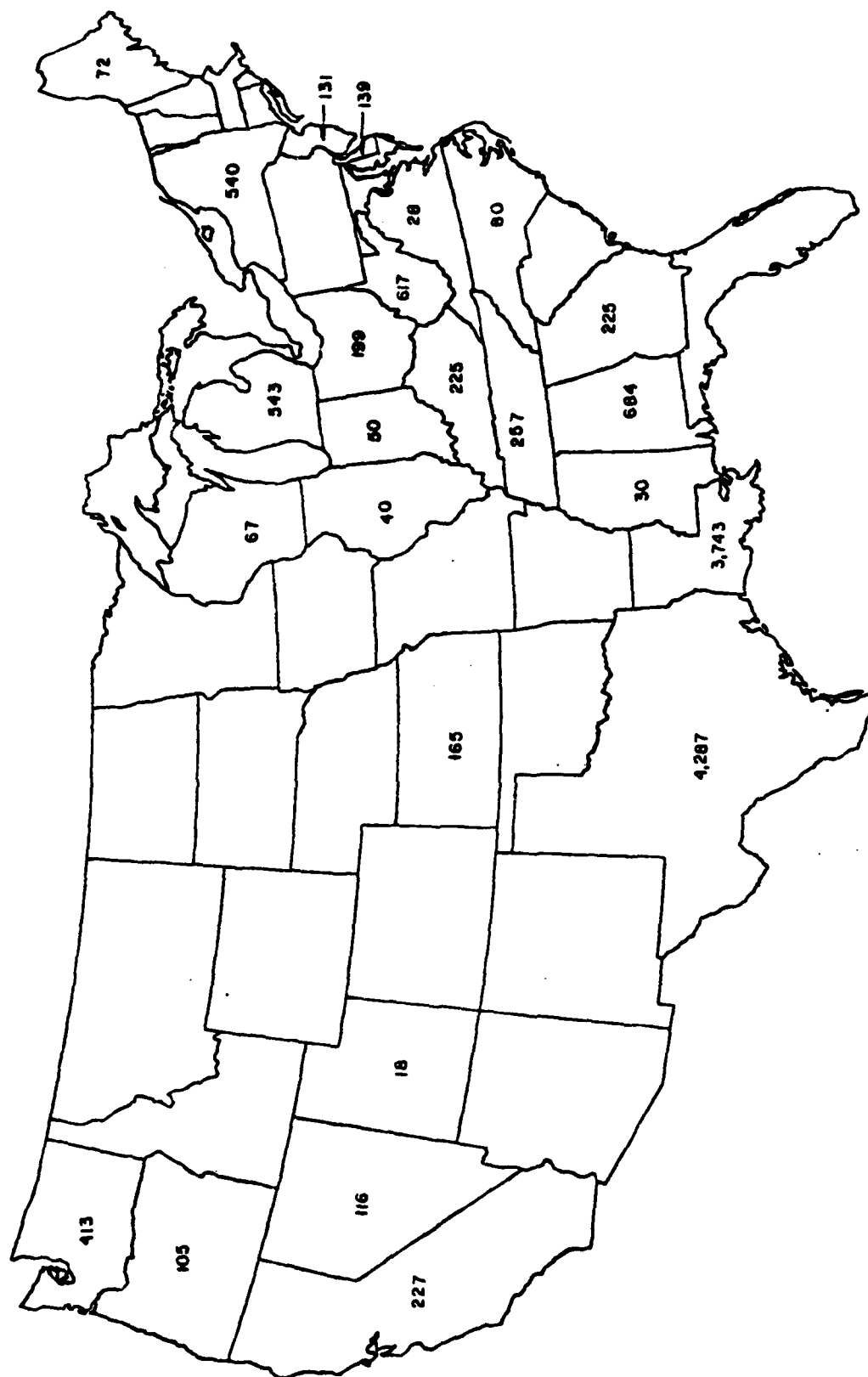


FIGURE 3-3. CHLORINE PRODUCTION-THOUSANDS OF METRIC TONS/YEAR
U.S. TOTAL: 13,001

TABLE 3-4. PRODUCTION SITES AND CAPACITIES OF ETHYLENE OXIDE

<u>Producer</u>	<u>Production Sites</u>	<u>Annual Capacity (Thousands of Metric Tons)</u>
BASF Wyandotte Corp. Indus. Chem. Group Organics Div.	Geismar, LA	141
Celanese Corp. Celanese Chem. Co., Inc.	Clear Lake, TX	216
Dow Chem. U.S.A.	Freeport, TX Plaquemine, LA	118* 204
Eastman Kodak Co. Eastman Chem. Products Inc., subsid Texas Eastman Co.	Longview, TX	89
Northern Natural Gas Co. Northern Petrochem. Co. subsid. Petrochem. Div.	Morris, IL	104
Olin Corp. Olin Chems. Group	Bradenburg, KY	50
PPG Indust., Inc. Chems. Group Chems. Div. - U.S.	Beaumont, TX	68
Shell Chem. Co.	Geismar, LA	123
SunOlin Chem Co.	Claymont, DE	45
Texaco, Inc. Jefferson Chem. Co. Inc. Subsid.	Port Neches, TX	216
Union Carbide Corp. Chems. & Plastics, Div.	Seadrift, TX Taft, LA	389 499
	TOTAL	2,259

* An additional 91-114 metric tons of capacity can be obtained from a unit normally used for propylene oxide manufacture.

Source: SRI 1979 Directory of Chemical Producers.

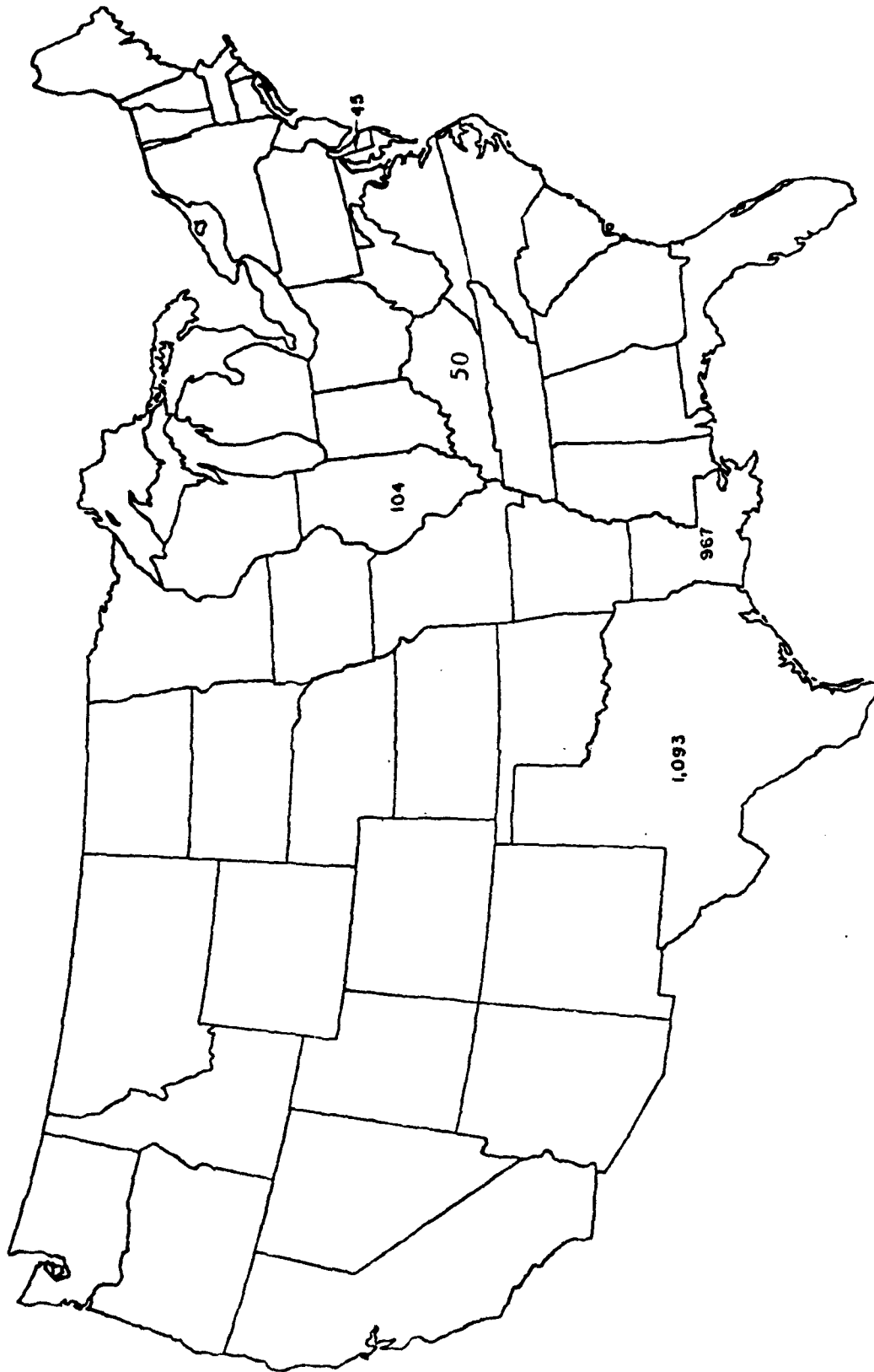


FIGURE 3-4. ETHYLENE OXIDE PRODUCTION-THOUSANDS OF METRIC TONS/YEAR
U.S. TOTAL: 2,259

synthesis, and as a solvent. UDMH is used in rocket fuels, chemical synthesis, in photographic chemicals, as a stabilizer for fuel additives, an absorbent for acid gases and as a plant growth control agent.

TABLE 3-5. PRODUCTION SITES AND CAPACITIES FOR HYDRAZINE, MMH, UDMH

<u>Producer</u>	<u>Annual Capacity (Thousands of Production Sites</u>	<u>Metric Tons)</u>
<u>Hydrazine</u>		
Fairmount Chem. Co., Inc.	Newark, NJ	1.4
Olin Chemicals Group	Lake Charles, LA	4.5
Uniroyal Chem. Div.		
Uniroyal Inc.	Geismar, LA	1.3
Mobay	Cedar Bayou, TX	10
	TOTAL	17.2 ¹
<u>MMH</u>		
Olin Corp.	Company Confidential	.02 ²
<u>UDMH</u>		
CTC Organics Corp.	N/A	0.6 ³

¹Chemical Week, 9/12/79

²USAF Directorate of Energy Management

³Ibid

Estimated Air Force requirements for hydrazine MMH and UDMH from 1980 through 1988 are shown in the following Table 3-6. These requirements include those of the Space Shuttle and other missile and launch vehicles.

TABLE 3-6. *ESTIMATED HYDRAZINE, MMH AND UDMH
FUEL REQUIREMENTS (METRIC TONS)

	80	81	82	83	84	85	86	87	88
Hydrazine	204	190	263	292.5	303.8	113.4	122.4	149.6	149.6
MMH	68	22.7	45.4	86.2	147.4	195	249	290	
UDMH	204	190	263	292.5	303.8	113.4	122.4	149.6	149.6

*Source "Current and Projected Availability of Amine Fuels", F.S. Forbes, AFRPL
Edwards AFB

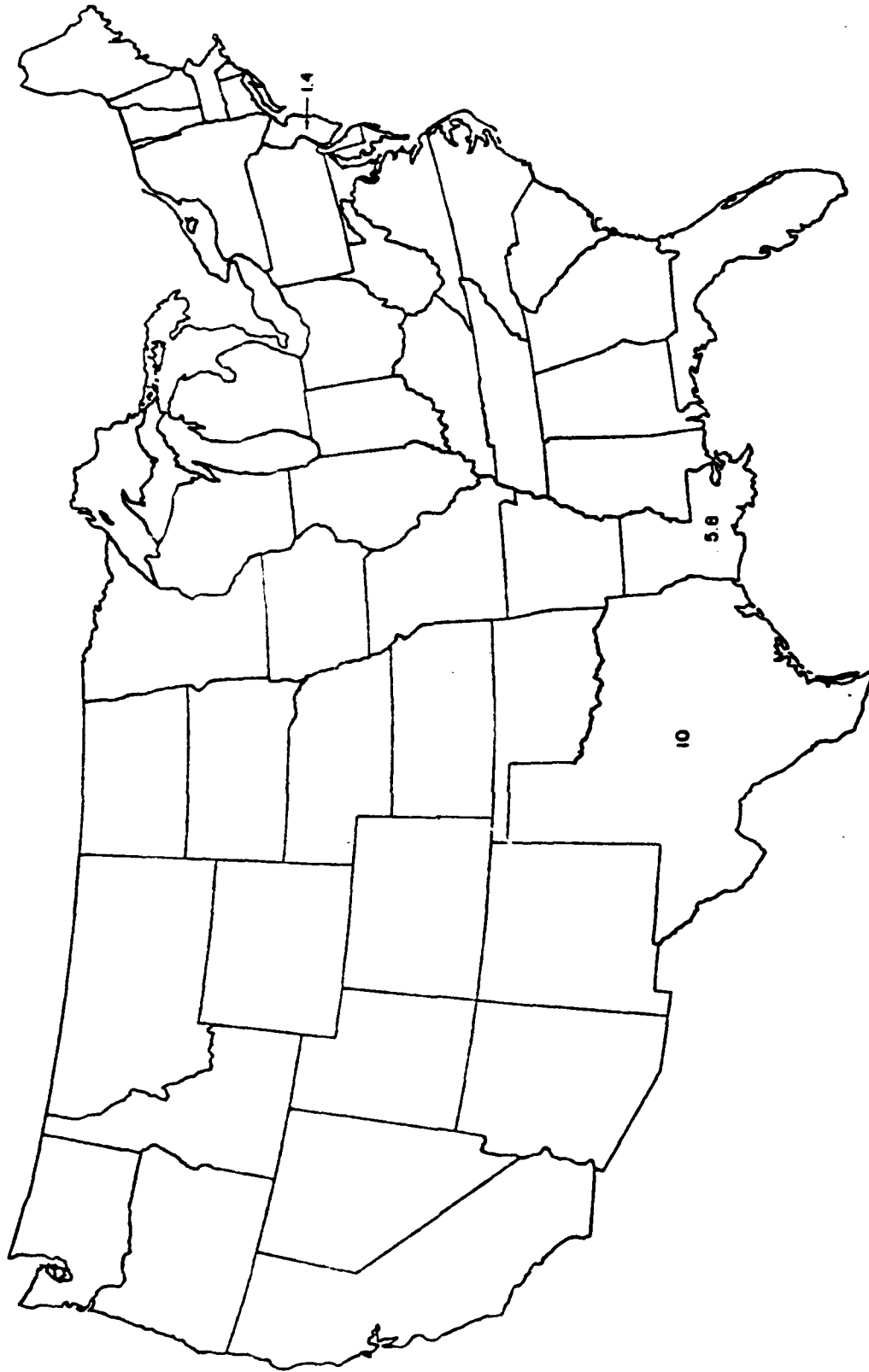


FIGURE 3-5. HYDRAZINE PRODUCTION-THOUSANDS OF METRIC TONS/YEAR
U.S. TOTAL: 17.2

3.2.2.6 Liquefied Hydrogen

Table 3-7 shows producers, production sites and production capacities for liquefied hydrogen. The total annual U.S. production capacity is 46,100 metric tons. Figure 3-6 shows annual production by state for liquefied hydrogen. Liquefied hydrogen is produced at hydrogen gas manufacturing plants by cryogenic liquefaction. The major uses of liquefied hydrogen include coolant and propellant; fuel for nuclear rocket engines; missile fuel and cryogenic research.

TABLE 3-7. PRODUCTION SITES AND CAPACITIES FOR LIQUEFIED HYDROGEN

<u>Producer</u>	<u>Production Sites</u>	<u>Annual Capacity (Thousands of Metric Tons)</u>
Airco, Inc.		
Airco Indus. Gases Div.	Pedricktown, NJ	1.4
Air Prod., & Chem., Inc.	Long Beach, CA	6.8
	New Orleans, LA	27.2
Union Carbide Corp.		
Linde Div.	Ashtabula, OH	3.9
	Ontario, CA	6.8
	TOTAL	46.1

Source: SRI 1979 Directory of Chemical Producers

3.2.2.7 Liquefied Oxygen

Table 3-8 lists producers, production sites and capacities for liquefied oxygen. The total annual U.S. production capacity is 4,835,000 metric tons. This figure is only approximate because capacities for air separation plants are sometimes reported for individual products and sometimes for gross production (including argon and nitrogen). Efforts were made to restrict the listing to basic air separation plants where air is liquefied and oxygen is obtained by fractionation. The production also excludes that from U.S. Government-run plants at Edwards AFB and Vandenburg AFB. Figure 3-7 gives an annual production capacity by state for liquefied oxygen. The uses of liquefied oxygen include oxidizer for liquid rocket propellants; decompression chambers; spacecraft; chemical intermediate; and in coal gasification.

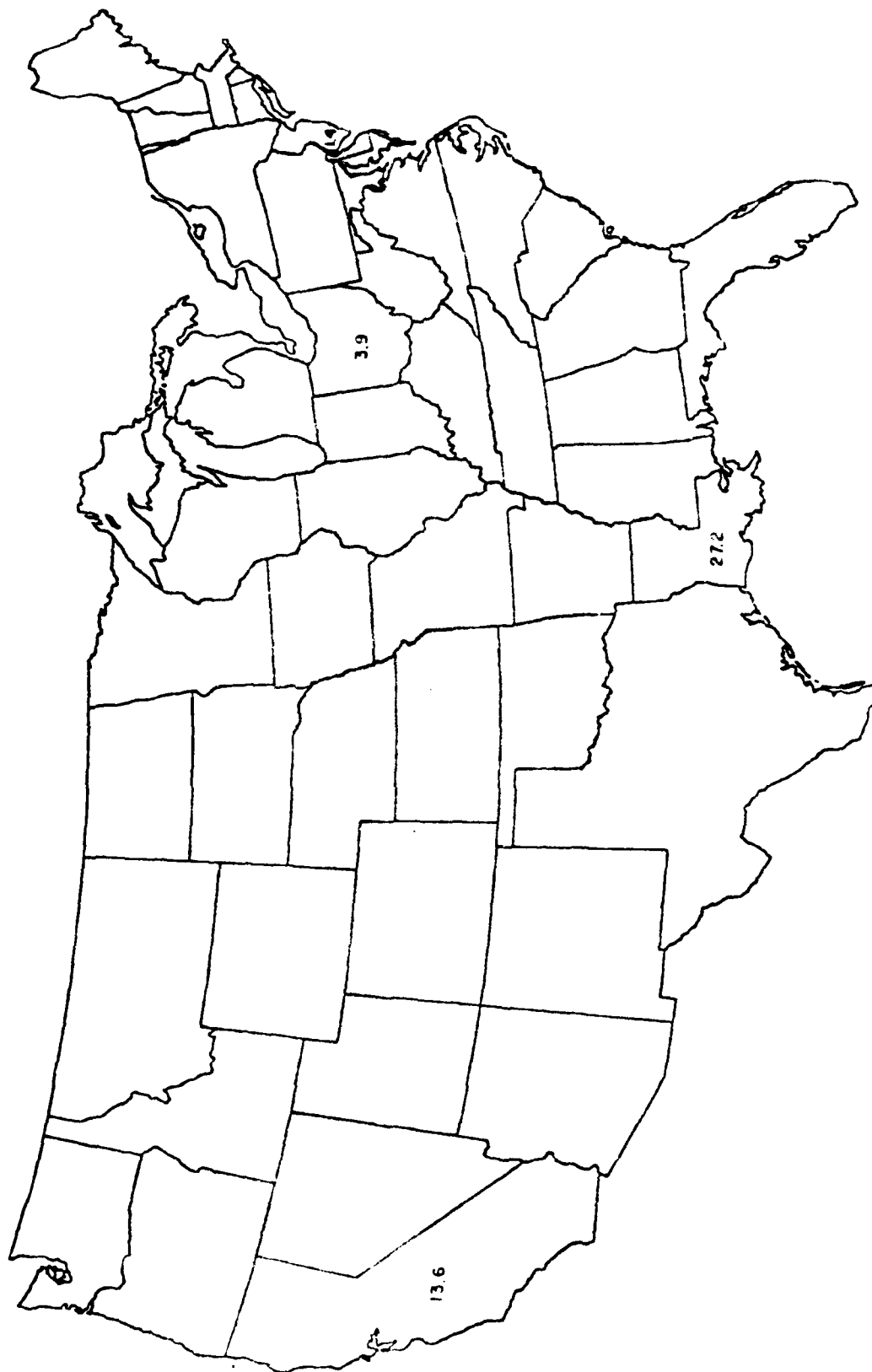


FIGURE 3-6. LIQUEFIED HYDROGEN PRODUCTION-THOUSANDS OF METRIC TONS
U.S. TOTAL: 46.1

TABLE 3-8. PRODUCERS AND PRODUCTION CAPACITY OF LIQUEFIED OXYGEN

<u>Producer</u>	<u>Production Sites</u>	<u>Annual Capacity (Thousands of Metric Tons)</u>
AGA Burdox, Inc.	Kalamazoo, Michigan	16
	Niagara Falls, N.Y.	18
	Parkersburg, W. Va.	22
AIRCO, Inc.	**Albany, N.Y.	27
AIRCO Indust. Gases Division	Albion, Mich.	9
	Arroyo, W. Va.	77
	Bethlehem, Pa.	23
	Buffalo, N.Y.	29
	Butler, Pa.	15
	City of Industry, Calif.	14
	Claymont, Del.	42
	Decatur, Ala.	20
	East Alton, Ill.	32
	El Paso, Tex.	6
	Fairfield, Ala.	45
	Indianapolis, Ind.	14
	Johnstown, Pa.	39
	Kellogg, Idaho	2
	Natrona, Pa.	18
	New Orleans, La.	32
	Richmond, Calif.	9
	South Acton, Mass.	9
	Tucson, Ariz.	2
	Vancouver, Wash.	7
	Warren, Ohio	29
AIR Products & Chemicals, Inc.	Ashland, Ky.	43
	Burns Harbor, Ind.	50
	Chicago, Ill.	6
	Cleveland, Ohio	54
	Conyers, Ga.	14
	Creighton, Pa.	9
	Decatur, Ala.	11
	Detroit, Mich.	20
	El Segundo, Calif.	77
	Glenmont, N.Y.	14
	Granite City, Ill.	39
	La Salle, Ill.	14
	Lathrop, Calif.	14
	Lone Star, Tex.	28
	Middletown, Ohio	56
	New Castle, Del.	23
	New Johnsonville, Tenn.	9
	New Martinsville, W. Va.	24
	New Orleans, La.	45
	North Baltimore, Ohio	14
	Pittsburgh, Pa.	20
	Pryor, Okla.	14
	Raidsville, N.C.	14
	Santa Clara, Calif.	11
	Sparrows Point, Md.	117
	Toledo, Ohio	14
	Weirton, W. Va.	68
	Wharton, N.J.	23
operated for the U.S. Government	Edwards Air Force Base, Calif.	n.a.
	Vandenberg Air Force Base, Ca.	n.a.

** AIRCO, Inc. AIRCO Industrial Gases Division also operates two 35 ton-per-day plants at unspecified locations in Arizona and Texas.

TABLE 3-8. PRODUCERS AND PRODUCTION CAPACITY OF LIQUEFIED OXYGEN
(continued)

<u>Producer</u>	<u>Production Sites</u>	<u>Annual Capacity (Thousands of Metric Tons)</u>
Allegheny Ludlum Industrial, Inc. Pigments Division Industrial Gases Division	Chattanooga, Tenn.	7
	Chicago, Ill.	26
	Dallas, Tx.	20
	Denver, Colo.	14
	East Helena, Mont.	2
	Holland, Ohio	11
	Mansfield, Ohio	8
	Mount Vernon, Ind.	39
	Oklahoma City, Okla.	11
	Orem, Utah	18
	Peoria, Ill.	3
	Richmond, Va.	10
	Sharon, Pa.	72
	Stafford, Tex.	15
Big Three Indust. Inc.	Albuquerque, N.M.	n.a.
	Baton Rouge, La.	15
	Bayport, Tex.	295
	Beaumont, Tex.	142
	Channelview, Tex.	138
	Corpus Christi, Tex.	59
	Etiwanda, Calif.	14
	Freeport, Tex.	83
	Longview, Tex.	11
	Norco, La.	46
	Odessa, Tex.	9
	Plaquemine, La.	138
	Santa Susana, Calif.	19
	Victoria, Tex.	9
	West Palm Beach, Fla.	13
Burdett Oxygen Co. Chesapeake Corp. of Va.	Reading, Pa.	7
	West Point, Va.	4
Ford Motor Company Steel Division	Dearborn, Mich.	28
Houston Natural Gas Corp. Liquid Carbonic Corp. subsid. I/M Div.	Burlington, N.J.	13
	Calumet City, Ill.	n.a.
	Canton, Ohio	11
	Tewksbury, Mass.	11
Liquid Air Corp. of North America Arizona Region	Phoenix, Ariz.	3
	Lake Charles, La.	n.a.
	Kent, Wash.	20
	Savannah, Ga.	18
	Spartanburg, S.C.	20
	La Porte, Tex.	27
	Santa Fe Springs, Calif.	7
Southwestern Region Western Region	Union City, Calif.	27
Mobay Chemical Corp. Agricultural Chems. Division	Kansas City, Mo.	2
Monochem, Inc.	Geismar, La.	59
Narox, Inc.	Hopewell, Va.	12
Northern Natural Gas Co. Northern Petrochem. Co. subsid. Petrochems Division	Morris, Ill.	56
Pacific Oxygen Co.	Oakland, Calif.	2

TABLE 3-8. PRODUCERS AND PRODUCTION CAPACITY OF LIQUEFIED OXYGEN
(continued)

<u>Producer</u>	<u>Production Sites</u>	<u>Annual Capacity (Thousands of Metric Tons)</u>
Selox, Inc.	Chattanooga, Tenn.	9
	Enka, N.C.	9
Tennessee Natural Gas Lines, Inc. Alabama Oxygen Co. subsidiary	Bessemer, Ala.	5
UGI Corp.		
AmeriGas, Inc.	Waukesha, Wisc.	9
Union Carbide Corp. Linde Division	Antioch, Calif.	2
	Ashtabula, Ohio	58
	Aurora, Minn.	3
	Babbitt, Minn.	3
	Baltimore, Md.	16
	Burns Harbor, Ind.	180
	Canton, Ohio	11
	Cape Kennedy, Fla.	23
	Cleveland, Ohio	52
	Coatesville, Pa.	5
	Deer Park, Tex.	90
	Duquesne, Pa.	68
	East Chicago, Ind.	450
	Ecorse, Mich.	135
	Fife, Wash.	31
	Fontana, Calif.	77
	Gadsden, Ala.	42
	Garland, Tex.	13
	Gary, Ind.	324
	Houston, Tex.	45
	Huntsville, Ala.	24
	Institute, W.Va.	n.a.
	Kansas City, Mo.	5
	Keasbey, N.J.	34
	Lackawanne, N.Y.	70
	Lorain, Ohio	45
	Middletown, Ohio	12
	Midland, Pa.	n.a.
	Morrisville, Pa.	n.a.
	Neosho, Mo.	6
	Pittsburg, Calif.	15
	Plaquemine, La.	n.a.
	Pueblo, Colo.	13
	Salt Lake City, Utah	30
	Sterling, Ill.	1
	Suffield, Conn.	11
	Texas City, Tex.	n.a.
	Wilmington, Calif.	81
	Wilmington, N.C.	16
	Youngstown, Ohio	n.a.
United States Steel Corporation	Fairless Hills, Pa.	36
Wheeling-Pittsburgh Steel Corporation		
Mingo Oxygen Co. subsidiary	Mingo Junction, Ohio	34

TOTAL 4,835

NOTE: Capacities of air separation plants are sometimes quoted for individual products and sometimes for gross production. Since this has led to frequent confusion and error, use capacity data with caution. Efforts have been made to restrict the above listing to basic air separation plants where air is liquefied and nitrogen, oxygen and argon are obtained by fractionation.

SOURCE: SRI 1979 Directory of Chemical Producers

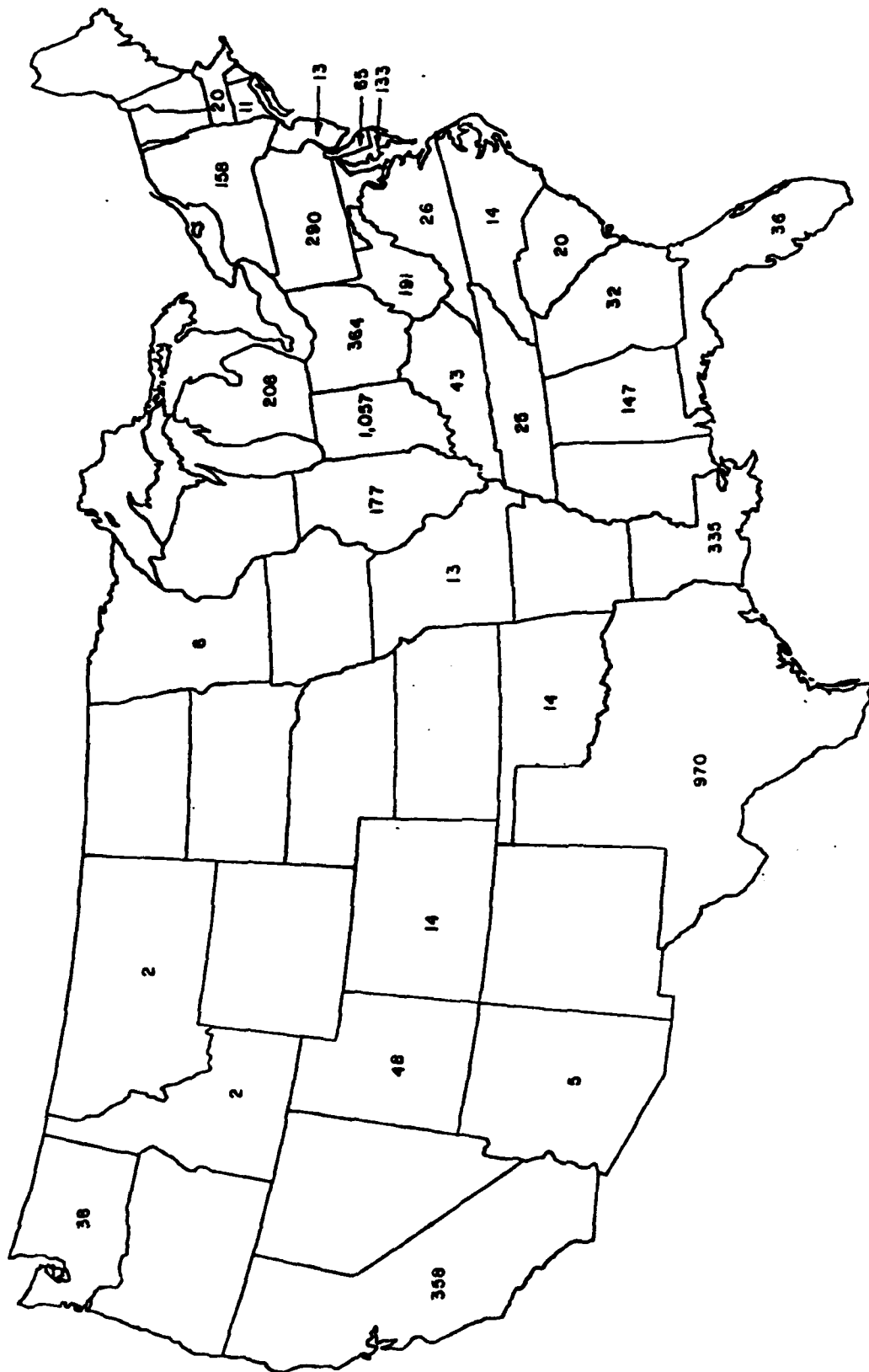


FIGURE 3-7. LIQUEFIED OXYGEN PRODUCTION-THOUSANDS OF METRIC TONS
U.S. TOTAL: 4,835

3.2.2.8 Nitrogen Tetroxide

Nitrogen tetroxide is produced by Vertac, Inc. in Vicksburg, MS. and Air Products & Chemicals, Inc. (Specialty Gas Dept.) in Allentown, PA⁷. Based on data supplied by the USAF Directorate of Energy Management, the annual production capacity of nitrogen tetroxide is estimated to be 1,406 metric tons/year. Nitrogen tetroxide is produced by oxidation of nitric oxide which is an intermediate stage in the production of nitric acid from ammonia. The major uses of nitrogen tetroxide include the production of nitric acid; agent in chemical synthesis; oxidizer for rocket fuels; and as a polymerization inhibitor for acrylates.

3.2.2.9 Propane

Propane production figures were provided by the National LP-Gas Association on a regional basis for propane produced at natural gas processing plants and propane produced at refineries. Total annual U.S. production of propane is roughly 2.9 billion metric tons. Table 3-9 lists the producers of propane from the OHMTADS printout. Figures 3-8 and 3-9 show annual regional production for propane produced at refineries and that produced at natural gas processing facilities. Propane is one of the liquefied petroleum gases used for residential and commercial fuel application; in internal combustion engines; chemicals manufacture; utilities fuel; industrial applications; and miscellaneous.

TABLE 3-9. PRODUCERS OF PROPANE

American Oil, TX
Atlas Processing
Ashland Chemical
Cosden Oil & Chemical
Cities Services Oil
Dura
DX Oil
Enjay Chemical
Gulf Oil, Pontiac Refinery
Marathon Oil, Texas Refinery
Olin Mathieson Chemical
Pan American Petroleum
Phillips Petroleum
Shell Oil, Sinclair Refinery
Mobil Chemical, Suntime Refinery
Signal Oil & Gas, American Oil, Union Carbide
Union Oil, California
National Distillers & Chemicals

Source: OHMTADS Printout

⁷ 1980-81 OPD Chemical Buyers Directory

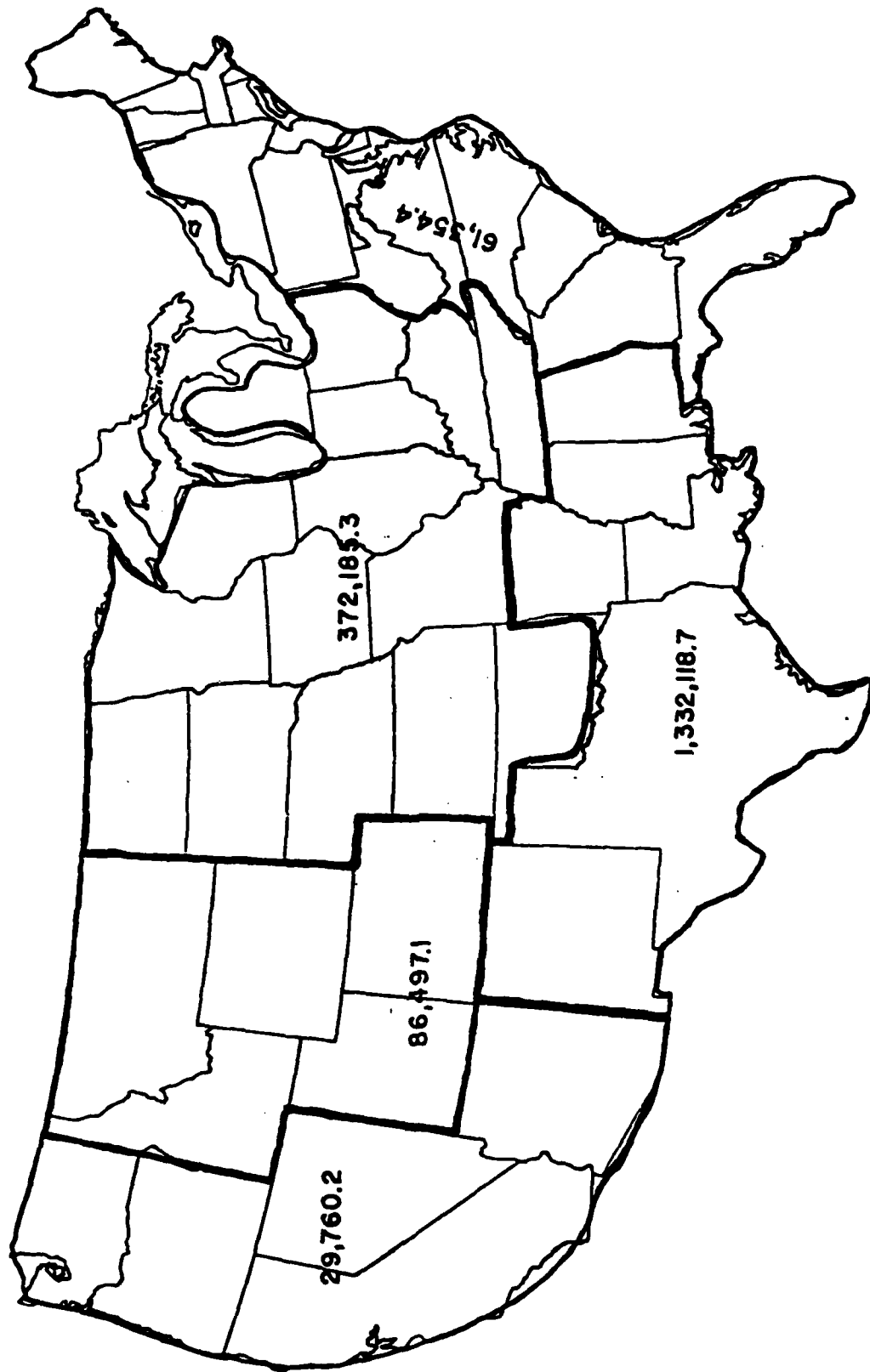


FIGURE 3-8. ANNUAL PROPANE PRODUCTION AT NATURAL GAS PROCESSING PLANTS/THOUSANDS OF METRIC TONS
U.S. TOTAL: 1,881,916

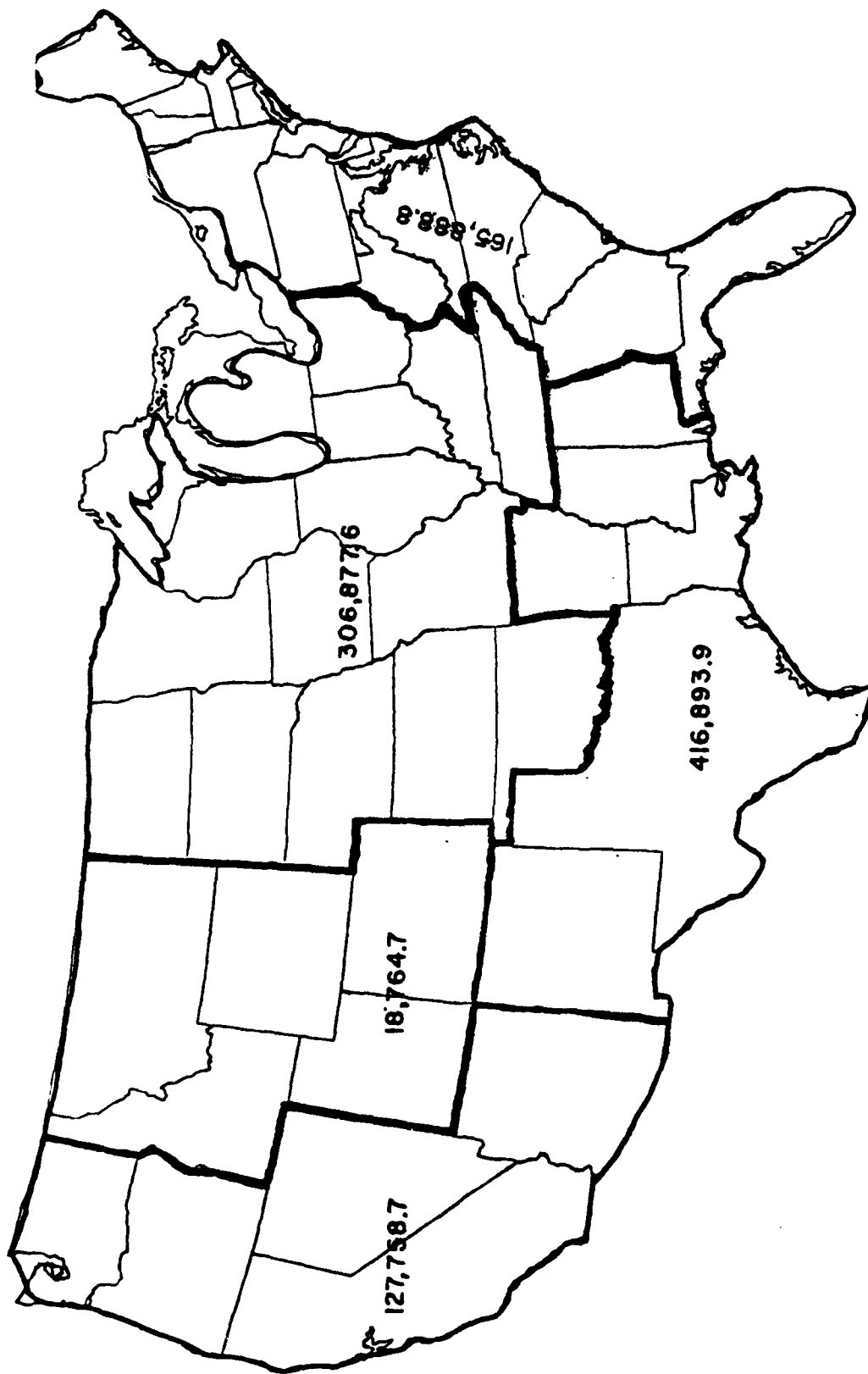


FIGURE 3-9. ANNUAL PROPANE PRODUCTION AT REFINERIES-THOUSANDS OF METRIC TONS
U.S. TOTAL: 1,036,184

3.2.2.10 Vinyl Chloride

Table 3-10 shows producers, production sites and capacities for vinyl chloride. The total annual U.S. production is 3,716,400 metric tons. Figure 3-10 shows annual production capacity on a state-by-state basis. Louisiana and Texas account for 86% of the total U.S. production of vinyl chloride. The major uses of vinyl chloride include production of PVC (90%); exports (7%); and miscellaneous, mostly vinyl acetate or copolymer resins (3%).

3.2.3 Storage Capacities

Storage capacities are defined for the purposes of this study at three major points in the transportation life cycle of the twelve chemicals and propellants. The first is storage at the production or shipping site while awaiting transport, and the second is storage at the consumption or receiving site awaiting use. The third is less well-defined and can be considered "in-transit" storage, when the commodity is enroute from shipper to consignee and is in the tank car, tank truck, cargo tank or other container. This amount of in-transit storage time will vary considerably on a daily and seasonal basis and as such is difficult to evaluate.

The bulk storage data at manufacturing and use/distribution sites are more clearly defined.

The following information was obtained from the National LP-Gas Association.⁽⁶²⁾ The distribution of propane (and other LP-Gas) involves some 225,000 miles of pipeline, 25,000 transport and delivery trucks; 22,000 railroad tank cars, 250 primary storage facilities with capacity of seven billion gallons (1.77×10^9 metric tons), 8,000 bulk storage and distribution points; and 25,000 retail outlets. Propane underground bulk storage capacities (1978) are presented below in Table 3-11 on a state-by-state basis.

TABLE 3-10. PRODUCTION SITES AND CAPACITY FOR VINYL CHLORIDE

<u>Producer</u>	<u>Production Sites</u>	<u>Annual Capacity</u> <u>(Thousands of</u> <u>Metric Tons)</u>
Borden Inc. Borden Chem. Div. Petrochem.	Geismar, LA	136
Continental Oil Co., Conoco Chems. Co., Div.	Lake Charles, LA	317.5
Diamond Shamrock Corp. Indus. Chems. & Plastics Unit Plastics Division	La Porte, TX	453.5
Dow Chem. U.S.A.	Freeport, TX Oyster Creek, TX Plaquemine, LA	90.7 317.5 566.9
Ethyl Corp.	Baton Rouge, LA	149.6
The BF Goodrich Co. BF Goodrich Chem. Div.	Calvert City, KY	453.5
ICI Americas Inc. Petrochem. Div.	Baton Rouge, LA	136
Monochem, Inc.	Geismar, LA	136
PPG Indust., Inc. Chems. Group Chem. Div. - U.S.	Lake Charles, LA	181.4
Shell Chem. Co.	Deer Park, TX Norco, LA	380.9 317.5
Stauffer Chem. Co. Plastics Div. Polymers, Long Beach, CA	Carson, CA	<u>79.4</u>
	TOTAL	3,716.4

Source: SRI 1979 Directory of Chemical Producers

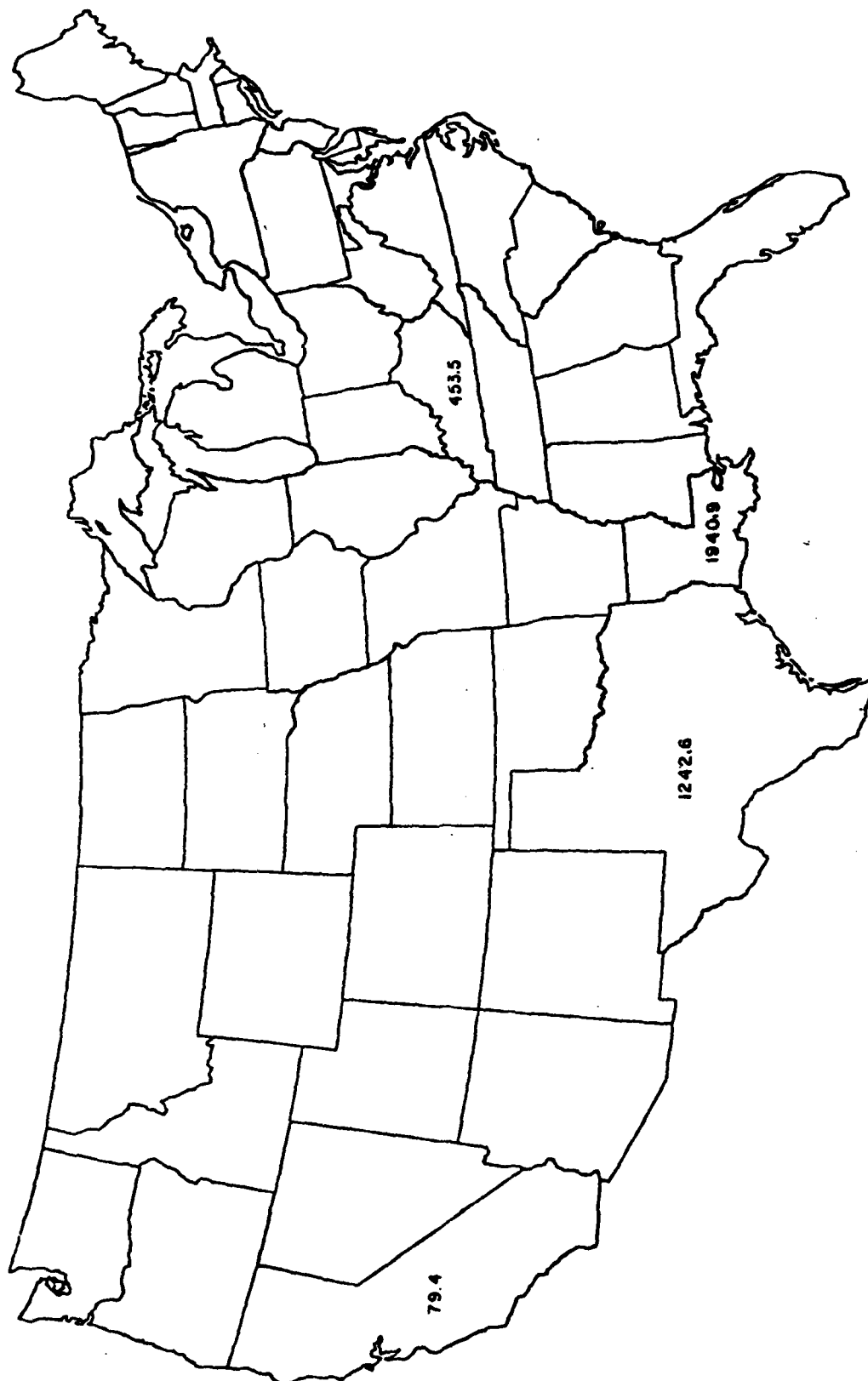


FIGURE 3-10. VINYL CHLORIDE PRODUCTION-THOUSANDS OF METRIC TONS/YEAR
U.S. TOTAL: 3,716.4

TABLE 3-11. PROPANE UNDERGROUND BULK STORAGE CAPACITIES

<u>State</u>	<u>Bulk Storage Capacity Thousands of Metric Tons</u>
Alabama	1,887
Georgia	2,319.2
Illinois	19,534.3
Indiana	10,352.2
Iowa	5,640
Kansas	481,695.6
Kentucky	6,188.2
Louisiana	180,900.7
Maryland & D.C.	1,507.5
Michigan	54,502.1
Minnesota	3,501.5
Mississippi	173,110.2
Missouri	11,142.9
Nebraska	7,959.2
New Jersey	2,635.5
New Mexico	8,865.8
New York	52,583.5
Ohio	65,265.5
Oklahoma	10,426
Pennsylvania	12,334.1
South Carolina	16,867.2
Texas	637,867.2
Utah	1,728.9

The geographic location and storage capacities for anhydrous hydrazine, MMH and UDMH as well as the storage capacity of nitrogen tetroxide were also identified. Since the DOD is the sole or major user of these commodities in the contiguous United States, data regarding storage were compiled from the USAF Directorate of Energy Management, Propellants Branch at Kelly AFB. Table 3-12 shows the storage capacities for these commodities at various DOD facilities. Figure 3-11 shows the geographic location of storage sites for hydrazine fuels (anhydrous hydrazine, MMH and UDMH).

TABLE 3-12. STORAGE CAPACITIES OF HYDRAZINE FUELS AND N_2O_4

<u>Location</u>	<u>Quantity (Metric Tons)</u>	<u>Contents</u>
Rocky Mountain Arsenal, CO	204	A-50
	68	AH
	104	UDMH
Aeroproject, CA	485	A-50
Patrick AFB	197	MMH
	333	N_2O_4
	75	A-50
Vandenberg AFB	22	UDMH
	120	N_2O_4
	262	MMH
Edwards AFB	262	MMH
White Sands, NM	98	N_2O_4

The above constitutes total capacity, not on-hand inventory at those locations. The capacity of holding tanks or other storage vessels used at these locations is not known.

A-50 - 50/50 mix of anhydrous hydrazine and UDMH
 AH - anhydrous hydrazine
 UDMH - unsymmetrical dimethylhydrazine
 MMH - monomethylhydrazine
 N_2O_4 - nitrogen tetroxide

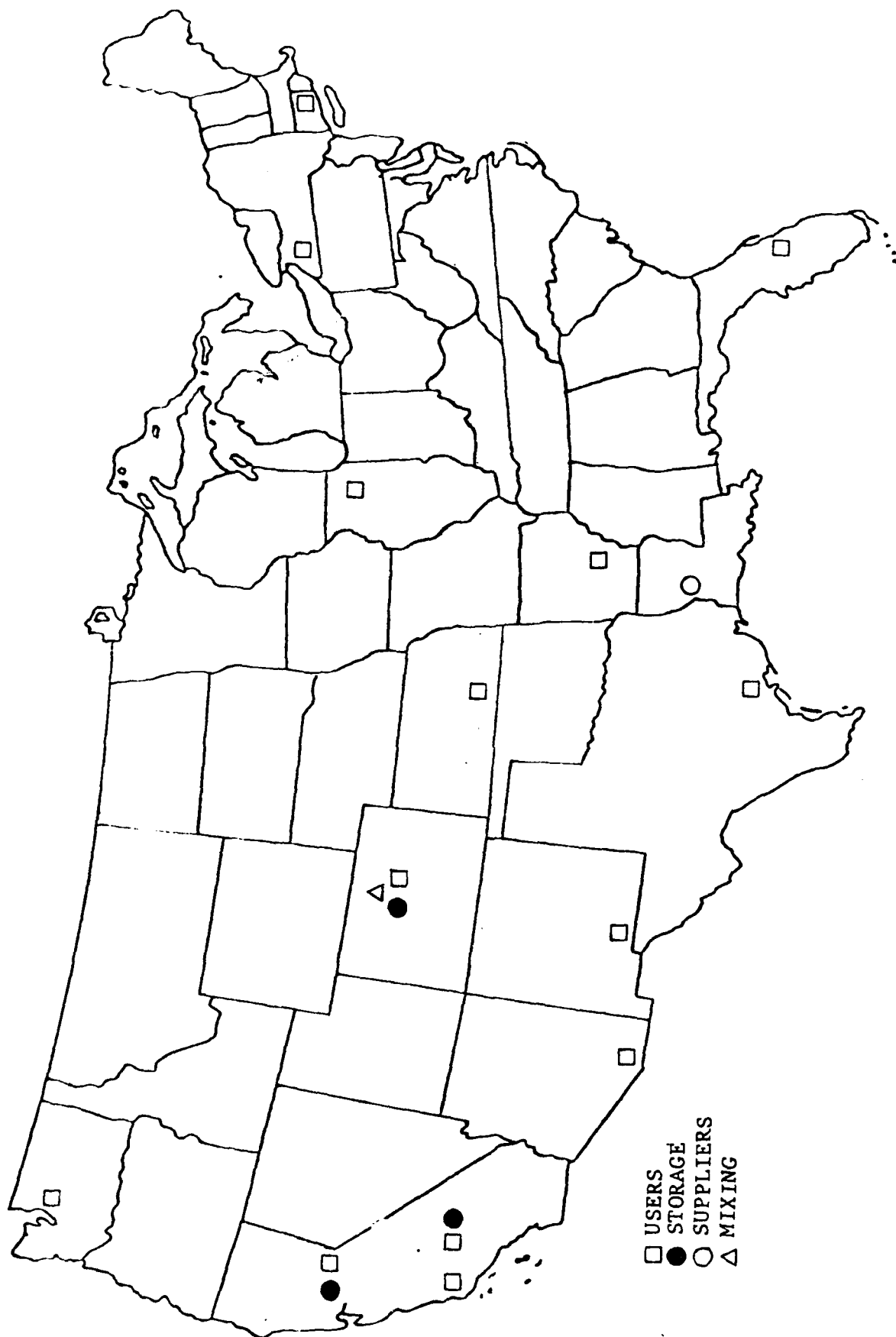


FIGURE 3-11. LOCATIONS OF HYDRAZINE FUELS FACILITIES

3.2.4 Shipment Quantities

To identify the annual quantity of each commodity shipped as well as the frequency of shipments by rail versus highway mode, data was compiled from the Association of American Railroads, U.S. Air Force Directorate of Energy Management, Bureau of Census Commodity Transportation Survey⁽⁹²⁾ and 1979 SRI Directory of Chemical Producers. It was determined that no comprehensive data base exists which provides a statistically significant sample of commodity specific shipments. The categories of rail, highway and other were used in determining the transport mode distribution data for shipment of these commodities.

The annual quantity of anhydrous ammonia and chlorine shipped was compiled through identifying their Transportation Commodity Code (TCC) in the 1972 "Commodity Transportation Survey". It was found that on a yearly basis it can be expected that approximately 7,832 thousand metric tons of anhydrous ammonia and 2,870 thousand metric tons of chlorine will be transported. The amount of ammonia shipped was verified by data received from The Fertilizer Institute. An analysis of the modes of transport used for shipment of anhydrous ammonia reveals the following modal distribution: 39.6% - rail, 47.3% - highway and 15.8% - other modes. For chlorine, the modal distribution is 76.9% - rail, 23.0% - highway and 0.1% - other modes.

Data on the annual quantities shipped of hydrazine, MMH, UDMH, and N_2O_4 were compiled through contact with the U.S. Air Force Directorate of Energy Management at Kelly AFB, TX. The average annual amount of hydrazine, MMH, UDMH and aeroxine 50 (UDMH/hydrazine mix) shipped is shown below:

Hydrazine	590 metric tons
MMH	227 metric tons
UDMH	635 metric tons
UDMH/hydrazine mix	907 metric tons

Hydrazine is usually shipped from Lake Charles, LA to Rocky Mountain Arsenal (RMA), Denver, CO. Bulk MMH is moved from Lake Charles to Edwards AFB, CA for storage and some is moved directly to the users. UDMH will be shipped from manufacturer to RMA. Most of the hydrazine and UDMH shipped to RMA is formulated into UDMH/hydrazine mix. RMA then ships a mix of pure hydrazine and UDMH in bulk and drum quantities to users or storage sites.

The average annual movement of N_2O_4 oxidizer totals 1,406 metric tons. Nitrogen tetroxide moves in carbon steel tank cars, tank trailers and ton containers all in dedicated service. An estimated 80 percent or more of N_2O_4 is shipped by the highway mode.

Data on the frequency of shipments by various modes for these commodities were also reviewed using the 1972 "Commodity Transportation Survey". Unfortunately, shipping data for these commodities are not specific but are grouped into general commodity categories. For example, nitrogen tetroxide is categorized as an industrial gas, n.e.c. Consequently, the distribution of shipments by mode for the hydrazines and N_2O_4 was estimated based on AF experience and data.

An approximation of the annual shipment quantities and percentage modal distribution for the remaining hazardous commodities except propane is given below

	<u>Estimated Annual Amount Shipped (1000 Metric Tons)</u>	<u>Rail</u>	<u>Volume % Shipped Highway</u>	<u>Other</u>
Butadiene	2,111	31	25	44
Ethylene Oxide	600	90	0	10
Liquefied Hydrogen	46.1	30	69	1
Liquefied Oxygen	4,835	34	65	1
Vinyl Chloride	1,935	90	0	10

Propane represents an interesting problem in determining shipment quantity and percentage modal breakdown. According to data from the National LP-Gas Association,⁽⁶²⁾ approximately 2.9 billion metric tons of LP-Gas were produced in the U.S. in 1978, 1.9 billion metric tons at natural gas processing plants and 1 billion metric tons at refineries. However, 4.7 billion metric tons were shipped in 1978. This figure involved movements of LP-Gas from not only production sites but also from import points and storage facilities. Imports of LP-Gas in 1978 totalled 434 million metric tons with 54 million metric tons exported. The breakdown of shipments by mode is also complex because propane moves by rail, truck, tanker or barge and combination pipeline - rail and pipeline - truck. These data from both 1977 and 1978 are presented in Table 3-13. It is important to note that volume shipments by rail increased by 8.8 percent from 1977 to 1978.

TABLE 3-13. SHIPMENT OF LP-GAS*

<u>MODE</u>	<u>QUANTITY SHIPPED</u> <u>(Thousands of Metric Tons)</u>		<u>PERCENT OF TOTAL</u>	
	<u>1977</u>	<u>1978</u>	<u>1977</u>	<u>1978</u>
Truck	200,560	168,136	3.4	3.5
Rail	66,855	12,746	0.9	1.5
Pipeline-Truck	4,522,568	4,887,728	90.6	90.3
Pipeline-Rail	238,031	106,456	4.6	4.4
Tanker or Barge	<u>23,147</u>	<u>13,747</u>	<u>0.5</u>	<u>0.3</u>
TOTAL	5,050,159	4,742,813	100	100

*Shipment figures reflect LP-Gas movements from production sites, import points and storage facilities

3.2.5 Containers Required for Shipping

Types of containers which can be used in transporting the chemicals and propellants are outlined in Title 49 of the Code of Federal Regulations.⁽⁸¹⁾ It should be noted that the types of containers which can be used for highway and rail transport will vary based on the type of commodity being shipped. Various shipping containers are available including cylinders, tank cars, cargo tanks, portable tank containers, and overpack containers such as wooden and fiberboard boxes and polystyrene packages.

Commodity specific requirements for container types and specifications can be found in 49 CFR, Parts 100-179. A list of the applicable container requirements including restrictions on container specifications and volumes for each commodity is given in Table 3-14.

A comprehensive list of pertinent Federal packaging requirements for each chemical is given in Appendix C. A listing of container types required for all commodities is given in Table 3-15. The container specifications for each chemical are discussed individually.

3.2.5.1 Anhydrous Ammonia

Anhydrous ammonia can be shipped in cylinders, tank cars, cargo tanks and portable tank containers as liquefied compressed gas. The cylinders and tank cars specified for anhydrous ammonia use and applicable container specifications are shown in Tables 3-16 and 3-17, respectively.

TABLE 3-14. REGULATIONS APPLICABLE TO CONTAINER REQUIREMENTS*

Hazardous Materials Descriptions and Proper Shipping Names	Hazard Class	Label(s) Required (if not excepted)	Exceptions	Packaging Specific Requirements
Ammonia, anhydrous	Nonflammable gas	Nonflammable gas	173.306	173.304 173.314 173.315
Butadiene, inhibited	Flammable gas	Flammable gas	173.306	173.304 173.314 173.315
Chlorine	Nonflammable gas	Nonflammable gas and Poison	none	173.304 173.314 173.315
Ethylene Oxide	Flammable liquid	Flammable liquid	none	173.315 173.314 173.315
Hydrazine, anhydrous	Flammable liquid	Flammable liquid and Poison	none	173.124 173.276
Hydrogen, liquefied	Flammable gas	Flammable gas	none	173.316 173.145
Methylhydrazine	Flammable liquid	Flammable liquid and Poison	none	173.336
Nitrogen tetroxide, liquid	Poison A	Oxidizer and Poisonous gas	none	173.304
Oxygen, pressurized liquid	Nonflammable gas	Oxidizer	none	173.304
Propane (LPG)	Flammable gas	Flammable gas	173.306	173.304 173.314 173.315
Dimethylhydrazine, unsymmetrical (UDMH)	Flammable liquid	Flammable liquid and Poison	none	173.145 173.304 173.314 173.315
Vinyl Chloride	Flammable gas	Flammable gas	173.306	173.304 173.314 173.315

* Container specifications found in parts 178 and 179 in the commodity specific sections

TABLE 3-15. APPROVED CONTAINER TYPES FOR ALL COMMODITIES

SPECIALIZED CONTAINER CAPACITY	IN NUMBER	TANK WAGON (NICHAS)	TANK CARS (RAIL)	LAND TANK CONTAINERS	PORTABLE TANK CONTAINERS	CITRUS	DRUMS/BARRELS		OUTSIDE PACKAGING		INSIDE CONTAINERS					POLYSTYRENE CONTAINER (N)
							STEEL	ALUMINUM	WOODEN BOXES	FIBERBOARD BOXES	GLASS BOTTLES OR VIDS	CANisters	GLASS CARBONS IN BOTS	GLASS BOTTLE	EXPANDED POLYSTYRENE	
ALUMINUM ALUMINUM	UN 1005		•	•	•	•										
BUTADIENE	UN 1010		•	•	•	•										
CHLORINE	UN 1011		•	•	•	•										
ETHYLENE OXYGEN	UN 1043		•	•	•	•	•		•	•	•	•				
HYDROGEN	UN 2029	•	•					•	•	•			•		•	•
LIQUID HYDROGEN	UN 1968		•			•										
LIQUID OXYGEN	UN 1073					•										
PERFLUORINATED HYDROGEN	UN 1744	•							•						•	
NITROGEN TRIMETHYLENE	UN 1067		•	•	•	•								•		
PROPANE	UN 1075		•	•	•											
USOMETHANOL DIETHYLENE HYDROGEN	UN 1163	•	•						•			•		•	•	
VINYL CHLORIDE	UN 1080		•	•	•	•										

*Container specification in 49 CFR § 100.175

TABLE 3-16. CYLINDERS SPECIFIED FOR SHIPPING ANHYDROUS AMMONIA

<u>KIND OF GAS</u>	<u>MAXIMUM PERMITTED FILLING DENSITY (PERCENT)</u>	<u>REQUIRED CYLINDERS</u>	<u>CONTAINER SPECIFICATIONS</u>
Anhydrous Ammonia	54	DOT-4;	§ 178.48
		DOT-3A480;	178.43
		DOT-3AA480	178.37
		DOT-3;	178.36
		DOT-4AA480;	178.56
		DOT-4L200	178.57

TABLE 3-17. TANK CARS SPECIFIED FOR SHIPPING ANHYDROUS AMMONIA

<u>KIND OF GAS</u>	<u>MAXIMUM PERMITTED FILLING DENSITY (PERCENT)</u>	<u>REQUIRED TANK CARS</u>	<u>CONTAINER SPECIFICATIONS</u>
Anhydrous Ammonia	50	DOT-106A500-X;	§ 179.300
	57	DOT-105A300-W;	179.104
	57	DOT-112A400-F;	179.105
		-112A340-W;	179.105
		-114A340-W;	179.105
	58.8	DOT-112A400-F;	179.105
		-112A340-W;	179.105
		-114A340-W	179.105

The cargo tanks and portable tank containers specified for anhydrous ammonia service and appropriate container specifications are shown in Table 3-18.

TABLE 3-18. CARGO TANKS AND PORTABLE TANK CONTAINERS FOR SHIPPING ANHYDROUS AMMONIA

<u>KIND OF GAS</u>	<u>MAXIMUM PERMITTED FILLING DENSITY</u>		<u>SPECIFICATIONS CONTAINER REQUIRED</u>		<u>CONTAINER SPECIFICATIONS</u>
	<u>Percent By Weight</u>	<u>Percent By Volume</u>	<u>Maximum Design Type</u>	<u>Pressure (psig)</u>	
Anhydrous Ammonia	56	82	DOT-51		§ 178.245
			MC-330	265	—
			MC-331		178.337

3.2.5.2 Butadiene

Butadiene can be shipped in cylinders, tank cars, cargo tanks and portable tank containers. The applicable cylinder requirements for shipment of butadiene are similar to those for shipping anhydrous ammonia. The tank car types specified for butadiene service and applicable container specifications are shown in Table 3-19.

TABLE 3-19 TANK CARS REQUIRED FOR SHIPPING BUTADIENE

<u>KIND OF GAS</u>	<u>MAXIMUM PERMITTED FILLING DENSITY (PERCENT)</u>	<u>REQUIRED TANK CARS</u>	<u>CONTAINER SPECIFICATION</u>
• Butadiene (pressure not exceeding 75 psi at 105° F), inhibited	See Appendix C	ICC-105A100, 105A100-W 111A100-W-4	§ 179.104 179.104 179.104
• Butadiene (pressure not exceeding 225 psi at 115° F), inhibited	See Appendix C	DOT-112A340-W, 114A340-W	179.105 179.105
• Butadiene (pressure not exceeding 300 psi at 115° F), inhibited.	See Appendix C	DOT-112A400-W, 114A400-W	179.105 179.105

The types of cargo tanks and portable tank containers specified for shipping butadiene and appropriate container specifications are shown in Table 3-20.

TABLE 3-20. CARGO TANKS AND PORTABLE TANK CONTAINERS FOR SHIPPING BUTADIENE

<u>KIND OF GAS</u>	<u>MAXIMUM PERMITTED FILLING DENSITY</u>		<u>SPECIFICATIONS CONTAINER REQUIRED</u>		<u>Maximum Design Container Specifications</u>
	<u>Percent</u>	<u>Percent</u>	<u>Type</u>	<u>Pressure (psig)</u>	
	<u>By Weight</u>	<u>By Volume</u>			
Butadiene	56	82	DOT-51, MC-330, MC-331	265	§ 178.337

3.2.5.3 Chlorine

Chlorine can be shipped in cylinders, tank cars, cargo tanks and portable tank containers. The cylinder types specified for shipping chlorine and applicable container specifications are given in Table 3-21.

TABLE 3-21. CYLINDERS FOR SHIPPING CHLORINE

<u>KIND OF GAS</u>	<u>MAXIMUM PERMITTED FILLING DENSITY (PERCENT)</u>	<u>REQUIRED CYLINDERS</u>	<u>CONTAINER SPECIFICATIONS</u>
Chlorine	125		§
		DOT-3A480;	178.43
		DOT-3AA480;	178.43
		DOT-25;	—
		DOT-3BN480;	178.42
		DOT-3E1800;	178.36
		DOT-3	178.36

The tank cars specified for chlorine service and appropriate container specifications are given in Table 3-22.

TABLE 3-22. TANK CARS SPECIFICATIONS FOR CHLORINE

<u>KIND OF GAS</u>	<u>MAXIMUM PERMITTED FILLING DENSITY (PERCENT)</u>	<u>REQUIRED TANK CARS</u>	<u>CONTAINER SPECIFICATIONS</u>
Chlorine	125		§
		DOT-106A500X;	179.300
		DOT-105A500W	179.104

The types of cargo tanks and portable tank containers required for chlorine shipment and appropriate container specifications are shown in Table 3-23.

TABLE 3-23. CARGO TANKS AND PORTABLE TANK CONTAINERS FOR SHIPPING CHLORINE

<u>KIND OF GAS</u>	<u>MAXIMUM PERMITTED FILLING DENSITY</u> Percent By Weight	<u>SPECIFICATIONS</u> <u>CONTAINER REQUIRED</u>		<u>Container Specifications</u> §
		<u>Type</u>	<u>Maximum Design</u>	
			<u>Pressure (psig)</u>	
Chlorine	125	MC-330	225	—
		MC-331		178.337

3.2.5.4 Ethylene Oxide

Ethylene oxide can be shipped in cylinders; in steel drums with capacities not exceeding 61 gallons equipped with fusible plug safety devices; 105A100W^(§179.104) or 111A100W4^(§179.200) tank cars; insulated portable tanks not exceeding 300 gallons in capacity; insulated 12 ounce metal containers with a safety vent, overpacked in wooden or fiberboard boxes; inside containers of sealed glass ampules or vials (capacity not more than 100 grams each) or aluminum cartridges (capacity not more than 135 grams each) cushioned in noncombustible material and overpacked in strong, noncombustible outside packaging.

3.2.5.5 Hydrazine

Hydrazine can be shipped in glass carboys overpacked in wooden boxes or expanded polystyrene packagings; Type 304 or 307 stainless steel barrels or drums; tank cars; tank motor vehicles (MC310, MC311, or MC312^(§178.343) with 304L or 347 stainless steel); and aluminum drums (spec. 42B,^(§178.107) or 42D^(§178.109)). The tank cars specified for service are: 103CW,^(§179.200) 111A60W7^(§179.200) or 111A100W6,^(§179.200) having tank types 304L or 347 stainless steel. Also, Specification 103A-ALW^(§179.200) or 111A60ALW2^(§179.200) tank cars are authorized. The safety relief devices must be set to 35 p.s.i. and vapor space in the tanks must be filled with nitrogen gas at atmospheric pressure.

3.2.5.6 Liquefied Hydrogen

The only containers specified for liquefied hydrogen are 4L cylinders^(§178.57) and 113A60-W-2^(§179.401) tank cars with a maximum filling density of 6.6 percent.

3.2.5.7 Liquefied Oxygen

Liquefied oxygen can be shipped only in a DOT-4L200 container^(§178.57) with a maximum permitted filling density of 96 percent.

3.2.5.8 Monomethylhydrazine

Packaging permitted for shipment of monomethylhydrazine includes glass carboys overpacked in wooden boxes or expanded polystyrene packagings; 1 gallon capacity glass bottles cushioned by vermiculite in closed tin cans overpacked in wooden boxes; metal barrels and drums (Spec 5,^(§178.80) 5A,^(§178.81) 5C^(§178.83) or 17E^(§178.116)) with type 304 or 347 stainless steel; and tank motor vehicles. Tank motor vehicle types MC300, MC301, MC302, MC303, MC304, MC305, MC306,^(§178.341) MC307,^(§178.342) MC310, MC311 or MC312^(§178.343) without bottom outlets and equipped with steel safety valves are specified.

3.2.5.9 Nitrogen Tetroxide

Nitrogen tetroxide can be transported in stainless steel cylinders, tanks or tank cars. Metal cylinder types 3A480 and 3AA480 (§178.43) tank types 106A500X (§179.300) and 110A500W (§179.300) without safety devices; and 105A500W (§179.104) dedicated tank cars are specified for nitrogen tetroxide transport.

3.2.5.10 Propane

Propane can be shipped in cylinders, tank cars and portable tank containers.

Propane may be shipped in types 3, 3A, (§178.36) 3AA, (§178.39) 3B, (§178.38) 3BN, (§178.39) 3D, (§178.41) 3E, (§178.42) 4, (§178.48) 4A, (§178.49) 4B, (§178.50) 4BA, (§178.51) 4B-ET, (§178.50) 4BW, (§178.50) 4E, (§178.68) 9, 25, 26, 38, 39 or 41 cylinders. Additional cylinder types may be used within the limits shown in Table 3-24 and overpacked in strong wooden or fiber board boxes to protect valves. Also, container specifications have been included.

TABLE 3-24. CYLINDERS FOR SHIPPING PROPANE (LPG)

TYPE OF CONTAINER	MAXIMUM CAPACITY		MAXIMUM CHARGING	Container Specifications
	CUBIC INS. GAL.		PRESSURE (p.s.i.g.)	
DOT-2P OR DOT-2Q	31.83		45 p.s.i.g. at 70 ⁰ F and 105 p.s.i.g. at 130 ⁰ F	178.33 ⁵
DOT 2P or DOT-2Q	31.83		35 p.s.i.g. at 70 ⁰ F and 100 p.s.i.g. at 130 ⁰ F	178.33
DOT-3C or DOT-4C	3,881	6+5% tolerance	145 p.s.i.g. at 130 ⁰ F	178.40 178.52

The tank cars specified for propane service and appropriate container specifications are identified in Table 3-25.

TABLE 3-25. TANK CARS FOR SHIPPING PROPANE (LPG)

PRESSURE NOT EXCEEDING p.s.i.	TEMPERATURE DEGREES F.	FILLING DENSITY	REQUIRED TANK CAR	Container Specifications
75	105	SEE APPENDIX C	ICC-105A100; 105A100-W; 11A100-W-4	170.104
150	105		DOT-105A200-W; 105A200AL-W	179.104
225	105		DOT-105A300-W	179.104
255	115		DOT-112A340-W; 114A340-W	179.105
300	105		DOT-105A400-W	179.104

TABLE 3-25. TANK CARS FOR SHIPPING PROPANE (LPG) (cont'd)

<u>PRESSURE NOT EXCEEDING p.s.i.</u>	<u>TEMPERATURE DEGREES F.</u>	<u>FILLING DENSITY</u>	<u>REQUIRED TANK CAR</u>	<u>Container Specifications</u> §
300	115		DOT-112A400F; 12A400-W; DOT 14A400W	179.105
375	105		DOT-105A500-W	179.104
375	130		DOT-106A500X	179.300
450	105		DOT-105A600-W	179.104

The cargo tanks and portable tank containers approved for shipping LPG are the DOT-51, MC-330 and MC-331.

3.2.5.11 Unsymmetrical Dimethylhydrazine (UDMH)

UDMH can be shipped in glass carboys overpacked in wooden boxes or expanded polystyrene packages; type 304 or 307 stainless steel barrels or drums; 1 gallon capacity bottles cushioned by vermiculite in closed tin cans overpacked in wooden boxes; aluminum drums, tank cars and tank motor vehicles. Tank cars specified for shipping UDMH are the 103W, 103CW, 105A100W, 111A60W1, 111A60W7 and 111A100W4. Also tank car types 105A200W, 105A300W, 105A400W, 105A500W and 105A600W tanks can be used if equipped with safety valves of the type and size used on 105A100W tank cars and the car is stenciled 105A100W. Tank motor vehicles approved for UDMH are MC300, MC301, MC302, MC303, MC304, MC305, MC306, (§178.341) MC307, (§178.342) MC310, MC311 or MC312 (§178.343) without bottom outlets and equipped with steel safety valves.

3.2.5.12 Vinyl Chloride

Vinyl chloride can be shipped in cylinders, tank cars, cargo tanks and portable tank containers. The types of cylinders approved for shipping vinyl chloride and appropriate container specifications are shown in Table 3-26.

TABLE 3-26. CYLINDERS FOR SHIPPING VINYL CHLORIDE

<u>KIND OF GAS</u>	<u>MAXIMUM PERMITTED FILLING DENSITY (PERCENT)</u>	<u>REQUIRED CYLINDERS</u>	<u>Container Specifications</u> §
Vinyl Chloride	84	DOT-4B150, without braced seams;	178.50
		DOT-4BA225, without braced seams;	178.51
		DOT-4BW225;	178.50
		DOT-3A150;	178.36
		DOT-3AA150	178.37
		DOT-25;	
		DOT-3E1800	178.42

The tank car types specified for vinyl chloride service and appropriate container specifications are outlined in Table 3-27.

TABLE 3-27. TANK CARS FOR SHIPPING VINYL CHLORIDE

<u>KIND OF GAS</u>	<u>MAXIMUM PERMITTED FILLING DENSITY (PERCENT)</u>	<u>REQUIRED TANK CARS</u>	<u>Container Specifications</u>
Vinyl Chloride	84	DOT-106A500X	179.300
	87	DOT-105A200W	179.104
	86	DOT-112A340W,	179.105
		114A340W	179.105

The types of cargo tanks and portable tank containers required for shipping vinyl chloride and appropriate container specifications are given in Table 3-28.

TABLE 3-28. CARGO TANKS AND PORTABLE TANK CONTAINERS FOR SHIPPING VINYL CHLORIDE

<u>KIND OF GAS</u>	<u>MAXIMUM PERMITTED FILLING DENSITY</u>	<u>SPECIFICATIONS CONTAINER REQUIRED</u>		<u>Container Specifications</u>
	<u>Percent</u>	<u>Type</u>	<u>Maximum Design Pressure (psig)</u>	
	<u>By Weight</u>			
Vinyl Chloride	84	MC-330;	50	178.337
		MC-331		

3.2.6 Commodity Flow Patterns

An origin-to-destination pattern was established for the chemicals and propellants between the census geographic divisions of the United States. The states included in each of the census geographic divisions are shown in Figure 11. The origin-to-destination pattern is based on the assumption that the commodity flow patterns of the chemicals and propellants can be identified by reviewing the MTB accident/incident files to provide a representative shipment pattern of regional commodity flow. No attempt has been made to quantify the level of shipments between regions. Using this assumption, Table 3-29 through 3-40 have been prepared to show commodity-specific regional origin-to-destination patterns. These tables present and identify the total percentage of shipments originating from and destined for particular census divisions. To observe the commodity flow between or within regions, one must only compare row to column in each table. This commodity flow is based on approximately 10 years of shipments involved in accidents/incidents.

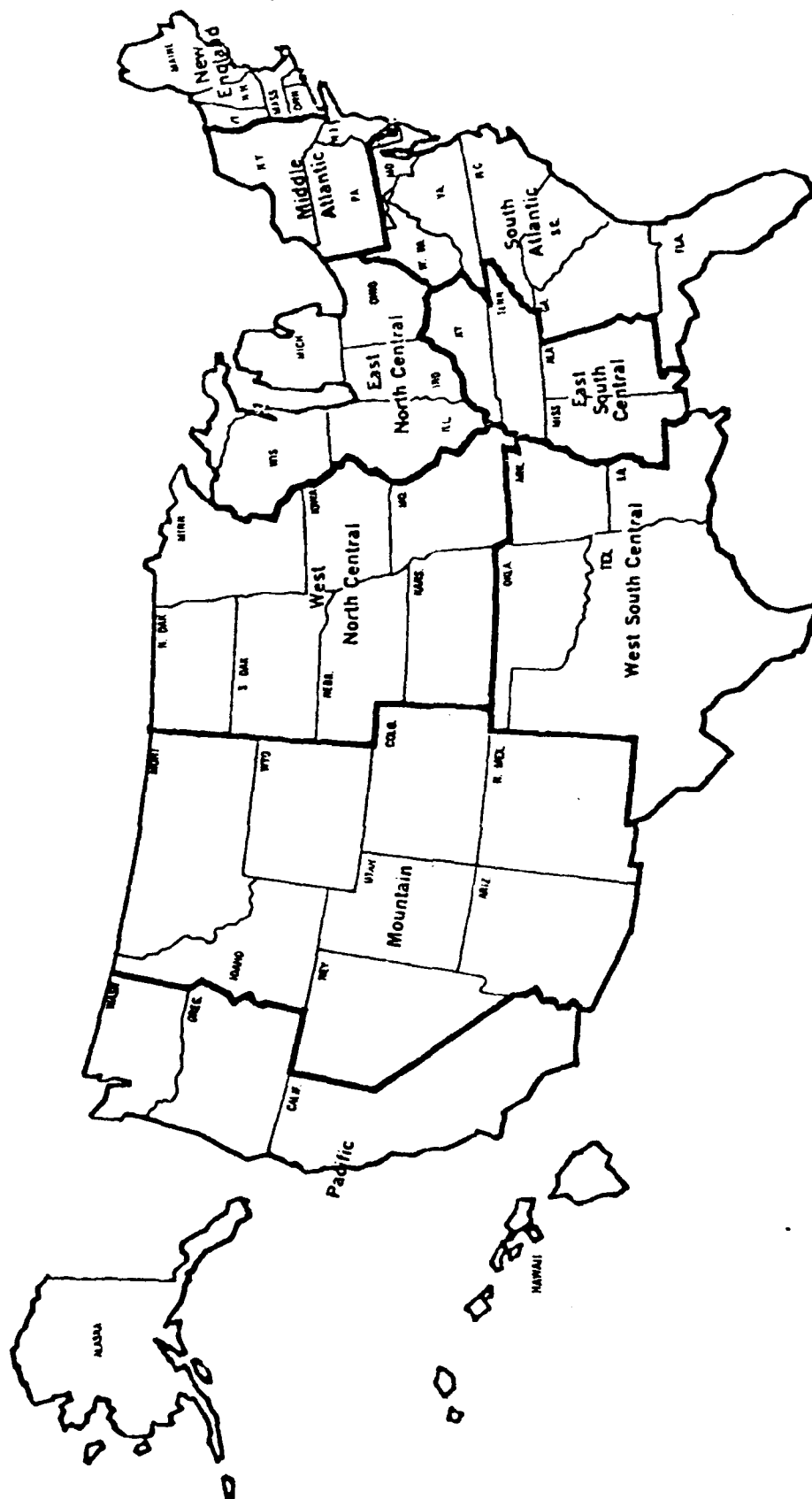


FIGURE 3-12. CENSUS GEOGRAPHIC DIVISIONS OF THE UNITED STATES

TABLE 3-29. ORIGIN-DESTINATION OF ANHYDROUS AMMONIA
(Percentage of total shipments observed)

Region	DESTINATION										Total
	New England	Middle Atlantic	East North Central	East South Central	West North Central	West South Central	South Atlantic	Mountain	Pacific		
New England	0.5	-	-	-	0.2	-	-	-	-	-	0.7
Middle Atlantic	-	4.6	1.0	-	-	-	1.2	-	-	-	6.8
East North Central	-	0.2	13.3	0.7	1.5	-	0.7	-	-	-	16.4
East South Central	0.2	0.3	1.3	3.2	0.2	0.7	2.9	0.2	-	-	9.0
West North Central	-	-	4.9	0.3	14.2	0.3	-	0.5	0.5	-	20.7
West South Central	-	-	1.7	2.0	4.4	12.6	2.9	0.9	0.5	-	25.0
South Atlantic	-	1.0	0.3	0.2	0.3	0.2	6.1	-	-	-	8.1
Mountain	-	-	-	-	-	0.2	-	2.9	0.3	-	3.4
Pacific	-	-	-	-	0.2	-	-	0.7	9.0	-	9.9
Total	0.7	6.1	22.5	6.4	21.0	14.0	13.8	5.2	10.3	-	100

Source: MTB

TABLE 3-30. ORIGIN-DESTINATION OF BUTADIENE
(Percentage of total shipments observed)

Region	DESTINATION										Total
	New England	Middle Atlantic	East North Central	East South Central	West North Central	West South Central	South Atlantic	Mountain	Pacific	Total	
New England	1.6	-	-	-	-	-	-	-	-	1.6	
Middle Atlantic	-	1.6	1.6	-	-	-	1.6	-	-	4.8	
East North Central	-	-	-	-	-	5.2	-	-	-	5.2	
East South Central	-	1.6	-	-	-	-	-	-	-	1.6	
West North Central	-	-	1.6	-	-	-	-	-	1.6	3.2	
West South Central	1.6	3.3	23.0	6.6	-	42.6	4.9	-	-	82.0	
South Atlantic	-	-	-	-	-	1.6	-	-	-	1.6	
Mountain	-	-	-	-	-	-	-	-	-	0	
Pacific	-	-	-	-	-	-	-	-	-	0	
Total	3.2	6.5	26.2	6.6	0	49.4	6.5	0	1.6	100	

Source MT8

TABLE 3-31. ORIGIN-DESTINATION OF CHLORINE
(Percentage of total shipments observed)

Region	ORIGIN										DESTINATION					Total
	New England	Middle Atlantic	East North Central	East South Central	West North Central	West South Central	South Atlantic	Mountain	Pacific	Total						
New England	1.2	-	-	-	1.2	-	-	-	-	2.4	-	-	-	-	-	2.4
Middle Atlantic	1.1	12.0	-	-	-	1.2	2.4	-	-	16.8	-	-	-	-	-	16.8
East North Central	-	1.2	6.0	-	-	-	-	-	-	7.2	-	-	-	-	-	7.2
East South Central	-	1.2	1.2	8.4	-	3.7	1.2	-	-	15.7	-	-	-	-	-	15.7
West North Central	-	-	-	-	1.2	-	-	-	-	1.2	-	-	-	-	-	1.2
West South Central	-	-	1.2	3.7	1.2	14.5	4.8	-	-	25.4	-	-	-	-	-	25.4
South Atlantic	-	2.4	-	-	-	-	16.9	-	-	19.3	-	-	-	-	-	19.3
Mountain	-	-	-	-	-	-	-	2.4	1.2	3.6	-	-	-	-	-	3.6
Pacific	-	-	-	-	1.2	-	-	-	7.2	8.4	-	-	-	-	-	8.4
Total	2.4	16.8	8.4	12.1	4.8	19.4	25.3	2.4	8.4	100	-	-	-	-	-	100

Source: MTB

TABLE 3-32. ORIGIN-DESTINATION OF ETHYLENE OXIDE
(Percentage of total shipments observed)

Region	ORIGIN										Total
	New England	Middle Atlantic	East North Central	East South Central	West North Central	West South Central	South Atlantic	Mountain	Pacific		
New England	-	-	-	-	-	-	-	-	-	0	
Middle Atlantic	-	-	-	9.25	-	-	-	-	-	9.25	
East North Central	-	-	-	-	-	-	-	-	-	0	
East South Central	-	-	-	-	-	-	-	-	-	0	
West North Central	-	-	-	-	-	-	-	-	-	0	
West South Central	-	9.25	27	-	-	18	9.25	-	-	63.5	
South Atlantic	-	18	-	-	-	-	-	-	-	18	
Mountain	-	-	-	-	-	-	-	-	-	0	
Pacific	-	-	-	-	-	-	-	9.25	-	9.25	
Total	0	27.25	27	9.25	0	18	9.25	9.25	0	100	

Source: MTB

TABLE 3-33. ORIGIN-DESTINATION OF HYDRAZINE
(Percentage of total shipments observed)

Region	ORIGIN										DESTINATION						Total
	New England	Middle Atlantic	East North Central	East South Central	West North Central	West South Central	South Atlantic	Mountain	Pacific	Total							
New England	-	-	-	-	-	-	-	-	-	0							
Middle Atlantic	-	50	-	-	-	-	-	-	-	50							
East North Central	-	-	-	-	-	-	-	-	-	0							
East South Central	-	-	-	-	-	-	-	-	-	0							
West North Central	-	-	-	-	-	-	-	-	-	0							
West South Central	-	-	-	-	-	-	-	-	50	50							
South Atlantic	-	-	-	-	-	-	-	-	-	0							
Mountain	-	-	-	-	-	-	-	-	-	0							
Pacific	-	-	-	-	-	-	-	-	-	0							
Total	0	50	0	0	0	0	0	0	50	100							

Source: MTB

TABLE 3-34. ORIGIN-DESTINATION OF LIQUEFIED HYDROGEN
(Percentage of total shipments observed)

Region	DESTINATION										Total
	New England	Middle Atlantic	East North Central	East South Central	West North Central	West South Central	South Atlantic	Mountain	Pacific		
New England	-	-	-	-	-	-	-	-	-	0	
Middle Atlantic	2.1	11.0	-	-	-	-	-	-	-	13.1	
East North Central	-	-	4.3	-	-	-	-	-	-	4.3	
East South Central	-	-	-	-	-	-	-	-	-	0	
West North Central	-	-	-	-	-	-	-	-	-	0	
West South Central	2.1	2.1	6.4	25.5	-	-	12.8	2.1	-	51.0	
South Atlantic	-	2.0	-	-	-	-	2.0	-	-	4.0	
Mountain	-	-	-	-	-	-	-	-	2.1	2.1	
Pacific	-	-	-	-	2.1	4.3	-	2.1	17.0	25.5	
Total	4.2	15.1	10.7	25.5	2.1	4.3	14.8	4.2	19.1	100	

Source: MTA

TABLE 3-35. ORIGIN-DESTINATION OF LIQUEFIED OXYGEN
(Percentage of total shipments observed)

Region	ORIGIN										DESTINATION					Total
	New England	Middle Atlantic	East North Central	East South Central	West North Central	West South Central	South Atlantic	Mountain	Pacific	Total						
New England	6	-	-	-	-	-	-	-	-	6	-	-	-	-	-	6
Middle Atlantic	-	6	-	-	-	-	-	-	-	6	-	-	-	-	-	6
East North Central	-	-	31	-	-	-	-	-	-	31	-	-	-	-	-	31
East South Central	-	6	-	-	-	-	-	-	-	6	-	-	-	-	-	6
West North Central	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	0
West South Central	-	-	-	-	-	13	6	-	-	19	-	-	-	-	-	19
South Atlantic	-	-	-	-	-	-	19	-	-	19	-	-	-	-	-	19
Mountain	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	0
Pacific	-	-	-	-	-	-	-	-	13	13	-	-	-	-	-	13
Total	6	12	31	0	0	13	25	0	13	100	-	-	-	-	-	100

Source: MTB

TABLE 3-36. ORIGIN-DESTINATION OF MMH
(Percentage of total shipments observed)

Region	DESTINATION										Total
	New England	Middle Atlantic	East North Central	East South Central	West North Central	West South Central	South Atlantic	Mountain	Pacific		
New England	-	-	-	-	-	-	-	-	-	-	0
Middle Atlantic	-	-	-	-	-	-	-	-	-	-	0
East North Central	-	-	-	-	-	-	-	-	-	-	0
East South Central	-	-	-	-	-	-	-	-	-	-	0
West North Central	-	-	-	-	-	-	-	-	-	-	0
West South Central	-	-	-	-	-	-	-	-	-	-	0
South Atlantic	-	-	-	-	-	-	-	-	-	-	0
Mountain	-	-	-	-	-	-	100	-	-	-	100
Pacific	-	-	-	-	-	-	-	-	-	-	0
Total	0	0	0	0	0	0	100	0	0	0	100

Source: MT8

TABLE 3-37. ORIGIN-DESTINATION OF NITROGEN TETROXIDE
(Percentage of total shipments observed)

Region	ORIGIN										DESTINATION						Total
	New England	Middle Atlantic	East North Central	East South Central	West North Central	West South Central	South Atlantic	Mountain	Pacific	Total							
New England	-	-	-	-	-	-	-	-	-	0							
Middle Atlantic	-	-	-	-	-	-	-	-	-	0							
East North Central	-	-	-	-	-	-	-	-	-	0							
East South Central	-	-	-	-	-	50	-	-	50	100							
West North Central	-	-	-	-	-	-	-	-	-	0							
West South Central	-	-	-	-	-	-	-	-	-	0							
South Atlantic	-	-	-	-	-	-	-	-	-	0							
Mountain	-	-	-	-	-	-	-	-	-	0							
Pacific	-	-	-	-	-	-	-	-	-	0							
Total	0	0	0	0	0	50	0	0	50	100							

Source: MTB

TABLE 3-38. ORIGIN-DESTINATION OF LPG (PROPANE)
(Percentage of total shipments observed)

Region	DESTINATION									Total
	New England	Middle Atlantic	East North Central	East South Central	West North Central	West South Central	South Atlantic	Mountain	Pacific	
New England	1.5	0.3	0.5	0.3	0.3	-	0.2	-	-	2.0
Middle Atlantic	2.5	6.9	0.5	0.4	0.1	0.4	0.9	0.1	-	11.8
East North Central	0.2	0.2	8.5	0.7	0.7	1.7	0.7	-	-	12.7
East South Central	0.1	0.1	1.1	3.2	-	0.7	1.9	-	0.1	7.2
West North Central	0.1	0.4	2.7	6.1	5.3	0.1	0.5	0.4	-	9.6
West South Central	-	0.4	2.2	3.8	0.9	11.9	4.2	0.4	0.6	24.4
South Atlantic	0.1	1.2	-	0.1	-	-	6.3	0.1	0.1	7.9
Mountain	-	-	0.1	-	0.7	0.2	0.1	12.3	2.6	16.0
Pacific	-	-	0.1	-	0.1	0.1	-	0.5	6.7	7.5
Total	4.5	9.5	15.5	8.6	8.1	15.1	14.8	13.8	10.1	100

Source: MTB

TABLE 3-39. ORIGIN-DESTINATION OF UDMH
(Percentage of total shipments observed)

Region	ORIGIN										DESTINATION									
	New England	Middle Atlantic	East North Central	East South Central	West North Central	West South Central	South Atlantic	Mountain	Pacific	Total	New England	Middle Atlantic	East North Central	East South Central	West North Central	West South Central	South Atlantic	Mountain	Pacific	Total
New England	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0
Middle Atlantic	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0
East North Central	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0
East South Central	-	-	-	20	-	-	-	-	-	20	-	-	-	-	-	-	-	-	-	20
West North Central	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0
West South Central	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0
South Atlantic	-	20	-	-	-	-	-	-	-	20	-	-	-	-	-	-	-	-	-	20
Mountain	-	-	-	-	-	-	-	-	-	20	-	-	-	-	-	-	-	20	-	20
Pacific	-	-	-	-	20	-	-	-	-	-	-	-	-	-	20	-	-	20	-	20
Total	0	20	0	20	20	0	20	0	0	100	0	20	0	20	20	0	0	40	0	100

Source: MTR

TABLE 3-40. ORIGIN-DESTINATION OF VINYL CHLORIDE
(Percentage of total shipments observed)

Region	ORIGIN										DESTINATION					Total
	New England	Middle Atlantic	East North Central	East South Central	West North Central	West South Central	South Atlantic	Mountain	Pacific	Total						
New England	-	-	-	-	-	-	-	-	-	0						
Middle Atlantic	-	7	-	-	-	-	-	-	-	7						
East North Central	-	-	3.5	-	-	-	-	-	-	3.5						
East South Central	-	-	3.5	7	-	-	-	-	-	10.5						
West North Central	4	-	4	-	-	-	-	-	-	8						
West South Central	7	11	14	7	-	32	-	-	-	71						
South Atlantic	-	-	-	-	-	-	-	-	-	0						
Mountain	-	-	-	-	-	-	-	-	-	0						
Pacific	-	-	-	-	-	-	-	-	-	0						
Total	11	18	25	14	0	32	0	0	0	100						

Source: MTB

3.2.7 Disposal Sites

Disposal of spill residues and debris resulting from hazardous materials accidents is considered a hazardous waste problem by the EPA and State and local agencies. It can become an extremely costly and time consuming issue for a carrier or shipper if no appropriate sites are available. Therefore, Figure 3-13 has been prepared to show the geographic distribution of hazardous waste disposal facilities with adequate hazardous waste management capabilities. A complete listing of each site including address, phone number, facility contact, wastes handled and disposal service available is presented in Appendix B. The appropriate hazardous waste management office, both at the State and EPA regional level, can also be found in Appendix B. Most of these data were obtained from EPA Office of Solid Waste. EPA has the congressional mandate of implementing the Resource Conservation and Recovery Act (RCRA) and last year (May 22, 1980) promulgated regulations concerning standards for storage, treatment and disposal facilities. The new standards are extremely stringent and have strict procedures for environmental controls, safety and security measures and monitoring requirements.

3.2.8 Chemical and Propellant Transportation Accidents

A computer listing of accidents/incidents reported to the MTB for the period January 1971 through August 1980 involving the specific chemicals and propellants in this study was reviewed. In particular, for the specific chemicals the following was identified:

- total number of accidents;
- annual number of accidents;
- total number of accidents and percentage of total accidents by railroad and highway modes;
- total number of fatalities and injuries;
- annual number of fatalities and injuries;
- average number of fatalities and injuries per accident;
- total damage (dollars) from all accidents; and
- dollar damage per accident.

Table 3-41 has been prepared to show variation in accident histories of the chemicals and propellants during transport. It can be seen that LPG has the greatest frequency of total accidents and the highest average annual number of accidents while monomethylhydrazine has the lowest. The data indicate that four (4) of the twelve chemicals and propellants (hydrazine, MMH, nitrogen tetroxide and UDMH) would be expected to be involved in less than one (1) accident per year.

An examination of the transportation mode reveals that in 100% of the accidents/incidents involving hydrazine, MMH, nitrogen tetroxide and UDMH, the shipments were by highway. The accident frequencies of the remaining chemicals were distributed between both the highway and the rail mode. However, 95% of all

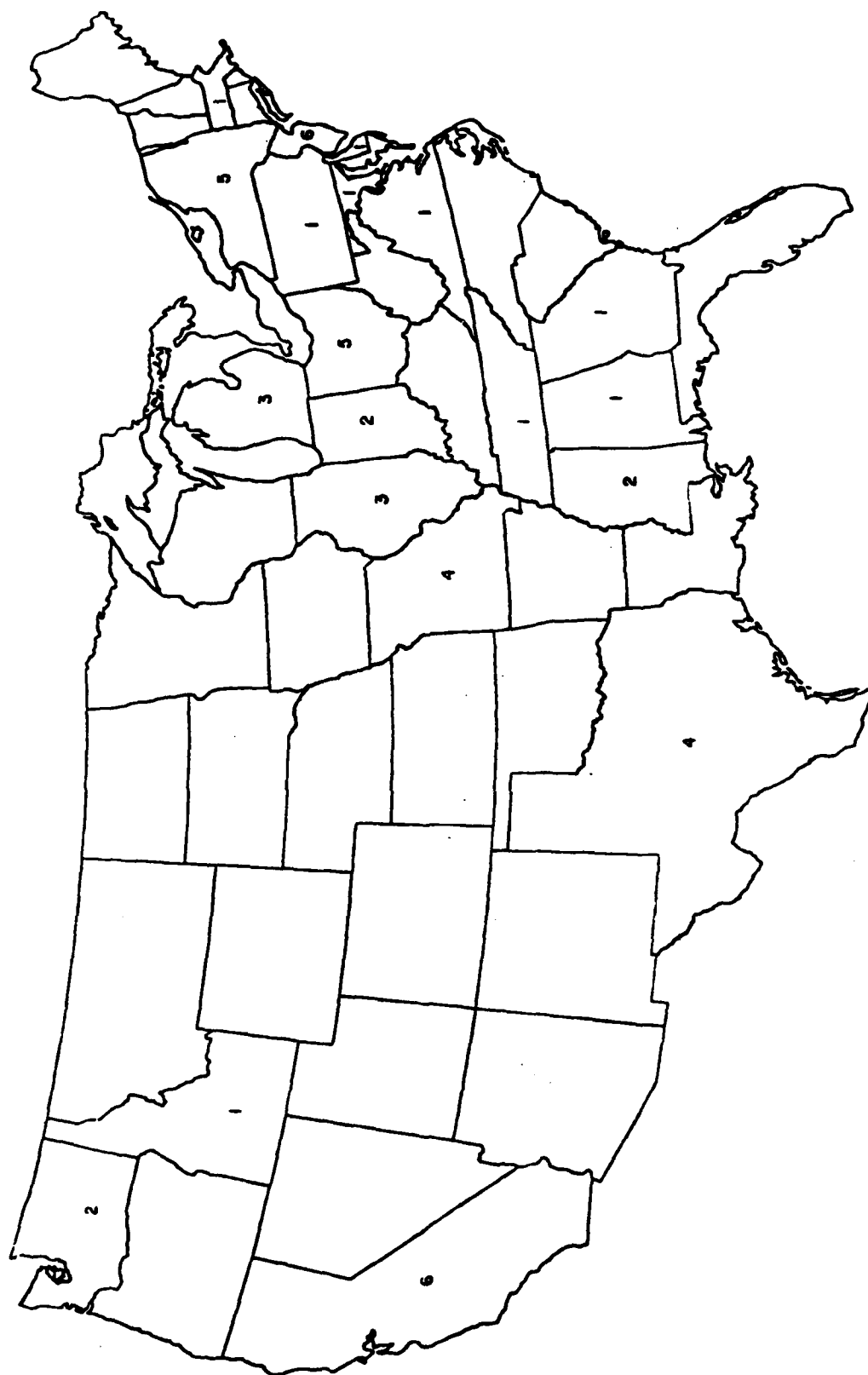


FIGURE 3-13. NUMBER OF HAZARDOUS WASTE DISPOSAL SITES PER STATE

TABLE 3-41. CHEMICAL/PROPELLANT ACCIDENTS

Chemical/Propellant	Total Number of Accidents	Average Number of Accidents Per Year	MODE OF TRANSPORTATION INVOLVED IN ACCIDENT				FATALITIES		INJURIES		ACCIDENT COST \$(1,000's)	
			HIGHWAY		RAILROAD		Total Number	Average Number of Fatalities Per Accident	Total Number	Average Number of Injuries Per Accident	Total Cost of Accidents	Average Cost Per Accident
			Total Number of Accidents	Percentage of Total Accidents	Total Number of Accidents	Percentage of Total Accidents						
Acetylene/Ammonia	586	61	149	25	637	75	17	0.03	473	0.82	1867.91	3.24
Butadiene	61	6	3	5	58	95	1	0.02	15	0.29	1881.65	36.19
Chlorine	83	9	17	20	66	80	8	0.1	377	4.6	1158.05	14.12
Ethylene Oxide	11	1	5	45	6	55	0	0	0	0	71.78	6.53
Hydrazine	2	0.2	2	100	0	0	0	0	0	0	0.022	0.011
Liquefied Hydrogen	47	5	44	94	3	6	0	0	0	0	106.04	2.26
Liquefied Oxygen	16	2	6	37	10	63	1	0.06	2	0.33	26.44	1.65
Monomethylhydrazine	1	0.1	1	100	0	0	0	0	0	0	0.001	0.001
Nitrogen Tetroxide	2	0.2	2	100	0	0	0	0	0	0	15.1	7.55
Propane (LPG file)	808	84	245	30	563	70	55	0.07	668	0.84	18523.27	23.15
Unsymmetrical Dimethylhydrazine	5	0.5	5	100	0	0	0	0	2	0.4	1.18	0.236
Vinyl Chloride	28	3	2	70	26	93	0	0	1	0.04	504.11	18.00

*Data Base Covers 9.6 Years

Source: MTB

accidents/incidents involving shipment of butadiene, 80% of chlorine-involved accidents, and 93% of the accidents involving vinyl chloride occurred during rail transport.

An analysis of accident severity involving highway and railroad shipments of these commodities reveals that in accidents/incidents involving transport of chlorine, one (1) fatality per ten accidents occurred. Other commodities in which fatalities have occurred include anhydrous ammonia, butadiene, liquefied oxygen and LPG, but the average is considerably lower. Accidents/incidents involving chlorine indicate a projected 4.6 injuries per occurrence. Other accidents/incidents involving shipments of anhydrous ammonia, butadiene, liquefied oxygen, LPG, UDMH and vinyl chloride resulted in injuries, but at a lesser frequency than in chlorine-related accidents. However this is slightly misleading because no chlorine-related deaths occurred at all until February, 1978 with the Youngstown, FL derailment.

Accident damage from these chemicals and propellants range from \$36,200 to an insignificant amount per occurrence. MMH had the lowest average accident cost of approximately \$1, but since this figure is comprised of data from only one accident, it cannot be considered representative of all accidents involving MMH. Total damage cost for accidents involving the 12 chemicals and propellants equalled \$24 million.

In summary, these data, on the average, indicate that LPG shipment results in the greatest frequency of accidents/incidents by both highway and rail modes; chlorine results in the most severe accidents in terms of fatalities and injuries; and accidents/incidents involving butadiene results in the greatest damage cost per accident. This data base excludes accidents not reported to the DOT Materials Transportation Bureau.

4. ASSESSMENT OF CURRENT METHODS AND PROCEDURES

In this chapter current capabilities for handling transportation emergencies involving the selected chemicals and propellants are reviewed. Following this, an in-depth review of the successes or failures of these procedures as applied to selected NTSB-investigated accidents are presented. This leads naturally into a detailed study to develop the most efficient procedures which begins with consideration of existing response guides and how they could be expanded or improved.

4.1 OVERVIEW OF EMERGENCY RESPONSE PROCEDURES AND RESOURCES AVAILABLE

This section presents an overview of current capabilities of the emergency response community in terms of on-scene accident procedures and resources available. The emergency response community is comprised of several segments at various levels.

The largest is, of course, the Federal segment under the National Oil and Hazardous Materials Contingency Plan. The National Response Team is headed by co-chairmen from the EPA and USCG with the National Response Center (NRC) as its nerve center. It reaches from Washington, D.C. throughout each EPA region and Coast Guard District in the form of regional response teams (RRT) which include State and local agencies as well as industrial and academic technical expertise.

The next autonomous level is the State, which sometimes in concert with the Federal program but more often on its own initiatives, develops a State contingency plan for hazardous material emergencies. This type of statewide planning for hazardous materials incidents is, however, at a very preliminary stage.

The state further stands on the shoulders of county, local and community agencies which deal with the problem face-to-face. It is the local fire, police, civil defense and emergency units which are the first responders. It is this segment which most urgently needs the written procedures and guidelines to protect life, property and the environment.

This governmental sequence appears logical and telescoping. However, the reality is that starting at the top, the Federal Government has attacked the emergency response problem in a diffuse, uncoordinated manner providing no overall guidelines for

all hazardous material emergencies until very recently with the expansion and revision of the National Contingency Plan. Funding for training programs, setting up and equipping response teams has also been difficult at the State and local levels.

The transportation industry is made up of vehicle and container manufacturers, chemical shippers, rail, highway, air and water carriers, and trade associations. Within this industry there are many different levels of sophistication and expertise, different views and responses to common problems. Most carriers depend upon shippers for information on a commodity and how it will react in various transportation environments. Shippers often provide this assistance on-scene to carriers (e.g., CHLOREP teams for spills or leaks of chlorine) and by telephone via CHEMTREC (Chemical Transportation Emergency Center). Rail carriers are developing in-house capabilities to augment existing response provided by the Bureau of Explosives. The problem of liability as well as the large gray area of uncertainty surrounding the whole emergency response picture has prevented industry from acting in a concerted and cooperative manner to develop procedures to address hazardous chemical transportation emergencies.

The large and persistent need for technical assistance in handling these emergencies, however, has fostered a new growing industry—the environmental cleanup and disposal contractor. This business has the personnel, equipment and expertise for quick emergency response and will sell these services which are in great demand.

The present overview of emergency response procedures and resources, therefore, shows a multifaceted mixture of players with varying levels of expertise and capabilities in terms of contingency plans, handling procedures, resources available (both personnel and equipment) and the problems peculiar to each individual segment.

The following groups were reviewed regarding emergency response procedures, contingency plans and resources available:

1. State Agencies
2. Local Emergency Services
3. Shippers
4. Rail Carriers
5. Tank Truck Carriers
6. Vehicle and Container Manufacturers
7. Trade Associations
8. Cleanup/Disposal Contractors

4.1.1 State Agencies

For many years every State has had a Civil Defense/Disaster Preparedness organization, which reached down to the community level and which was tied into the former Defense Civil Preparedness Agency (DCPA). This organization and its functions were incorporated into the recently established Federal Emergency Management Agency (FEMA). The DCPA organization concentrated on defense against nuclear attack, but has played an assistance role in various natural catastrophies and other serious accidents, as well as in emergency planning activities. In 1978-1979, DCPA officials were convinced of the common interests and factors involved between emergency preparedness and the transportation of hazardous materials (HM). Thus, DCPA and agencies concerned with hazardous materials transportation approved the utilization of remaining State grant monies for purchasing the DOT-NFPA course and attending the related seminars conducted by NFPA on handling hazardous materials transportation emergencies.

These actions and the increasing public awareness of HM transportation, publicity from the news media, additional occurrences of HM accidents and the deliberate efforts by government and industry to develop and promulgate training courses have created an awareness of HM transportation hazards and stimulated action to improve safety.

For the most part, these have been independent efforts, however, there exists a nearly universal recognition that these must all be tied together into one system for obtaining safety and cost-effectiveness. The current status at the state, regional and local levels varies from highly sophisticated plans, training, capabilities and equipment to essentially no capability or preparation. If the trends of the last five years continue, there should be continued significant improvement in HM transportation emergency response and hazards mitigation efforts.

The following are examples of what states have been or are doing with respect to improving HM transportation safety. This analysis is based on a survey of selected states.

1. South Dakota. The Division of Emergency and Disaster Services is responsible for putting together a Hazardous Materials Emergency Response Plan (no plan presently exists) with input from all Department Secretaries via a questionnaire about HM response within their organizations. They are reworking a previously proposed plan, which was vetoed by the Governor because of some conflict and confusion concerning certain departmental authorities. This proposed plan should see action early in 1981 in the State Legislature.

2. Pennsylvania. The Pennsylvania Emergency Management Agency has a disaster control contingency plan. One procedural area addressed is evacuation. The decision to evacuate if a hazardous product is released is usually made by the fire chief and/or police and/or elected local officials after contact with CHEMTREC or the State's Hazardous Substances Transportation Board (HSTB) based on such criteria as hazard potential, estimated time to evacuate, risk of evacuation to the populace and the number and types of evacuees.

Metropolitan areas are usually well equipped to handle emergencies. However, all the fire departments are inadequately or inappropriately equipped, particularly with respect to apparatus and personnel protective equipment for handling exotic chemicals. Usually no specialists are close enough to be of assistance. First responders usually have only basic training and are not prepared to handle a severe HM emergency.

Other problems and deficiencies were noted. Most training programs focus on pre-planning and this is important. However, there is an urgent need to prepare the personnel for making decisions that must be made at the immediate scene. Many communities do not have response plans. This creates confusion and a severe problem in identifying the on-scene commander. This is compounded with volunteer organizations because no clean lines of authority exist. Thus, depending upon the severity of the situation, everyone or no one wants to be in charge. This situation cripples response efforts. The time elapsed before response by qualified personnel can be lengthy for such reasons as: (1) existence of few organized (and prepared) response organizations; (2) no structured geographically aligned response network; and (3) usually travel is by car, so adverse weather and reaching remote locations consume time.

Until early 1980, the HSTB responded to accidents and incidents. This was discontinued primarily due to lack of trained personnel. However, a 24-hour advisory service continues to be provided.

3. Virginia. The Commonwealth of Virginia has designated its Office of Environmental and Emergency Services (OEES) as the focal point for state planning and response activities to hazardous materials accidents. The OEES operates a fully-equipped response van. The mobile state-operated response van is equipped with such gear as communications equipment, breathing apparatus, toxic gas detectors, etc. Virginia has geographically divided the state into four response regions, each region being served by a Regional Response Team. Each team consists of personnel trained in fire science, chemistry, command and control techniques, on-scene coordination, industrial

hygiene, equipment requirements for handling hazardous materials (e.g., heavy equipment, fire equipment, emergency medical equipment and pollution response equipment), public information and communications.

The Regional Response Teams are activated at the request of any of the 139 local jurisdictions who may be faced with a hazardous material transportation accident.

The State has a contingency plan for manmade disasters but response procedures most often are based on policy developed on the local level. Evacuation procedures are identified by the officer-in-charge based on knowledge and "worst case" hazards of the material involved. Private contractors who have response capabilities and equipment also assist the state.

Mutual aid agreements exist between the many localities in Virginia. Consequently, Virginia contends that these mutual aid agreements provide adequate protection to the civilian population.

Experience, however, has shown that responders in urban areas have more response capabilities than rural areas. This is most likely due to the fact that urban areas have larger populations which need to be protected and more money to commit to response efforts.

4. California An analysis of current hazardous materials emergency response capabilities was conducted by the California Highway Patrol for the State legislature to identify problem areas for improving statewide response. The existing response capabilities were analyzed for a hypothetical hazardous materials spill as shown in Table 4-1. From this analysis, required items such as initial response, material identification, containment and cleanup and disposal procedures were identified. Action items were also established in terms of containment procedures. Table 4-2 outlines these guidelines.

The results of this analysis emphasized the need for: (1) a uniform statewide hazardous material contingency spill plan, which outlines management, identification, containment, cleanup and disposal and site restoration procedures for transportation-related accidents; (2) improved training of firefighting personnel; (3) improved communications between the public and response groups; (4) immediate identification of the on-scene coordinator at the accident site; (5) regionalized response teams with mobile capabilities; (6) an integrated statewide response communication network; (7) local contingency plans integrated into the state plan; (8) a single agency in state government responsible for handling response planning; (9) a state superfund which would be available for emergency cleanup and disposal needs as warranted; and (10) any

TABLE 4-1

SEQUENCE OF EVENTS FOLLOWING A HAZARDOUS MATERIAL SPILL
FROM THE CALIFORNIA HAZARDOUS SUBSTANCE HIGHWAY SPILLS STUDY

<u>Sequence of Events</u>		<u>Action Items</u>	<u>Responsibility</u>
1.	Accident Occurs	No action items or responsibility by any governmental agency because it is assumed they have not yet arrived on the scene.	
2.	Spill Results		
3.	Public Exposure		
4.	Confusion		
5.	Incident Reported	Receive and transmit all pertinent information, call ambulance and fire department, if necessary, with pertinent information.	Dispatcher with law enforcement agency which first arrives on scene
6.	Public Aids Scene	May arrive prior to emergency vehicles	
7.	Initial Emergency	Responding agency (i.e., CHP, FD, Sheriff) receives information enroute to the scene.	Responding law enforcement agency
8.	Incident Appraisal a. Rescue Victim(s) b. Protect Scene c. Recognition of material	Responding emergency or law enforcement agency "sizes up" the scene on arrival and requests assistance if necessary.	Responding law enforcement agency
9.	Initial Decision-Making Process On Scene. a. Recognition of spill b. Rescue c. Protect surroundings	Request presence of a fire dept. Call for a road agency: a. Caltrans b. Local public works dept. c. Call emergency medical if necessary	Responding law enforcement agency
10.	Identification of the material by the responding agency a. Known substance b. Unknown substance	Check with driver if he is conscious. Check the placards on the vehicle. Check the bill of lading in the vehicle. Check the container(s) itself.	Law enforcement with assistance of Fire Department

TABLE 4-1 (continued)

<u>Sequence of Events</u>	<u>Action Items</u>	<u>Responsibilities</u>
11. Call for assistance in the identification of the substance. a. Known b. Unknown (Call to be made in both cases)	Call CHEMTREC immediately Call the carrier immediately Call the product manufacturer (if known).	Through the responding law enforcement's radio dispatcher
12. Initial Control Measures (Containment)	Confine the incident to protect the public a. Detour traffic? b. Evacuate the area?	Law enforcement with assistance of Caltrans, Public Works & Fire Dept.
13. Set up a Field Coordination Post	Communication Center at spill site. A one spot public information area.	Law enforcement with assistance from Caltrans, Public Works & Fire Dept.
14. Containment of the spill	Attempt to localize the incident until the cleanup crew arrives.	Law enforcement with much assistance from Caltrans or Public Works
15. Cleanup of the spill	Absorb, neutralize and pick-up.	Chemical Co. Carrier Contracted Vacuum Truck
16. Disposal of the Spilled Material	In accordance with government guidelines or regulations.	Carrier Chemical Co. Vacuum Truck
17. Reports re: Accident and Clean-up	All parties involved are to complete necessary forms.	Each agency

TABLE 4-2

CONTAINMENT GUIDELINES
FROM THE CALIFORNIA HAZARDOUS SUBSTANCE HIGHWAY SPILLS STUDY

Containment of a hazardous substance spill on a highway is one of the primary actions to be considered during appraisal of an incident.

After determining the hazard classification (explosive, poison, flammable, etc.), these basic steps may be taken to prevent further contamination.

1. Determine if material can be contained by:
 - a. Covering with sheeting (powders, granules, crystals)
 - b. Diked, with sand bags or earthen dams (liquids)
 - c. Covering with sand or an absorbent material
2. Determine if material can be diluted with water or neutralized by using additives. This step should be considered only after consulting with containment and cleanup experts and all information sources available.
3. In some incidents, the only alternatives may be to close down the highway and:
 - a. Evacuate the immediate area, determined by size of spill, leak, and/or the amount being transported.
 - b. Evacuate downwind or downhill from spill or leak area. Determined by geographical location and/or weather conditions.
 - c. Follow procedures 3a, 3b, and wait for the hazardous substance to dissipate, such as flammable or poisonous gases, etc.
4. List of local containment and clean-up agencies or industries.
 - a. Chemical, City, Highways, or Road Departments.
 - b. Chemical companies, oil, pesticides, etc.
 - c. Private industry, vacuum trucks, etc.
 - d. Emergency phone number of above and other information.
 - e. Selection checklist. Used to determine if responders will be adequately equipped.

TABLE 4-2 (continued)

- (1) Communications: Are adequate communications facilities available between field and office and are they sufficiently manned? Are communications available for use among workers at the spill site?
- (2) 24-Hour Availability: Are management personnel available by designation on a 24-hour basis? Is a labor force 24-hour available? Will they submit and maintain a list of available management people to call during other than normal business hours? Is their equipment 24-hour available?
- (3) Trained Personnel: Are their supervisory people properly trained in the handling of hazardous materials spills? Is their labor force so trained? Do they have a trained technical force? Are adequate training records kept, and are these records subject to your inspection?
- (4) Equipment:
 - (a) Vacuum trucks: What sizes, how many, what types, i.e., mild steel, stainless steel, coated, rubberlined, etc. Are both wet and dry type trucks available? Check to see if tanks are ASME Coded; if the contractor is a State licensed liquid waste hauler; if fire marshal permits are current; check for types of hose ends, valves, or miscellaneous fittings used (some oil haulers, drilling field operators, and septic tank operators use aluminum fittings that are not acceptable in corrosive service). Diesel driven trucks and compressors are preferable to gas driven, especially where volatile chemicals are involved. Check on the safety reputation of the carrier. Ensure all trucks carry and use ground cables. Ensure that drivers/operators are aware of smoking regulations around flammables. Ask to see and inspect training programs.
 - (b) Support Equipment: Fresh air breathing apparatus, construction equipment, pumps, hoses, heavy duty cleaning equipment, containment equipment. Dedicated hazardous spill response equipment, spark resistant tools and lighting.
- (5) Industry Reputation: Will he submit a list of customers utilizing his service in the transportation, handling or cleaning up of hazardous materials or their vessels?

TABLE 4-2 (continued)

- (6) Access to State Approved Disposal Facilities Does contractor use State Approved Class I facilities? Is he a licensed waste hauler? if he does not have 24-hour access to the waste facility, can he safely and legally store the hazardous material until the waste facility opens?
- (7) Heavy Duty Tow Trucks: Does he own or have 24-hour access to a reliable heavy duty tow service that is familiar with and will comply with his safety standards?
- (8) Cranes: Same as (7).
- (9) Adequate Insurance Coverage: Does the contractor have, or is he willing to acquire adequate insurance coverage for not only his own people, but other potential liabilities?

contingency plan to be sensitive to the dynamics of future chemical technology development and production and changing demographic patterns.

4.1.2 Local Emergency Services

The response capabilities and available resources of emergency services in various localities show that problems exist in terms of hazardous material identification, tank damage assessment, firefighting procedures and lack of sufficient equipment and trained personnel. Due to the fragmentation and diversity of the local response community it is difficult to transmit hazardous materials information to all groups. In fact, the majority of groups have not been trained in hazardous materials response. It is not because of the lack of availability of training programs or groups willing to present them. Groups such as the AAR and NFPA have excellent training programs. The problem is rather due to the fact that response organizations such as fire departments are, in many localities, made up of volunteers who hold other jobs and find it difficult to make time for such training courses. Also, volunteer firefighters often feel that hazardous materials training based on the very small percentage of HM incidents, is not really necessary. There is also a lack of sufficient equipment on a local basis because of the economics involved. Most localities have the basic equipment necessary for handling fires, but specialized equipment is usually found only in highly populated areas where the threshold population is large enough and the hazards presented are big enough to warrant and support specialized equipment and services. Due to this lack of training, the diversity of hazardous materials being transported, economic factors, and the fragmentation of firefighting units in the U.S., commodity-specific firefighting procedures have not been adopted for all chemicals. The new DOT emergency guidebook keys responses to UN identification numbers. Perhaps this system will help the local emergency services with the identification problems which are so vital to them as the first responders at an accident scene.

4.1.3 Shippers

Many rail and highway shippers have the resources and capabilities to send trained personnel to respond to a transportation emergency and provide expertise in handling hazardous materials. Most carriers will seek assistance through CHEMTREC, an information clearinghouse formed by the Chemical Manufacturers Association (CMA), which provides recommended emergency information to callers from the scene of an accident. Response teams such as CHLOREP for chlorine emergencies arrive equipped with recommended safety equipment and provide technical expertise to the on-scene coordinator. It appears that shippers are more than willing to provide assistance when needed.

4.1.4 Rail Carriers

Rail carriers have historically relied upon shippers, the AAR Bureau of Explosives and more recently, contractors for on-scene emergency response assistance in terms of correcting leaks, transferring loads and cleaning up chemical spills. Some railroads rely solely on outside sources; they do not train personnel to respond to chemical spills and do not maintain specialized response material or equipment other than sorbents. However, a few railroads are training personnel to develop in-house capabilities to respond to chemical transportation emergencies, identify materials and hazards and assess container integrity (excluding pressure vessels) at a derailment, while still depending on the shipper, Bureau inspector and contractors for specialized expertise and equipment, including transfer pumps, hoses, patching devices and tools. One railroad is further developing a sophisticated response system complete with a network of inspectors, vehicles with personnel protective equipment, analytical sampling and testing equipment and communications equipment to respond to derailments. However, cleanup and disposal is still contracted out. Another railroad has trained and equipped a response team complete with the latest personnel protective equipment, tools for adjustments and repairs on tank cars and equipment for assessing toxic and explosive vapor levels. This railroad has a detailed "Emergency Action Plan for Accidents Involving Hazardous Materials" which is updated regularly.

Even with the various approaches of different railroads to the emergency response problem, all seem to agree upon the necessity of the shippers' cooperation in providing assistance on handling specific commodities, and on the use of contractors for cleanup and disposal.

4.1.5 Tank Truck Carriers

Tank truck carriers face many problems similar to those of rail carriers. However, the potential consequences of an accident involving highway shipments are less severe than in a derailment because of the smaller quantities of hazardous material involved. In the rail mode, many hazardous materials may be involved in the accident at one time, while highway accidents usually involve only a single hazardous commodity. The major shippers of hazardous materials provide training for drivers in handling emergency situations involving some of the propellants such as the hydrazines. Most rely on the technical expertise of the shipper for hazard assessment capabilities and emergency response. Tank truck carriers do not provide or recommend cleanup/disposal or wreckage removal services. Local contractors are used as appropriate for these services.

4.1.6 Vehicle and Container Manufacturers

The tank manufacturing industry does not respond to rail or highway accidents involving their products. Since they are concerned with the container and not the potentially hazardous contents to be carried, damaged tank cars or tank trucks are handled by wreckage removal contractors. There seems to be a consensus that once a tank is manufactured, the responsibility for its maintenance is that of the owner. There have been improvements and a standardization of tank designs, but this has been carried out to provide quality control in the manufacturing process and not necessarily to improve safety.

4.1.7 Trade Associations

Trade associations provide useful handling and response information and procedures to local jurisdictions through which hazardous materials are being transported. Several trade associations (e.g., AAR Bureau of Explosives, CMA, CHLOREP, Pesticide Safety Team Network) have specifically trained response teams strategically located around the U.S. ready to respond to an accident. These teams have specific expertise in handling and hazard mitigation techniques for use at accidents involving these materials. Liability considerations have in the past hampered industry cooperative efforts to pool expertise for response purposes. However, these cooperative efforts are on-going and hopefully will continue.

4.1.8 Cleanup and Disposal Contractors

Cleanup and disposal contractors are hired by carriers to discard lading once spilled, damaged or destroyed in an accident. During a hazardous materials accident, however, the situation is extremely complex. Due to the specialized nature of many hazardous materials, very few companies have moved into the business of handling cleanup and disposal of hazardous materials. Also, since there are so many hazardous materials being transported, it is believed that industry is logistically and financially unable to purchase sufficient equipment for adequately handling many of the hazards which might be encountered. In fact, technology has yet to be developed to treat all hazardous materials. The industry feels that a contributing factor to several hazardous materials accidents is the laxity of shippers and carriers in strictly complying with the government regulations for shipping hazardous materials. Some contractors believe that to optimize safety and minimize costs, local jurisdictions and regional organizations need to pool resources and equipment to use effectively specialized service.

4.2 ACCIDENT OVERVIEW

4.2.1 General Overview

Sixteen NTSB accident reports⁽⁶⁴⁻⁸⁰⁾ were reviewed to obtain both highway and rail transportation accident pictures for the chemicals and propellants in this study. The accidents of interest are listed in Table 4-3, along with their NTSB report number for easy access. General information on notification emergency responders and equipment, communications systems, on-scene coordination, and cleanup and disposal procedures were catalogued.

The rail incidents involving ammonia and propane appeared more severe than the highway in terms of product loss with resultant fire and explosions and number of hazardous materials potentially involved because rail transportation involves multiple bulk containers (up to 33,000 gallons per tank car) in one train move. While the highway tank truck accidents were smaller in scope and number of hazardous materials involved, they were equally as severe as the rail accidents in terms of death, injuries and damage to property. Both rail and highway accident severity can be increased or decreased depending on location and the population density exposure near the accident scene.

The major safety issue involved in all these accidents appeared to be the threat of leak, ignition, fire, tank rupture and explosion. The only incident which had other imperatives was the Crestview, Florida derailment involving chlorine, ammonia and several other hazardous materials. Release of these materials posed a serious pollution threat to the Yellow River which brought the Federal Regional Response Team with a designated On-Scene Coordinator to the scene. However, this organization was activated in response to potential environmental damage rather than to address safety and hazard mitigation needs.

In all cases, local police and fire departments or emergency rescue units were the first responders at the accident scene. The fire departments, many of which were manned by volunteers, were almost totally untrained, unprepared and ill-equipped to handle fires of the magnitude and intensity of propane, butadiene or vinyl chloride. In several cases, firefighting personnel were injured or killed because they did not fully realize the hazards involved and were simply too close to resulting explosions and fire. There were pre-established systems or community contingency plans in only seven of the sixteen accidents, and even in those seven cases, local emergency response personnel were still not prepared for the magnitude of the incident.

In the accident involving ammonia and chlorine, fire was not the overriding safety issue; rather, it was reducing the risk of exposure to people in the area from inhalation of toxic, corrosive vapors.

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POST ACCIDENT PROCEDURES FOR CHEMICALS AND PROPELLANTS

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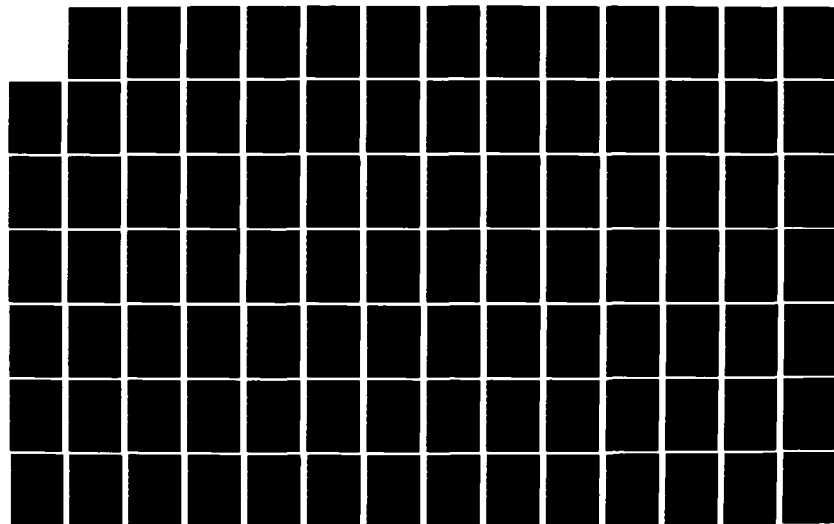
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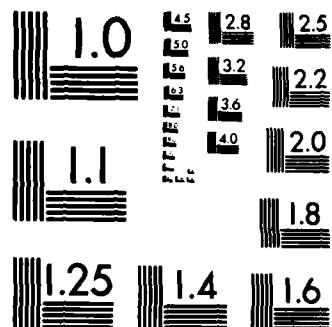
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MICROCOPY RESOLUTION TEST CHART
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TABLE 4-3. NTSB REPORTS REVIEWED

MODE	CHEMICAL	HAZARD CLASS	NTSB REPORT NO.	GEOGRAPHIC LOCATION	DATE	ACCIDENT TYPE
Rail	Anhydrous Ammonia	Nonflammable Gas	RAR-71-2	Crete, NE	2/18/69	Derailment
Highway	Anhydrous Ammonia	Nonflammable Gas	HAR-77-1	Houston, TX	5/22/76	Tractor-Semitrailer
Rail	Anhydrous Ammonia	Nonflammable Gas	RAR-77-2	Glen Ellyn, IN	5/16/76	Collision & Release
Rail	Anhydrous Ammonia	Nonflammable Gas	RAR-78-4	Pensacola, FL	11/9/79	Derailment
Rail	Butadiene	Flammable Gas	RAR-75-7	Englewood, TX	9/21/74	Derailment
						Coupler Override and Tank Puncture in Yard
Rail	Chlorine	Nonflammable Gas	RAR-78-7	Youngstown, FL	2/26/78	Derailment
Rail	Anhydrous Ammonia and Chlorine	Nonflammable Gas	RAR-79-11	Crestview, FL	4/8/79	Derailment
Highway	Liquefied Oxygen	Nonflammable Gas	HAR-71-6	Brooklyn, NY	5/30/70	Tank Explosion
Highway	Propane	Flammable Gas	HAR-73-3	Lynchburg, VA	3/9/72	Tractor-Semitrailer
						Overturn & Fire
Highway	Propane	Flammable Gas	HAR-76-4	Near Eagle Pass, TX	4/29/75	Tank-Semitrailer
						Overturn Explosion and Fire
Rail	Propane	Flammable Gas	RAR-72-2	Crescent City, IL	6/21/70	Derailment
Rail	Propane	Flammable Gas	RAR-74-4	Oneonta, NY	2/12/70	Derailment
Rail	Propane	Flammable Gas	RAR-76-8	Des Moines, IA	9/1/75	Derailment
Rail	Propane	Flammable Gas	RAR-79-1	Waverly, TN	9/22/78	Derailment
Rail	Vinyl Chloride	Flammable Gas	RAR-72-6	Houston, TX	10/19/71	Derailment
Rail	Vinyl Chloride	Flammable Gas	ORI Rt(152)	S. Portsmouth, KY	6/25/76	Derailment

The release, firefighting, cleanup and disposal procedures insofar as they were detailed in the NTSB reports are basic and straightforward with greatest emphasis on extinguishing fires, cooling tank cars and clearing wreckage. Cleanup and disposal of materials was not an issue except in three accidents: (1) one in which ammonia-contaminated runoff reached a lake and caused a fish kill; and (2) two accidents in which chlorine was neutralized by bleeding it into a pit of caustic soda.

The accident review information for ammonia, butadiene, chlorine, liquefied oxygen, propane and vinyl chloride is presented in Tables 4-4 through 4-9, respectively.

4.2.2 Comparison of Recommended Versus Actual Procedures

The major conflict or disagreement between the recommended procedures of various groups and what happened on-site occurred in a train derailment with a release of ammonia. The DOT Emergency Action Guide⁽³⁰⁾ was taken literally in terms of evacuation radius and officials soon discovered that the movement and spread of the vapor cloud necessitated reevaluating and extending the evacuation zone. However, a problem more basic to emergency response than agreement with the existing response system appears from studying these accidents. In many, if not most of these cases, the local emergency response personnel were unaware of and did not have the benefit of mitigation and handling procedures from ANY response system. The accident environment is dynamic and no two releases of hazardous materials were exactly the same in nature, severity or required responses to alleviate safety hazards. Therefore, this initial cut at a comparative data base of commodity-specific accident responses should, with additional input and refinement, provide a sound basis for developing criteria for improved and innovative procedures to mitigate hazards, handle wreckage removal and cleanup and disposal following hazardous materials transportation accidents.

4.3 PROCEDURAL ANALYSIS OF TEN MAJOR ACCIDENTS

In the next phase of the project 10 NTSB-investigated accidents were selected for an in-depth procedural analysis of the emergency response, hazards mitigation, wreckage removal and cleanup and disposal procedures used. Each of the ten accidents involves either a rail or highway shipment of one of the specified chemicals or propellants, except the tractor-semitrailer-cargo-tank-overturn accident at Beattyville, Kentucky which involved gasoline. This section contains a brief overview of each accident investigated. An in-depth analysis of the procedures used at each accident is found in Appendix H. Table 4-10 presents some details of the ten (10) NTSB-investigated accidents which were examined.

TABLE 4-9. REVIEW OF NTSB ACCIDENT REPORTS ON PROPANE

General Information	Notification	Emergency Response Contingency Plan	Emergency Responders	Incident, Location, Date, Time	On-Scene Coordination & Communication	Resource Status & Location	Release Handling Procedures	Fire Fighting Procedures	Cleanup & Disposal Procedures
General Information Location: VA, Tector Incident: 1000 gallons were released and 2000 gallons were released. 7 deaths and 10 injuries were reported.	Notification Report to: Tector within 5 min after over-run 1000 gallons were released. 7 deaths and 10 injuries were reported.	Emergency Response Contingency Plan Fire dept. was in contact with Tector. 1000 gallons were released. 7 deaths and 10 injuries were reported.	Emergency Responders Volunteer fire dept. 1000 gallons were released. 7 deaths and 10 injuries were reported.	Incident, Location, Date, Time 1000 gallons were released. 7 deaths and 10 injuries were reported.	On-Scene Coordination & Communication 1000 gallons were released. 7 deaths and 10 injuries were reported.	Resource Status & Location 1000 gallons were released. 7 deaths and 10 injuries were reported.	Release Handling Procedures 1000 gallons were released. 7 deaths and 10 injuries were reported.	Fire Fighting Procedures 1000 gallons were released. 7 deaths and 10 injuries were reported.	Cleanup & Disposal Procedures 1000 gallons were released. 7 deaths and 10 injuries were reported.
General Information Location: VA, Tector Incident: 1000 gallons were released and 2000 gallons were released. 7 deaths and 10 injuries were reported.	Notification Report to: Tector within 5 min after over-run 1000 gallons were released. 7 deaths and 10 injuries were reported.	Emergency Response Contingency Plan Fire dept. was in contact with Tector. 1000 gallons were released. 7 deaths and 10 injuries were reported.	Emergency Responders Volunteer fire dept. 1000 gallons were released. 7 deaths and 10 injuries were reported.	Incident, Location, Date, Time 1000 gallons were released. 7 deaths and 10 injuries were reported.	On-Scene Coordination & Communication 1000 gallons were released. 7 deaths and 10 injuries were reported.	Resource Status & Location 1000 gallons were released. 7 deaths and 10 injuries were reported.	Release Handling Procedures 1000 gallons were released. 7 deaths and 10 injuries were reported.	Fire Fighting Procedures 1000 gallons were released. 7 deaths and 10 injuries were reported.	Cleanup & Disposal Procedures 1000 gallons were released. 7 deaths and 10 injuries were reported.
General Information Location: VA, Tector Incident: 1000 gallons were released and 2000 gallons were released. 7 deaths and 10 injuries were reported.	Notification Report to: Tector within 5 min after over-run 1000 gallons were released. 7 deaths and 10 injuries were reported.	Emergency Response Contingency Plan Fire dept. was in contact with Tector. 1000 gallons were released. 7 deaths and 10 injuries were reported.	Emergency Responders Volunteer fire dept. 1000 gallons were released. 7 deaths and 10 injuries were reported.	Incident, Location, Date, Time 1000 gallons were released. 7 deaths and 10 injuries were reported.	On-Scene Coordination & Communication 1000 gallons were released. 7 deaths and 10 injuries were reported.	Resource Status & Location 1000 gallons were released. 7 deaths and 10 injuries were reported.	Release Handling Procedures 1000 gallons were released. 7 deaths and 10 injuries were reported.	Fire Fighting Procedures 1000 gallons were released. 7 deaths and 10 injuries were reported.	Cleanup & Disposal Procedures 1000 gallons were released. 7 deaths and 10 injuries were reported.

TABLE 4-10. HAZARDOUS MATERIALS ACCIDENT CASES EXAMINED

<u>LOCATION</u>	<u>MODE</u>	<u>DATE</u>	<u>HAZARDOUS MATERIALS INVOLVED</u>
Beattyville, Kentucky	Highway	9/24/77	Gasoline
Brooklyn, New York	Highway	5/30/70	Liquefied oxygen
Crestview, Florida	Rail	4/8/79	Anhydrous ammonia, Chlorine
Englewood Yard, Houston, Texas	Rail	9/21/74	Butadiene
Houston, Texas	Highway	5/11/76	Anhydrous ammonia
Houston, Texas	Rail	10/19/71	Vinyl Chloride
Near Eagle Pass, Texas	Highway	4/29/75	Propane
Pensacola, Florida	Rail	11/9/77	Anhydrous ammonia
Waverly, Texas	Rail	2/22/78	Propane
Youngstown, Florida	Rail	2/26/78	Chlorine

4.3.1 Accident at Beattyville, Kentucky, Tractor-Cargo-Tank Semitrailer, (151)
September 24, 1977

The hazardous material involved in this highway accident was gasoline, which while it is not one of the twelve propellants and chemicals, is transported in enormous quantities throughout the country and presents a serious flammable vapor hazard similar to many of the other chemicals. The accident involved a tractor-cargo-tank-semitrailer overturn which released more than 8,000 gallons of gasoline which ignited and resulted in fire which engulfed and destroyed the tank truck and a number of nearby vehicles and buildings. Seven persons died in the fire.

Fire was the principal hazard following this accident. The procedural analysis indicates that notification of the fire department was rapid, standard firefighting techniques were employed, the shipper was contacted for assistance and a command post was established. However, problems arose in the actual emergency operations used at the accident site. These include: (1) a lack of enforcement by local Beattyville officials of all provisions of a State-adopted NFPA emergency action plan for escaping from burning buildings; and (2) handling a damaged vehicle without properly assessing its integrity in terms of explosive hazard potential to emergency responders. Also, five other accidents had occurred prior to this one in a similar location over an eight year period. No improvements in the highway surface or signalling systems were made during

this period. Truck traffic was prohibited after this accident until the roadway was improved. Local insensitivity to the significance of transportation accidents involving hazardous materials indicates that a program to educate and assist local communities with contingency planning is badly needed.

4.3.2 Accident at Brooklyn, New York,⁽⁶⁴⁾ Tank Truck Explosion, May 30, 1970

This accident involved the unexpected explosion of a tank truck partially filled with liquefied oxygen after making a delivery to a hospital. The force of the explosion and subsequent fire resulted in two fatalities and 30 injuries.

The fire resulting from the explosion was handled using conventional firefighting techniques. Six members of the local response agencies were injured in the course of the emergency response efforts. This could be due to the fact that liquefied oxygen, a cryogenic substance, has unique properties and handling requirements which were not known in the boundaries of conventional firefighting techniques. Where special handling procedures are required for hazardous materials, emergency responders ought to be appraised of the situation and adequately trained.

4.3.3 Accident at Crestview, Florida,⁽⁷⁵⁾ Train Derailment, April 8, 1979

This accident involved the rupture and rocketing of two tank cars of anhydrous ammonia, and the rupture, release and subsequent burning of 12 other cars containing chlorine, acetone, methanol, and phenol. The releases necessitated the evacuation of about 4,500 persons and resulted in 14 persons requiring treatment for inhalation of ammonia and other toxic fumes.

The local and county officials put the contingency plan for hazardous materials emergencies into operation immediately after notification from the railroad operator of the derailment. The train crew following standard operating procedures, cooperated with local officials and furnished the waybills and consist to firefighters who in turn contacted shippers for assistance. However, there was still confusion on-scene for the first hours with no identifiable OSC, delays in identifying materials involved and the delay of special technical help by the exclusion of a CHLOREP team from the scene by local officials.

The magnitude of the hazardous materials released warranted activation by the NPC of the EPA Regional Response Team (RRT) with an OSC to respond to the accident and help mitigate environmental damage and prevent further water pollution. The RRT is a logical body to coordinate all aspects of emergency response to hazardous materials transportation accidents, not just pollution episodes.

One of the most important steps forward in emergency response procedures was the aerial surveillance and monitoring of the ammonia vapor cloud. This allowed the command post to be shifted to safety when meteorologic conditions changed; the FAA to restrict local air space to unauthorized aircraft; and emergency responders to evaluate evacuation priorities.

This accident also pointed out the lack of procedures for assessing tank integrity; the need for cleanup and wrecking crews to be properly equipped even when the obvious initial fires, explosions and releases have been brought under control; and the need to monitor and continue monitoring the area for toxic fume concentrations posing potential problems to people at the accident site.

4.3.4 Accident at Englewood Yard, Houston, Texas,⁽⁷⁴⁾ Tank Car Puncture and Subsequent Explosion, September 21, 1974

This accident occurred at the Englewood hump yard when the retarders failed to decelerate two jumbo tank cars of butadiene. The two tank cars struck an empty car, which caused a coupler override and puncture, releasing butadiene vapor into the atmosphere. The vapor exploded and resulted in one death and 235 injuries.

This accident occurred during hump yard operations with a tank car head puncture, vapor release and resulting explosion. The retarder operator used the yard loudspeaker to clear the area of employees, however, the vapor-air explosion occurred almost immediately (3 minutes).

The Fire Department established a command post to coordinate firefighting efforts which were complicated by other hazardous materials involved in the fire.

The major problem areas pointed out in this accident were: (1) identification of materials involved; (2) training of yard personnel in basic self-protective responses; and (3) minimizing response times.

The railroad revised yard operating procedures restricting the humping of tank cars of several hazardous materials following several overspeed accidents. The DOT eventually established E.O.#5 prohibiting humping of compressed gas tank cars not equipped with headshields or jackets.

4.3.5 Accident at Houston, Texas,⁽⁶⁷⁾ Tractor Semitrailer (Tank) Collision, May 11, 1976

The hazardous material involved in this accident was anhydrous ammonia. The tank truck collided with a bridge rail, causing release of more than 7,000 gallons of ammonia. Five persons died and 178 were injured as a result of inhaling ammonia fumes. The truck driver was killed by the crush force of the truck upon impact.

This highway accident highlights the significance of a sound plan with defined authority, responsibilities, procedures and practices used by local emergency planners and emergency responders in an accident situation. The potential severity of such a massive ammonia release was reduced by the following: (1) implementation of the city's Emergency Operations Plan, which designates specific authorities and duties for each local government agency in the event of an accident or other civil defense need; (2) immediate identification of an on-scene coordinator; (3) communication transmitted the identity of the hazardous material to the dispatcher who in turn transmitted this information to the hospital; (4) the area was quickly sealed off using helicopters to guide patrols; (5) responders had the breathing apparatus necessary for handling this type of emergency; and (6) sufficient firefighting equipment was on-scene quickly.

A few areas of concern, however, were also found. Using a helicopter is a high risk method for dispersing a toxic vapor cloud. A water spray to knock down vapors would have been as effective with less risk.

Also, no procedures were in evidence to contain ammonia-contaminated firefighting runoff or water spray which could contaminate waterways or cause a severe upset of a publicly-owned treatment works (POTW) by destroying active bacteria.

4.3.6 Accident at Houston, Texas,⁽⁷²⁾ Train Derailment, October 19, 1971

This accident involved the derailment of a freight train containing six tank cars of vinyl chloride monomer and two cars of another hazardous material. Two of the tank cars were punctured in the derailment, releasing vinyl chloride vapor which then ignited. Approximately 45 minutes after the initial derailment, one tank car ruptured violently and another tank car "rocketed" roughly 300 feet from its initial resting place. During the response activities to this accident, one fireman was killed and 50 people were injured.

The response to this accident by local emergency services was timely after notification from both residents and railroad personnel. However, numerous injuries occurred to spectators, photographers and press personnel, indicating that a hazard perimeter had not been established or enforced. Keeping unauthorized personnel a safe distance from the accident site is a very important procedure.

Other procedural problems indicated in the assessment include: (1) delays in identifying the hazardous materials involved; (2) delays in evacuation of residents in the adjacent area; (3) lack of proper procedures for assessing tank car integrity; and (4) lack of proper training of firefighters in assessing safety of damaged tank cars.

4.3.7 Accident at Near Eagle Pass, Texas, (66) Tank Semitrailer Overturn, April 19, 1975

This highway accident involved the release of liquefied petroleum gas (LPG), produced an explosion and fireball, and resulted in 16 deaths and 35 injuries due to severe burns.

The fire and explosion resulting from this accident were almost instantaneous and the hazards facing local emergency responders were extensive fires and keeping unauthorized personnel away from the accident scene. The local police and fire departments responded quickly, however, no formalized emergency response plan was in evidence especially for transporting the badly burned victims to hospitals.

The fires were extinguished within an hour using standard techniques. This accident indicates the need for development of improved vehicle design and containers giving greater safety margins for transporting a cargo such as LPG.

4.3.8 Accident at Pensacola, Florida, (76) Train Derailment, November 9, 1977

In this rail accident, two tank cars of anhydrous ammonia sustained head punctures. The subsequent release of ammonia forced the evacuation of roughly 1,000 people and resulted in two deaths and 46 injuries.

As a result of previous accidents, a local contingency plan had been developed and was implemented early in the accident. However, the question of who was in charge was not adequately defined and some confusion arose. The responders (fire) had been trained in the use of breathing apparatus and used it in following established procedures for finding the conductor to identify the hazardous materials involved. A local air traffic controller spotted and tracked the ammonia vapor cloud in order to detour aircraft. The shipper was contacted and sent an equipped response team to the scene.

Many problems also surfaced in analyzing this accident: (1) techniques are needed for monitoring levels of toxic pollutants in the air for emergency response personnel; (2) constant two-way communications are required between firefighters, rescue personnel and the command post; (3) residents need education as to the effects of a hazardous material emergency and when to evacuate versus when to remain inside; (4) sufficient personnel protective equipment is needed on-site; (5) procedures for containing contaminated runoff water are necessary to preclude future environmental damage; and (6) the assessment of integrity of damaged containers is absolutely necessary for safe transfer and wreckage removal.

4.3.9 Accident at Waverly, Tennessee,⁽⁷⁷⁾ Train Derailment, February 22, 1978

Two days after this rail accident occurred, a damaged tank car containing liquefied petroleum gas (LPG) ruptured during transfer operations. The resulting explosion caused 16 deaths and 43 injuries.

The deaths and injuries occurred after the derailment situation was believed to be stabilized and the only tasks remaining were transfer of product from damaged containers to intact ones. The major lesson of Waverly is that detailed procedures and hardware are needed in the field to assess structural integrity of a damaged, loaded tank car especially before moving it or attempting to transfer its contents. Many experienced firefighters and wreckage removal personnel miscalculated the hazard of the damaged tank car of LPG and were killed when it ruptured and exploded in fire.

4.3.10 Accident at Youngstown, Florida,⁽⁷¹⁾ Train Derailment, February 26, 1978

This accident involved the release of chlorine and other hazardous materials; necessitated the evacuation of about 1,500 persons; and resulted in 8 deaths and 133 injuries, all of which were attributed to chlorine gas inhalation.

One of the biggest problems associated with this accident was that no local emergency plan existed to mobilize local emergency responders and their efforts and to protect residents. Notification was hampered because no dispatcher was on duty at the time of the derailment and the conductor had to telephone the news to the local sheriff. Communications between train crew members was inadequate as radio equipment malfunctioned. Crew members did awaken local residents and tried to stop motorists from approaching the chlorine cloud, however, eight persons died as a result of chlorine inhalation while driving by or stopping at the scene. The positive identification of the hazardous materials involved did not occur until 5 hours after the derailment. Early knowledge of the hazardous materials involved is necessary for an effective response.

Residents were evacuated and the chlorine cloud tracked through use of aerial surveillance. However, rescue personnel were not promptly notified nor alerted to the fact of chlorine involvement. The first ambulance driver was forced to turn back because he was not equipped for the chlorine levels in the air. Proper personnel protective equipment and gear is needed for adequate emergency response. In this case, an expert industry response group called CHLOREP, should have been immediately alerted to respond and assist the local responders in handling chlorine involvement.

4.4 OVERVIEW OF EXISTING RESPONSE SYSTEMS

The emergency response guidelines and handling procedures recommended for each of the twelve chemicals and propellants were identified in the following system:

1. The USCG "Chemical Hazards Response Information System" (CHRIS);
2. The EPA "Manual for the Control of Hazardous Materials Spills: Volume 1";
3. The Association of American Railroads' "Emergency Handling of Hazardous Materials in Surface Transportation"; and
4. The DOT "1980 Hazardous Materials Emergency Handling Guide".

4.4.1 U.S. Coast Guard" Chemical Hazards Response Information System"

In general, CHRIS consists of four reference manuals, a regional contingency plan, a hazard-assessment computer system (HACS) and the National Response Center. The four manuals provide appropriate chemical hazards data, emergency handling procedures, fire fighting procedures, explosive information as well as spill and leak handling procedures. The chemical data guides for eight of the twelve chemicals and propellants are found in Volume II of the CHRIS manuals. These have been included as Appendix D.

The Hazards Response Manual, Volume IV, of the CHRIS system does, however, recommend cautionary as well as corrective responses for all but liquefied hydrogen. The tables in Appendix D show the cautionary and corrective responses for the twelve chemicals and propellants. It is notable that only butadiene, hydrazine and propane have suggested corrective responses; all advise restricted access and evacuation. Ignition sources are perceived as a problem for all but ammonia, chlorine and nitrogen tetroxide. Therefore, it appears that fire and associated thermal reactions are much more at issue than water pollution damage in accidents involving these chemicals.

4.4.2 The EPA "Manual for the Control of Hazardous Material Spills: Volume I"

The tables found in Appendix E present EPA's approach for determining optimum procedures for spill handling. Table E-1 shows containment methods for spills on land. Procedures for spills into water bodies are subdivided based on density and solubility of the spilled material into the following categories: heavier than water spills (e.g., chlorine, liquefied oxygen); soluble or miscible spills (e.g., ammonia, ethylene oxide, nitrogen tetroxide, hydrazine, monomethylhydrazine, unsymmetrical dimethylhydrazine); and floating spills (e.g., butadiene, liquefied hydrogen, propane, vinyl chloride). These are shown in Tables E-2, E-3 and E-4, respectively. Table E-5 presents methods for containing air spills. This system is geared toward hazardous material spill assessment, spill control and treatment techniques. However as can be seen in Table E-

6, there are treatment schemes recommended for only ammonia, chlorine and nitrogen tetroxide of the chemicals in our study. This is in large part due to the volatile nature of most of the chemicals being assessed and as such they do not pose the same magnitude of water pollution threat as the other hazardous materials addressed by EPA. Further, the EPA procedures do not address fire, explosion, or associated thermal or reactive problems presented in a spill environment.

4.4.3 The Association of American Railroads "Emergency Handling of Hazardous Materials in Surface Transportation"

The Bureau of Explosives of the Association of American Railroads provides an emergency response guide entitled "Emergency Handling of Hazardous Materials in Surface Transportation." Unlike the EPA's system which is geared toward the environmental damage aspects of an accident and the USCG's which is aimed at response to accidents involving bulk transport by water, the AAR system is multi-modal with emphasis on rail transportation. The specific commodity identification response is keyed using the 4-D Series of the Standard Transportation Commodity Code. These responses can be computer-generated on a rail move and can accompany hazardous shipment waybills to aid in initial identification of hazards, procedures for fire involvement, leak handling procedures, personnel protective measures and evacuation considerations. Appropriate responses for all the chemicals except UDMH can be found in Appendix F.

4.4.4 The DOT "1980 Hazardous Materials Emergency Response Guidebook"

The DOT has developed a new emergency action/response guide system keyed to UN identification numbers. This system is different from the others in that it has 56 unique response guides to cover primary and secondary hazards of materials as opposed to having a response associated with and listed for each commodity as in the AAR and Coast Guard Systems. For example, the applicable emergency response guide is the same for vinyl chloride and butadiene.

The DOT response guides present two levels of data: (1) potential hazards and (2) emergency response actions for accident situations. The guides associated with the twelve chemicals and propellants in this study are found in Appendix G.

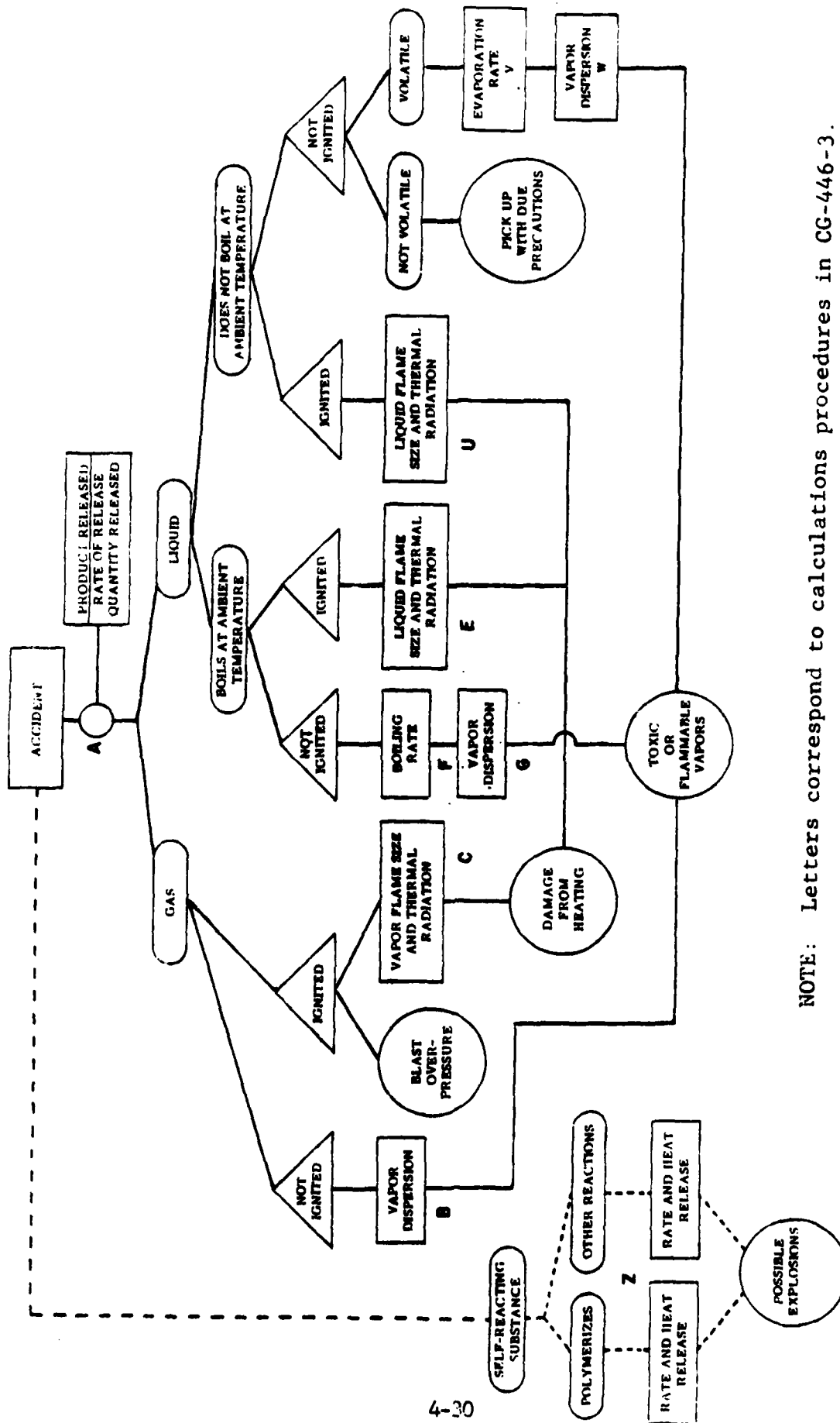
There has been a great deal of controversy within the various segments of the emergency response community regarding this hazard information system. However, at this time the UN numbers are a required part of the DOT proper shipping name for hazardous materials and the system will probably be tested under accident conditions in the future.

5.5 OVERVIEW ASSESSMENT OF USCG, AAR, EPA AND DOT RESPONSE SYSTEMS

None of the above mentioned documents is really contradictory. They differ mainly in format and level of detail. Examination of these documents focused on the applicability of the procedures to accidents involving transport of the 12 chemicals and propellants by highway and rail mode. Information on emergency response was found for all 12 chemicals and propellants in the DOT Guide⁽³⁰⁾ and the AAR/ B.E. publication.⁽²⁷⁾ Liquid hydrogen, methylhydrazine, nitrogen tetroxide and cryogenic liquid (liquefied) oxygen were not listed in CHRIS Volume 1⁽³¹⁾ or CHRIS Volume 2.⁽³⁴⁾ The EPA manual dealt only with treating diluted or reduced aqueous solutions of ammonia, chlorine and nitrogen dioxide (the monomeric gaseous form of nitrogen tetroxide). The Coast Guard Chemical Data Guide for Bulk Shipment by Water⁽¹³⁷⁾ lists responses for nine of the twelve chemicals.

The Coast Guard and EPA documents were designed to support the National Oil and Hazardous Substances Pollution Contingency Plan, the Coast Guard operated National Response Center, the National Response Team and the On-Scene Coordinator--all required by the Federal Water Pollution Control Act. This was designed for releases to water as opposed to land spills. The Secretary of Transportation has initiated the expansion of the National Response Center and its capabilities to serve the full spectrum of hazardous materials transportation emergencies. The Coast Guard, EPA and other documents have been examined in this light.

If a particular rail or highway incident resulted in a hazardous material entering a pond, lake, stream or other waterway, the procedures identified for water spills would be applicable, providing the basic technical data were available for the specific chemical(s) or propellant(s) involved. They would not necessarily be applicable to a spill on land. Precautions, protective clothing and equipment would, for the most part, be identical because of the intrinsic characteristics of the hazardous materials. The techniques, materials, equipment, and procedures for containment and cleanup would be different for the land and marine modes. Procedures used to predict and estimate the spill danger area (e.g., fireball size and duration, vapor cloud size and dispersion characteristics and downwind flammable or toxic hazard) may or may not be applicable to land spills as well as spills into waterways. The surface characteristics of land areas are different from those of water. Many substances are soluble in water whereas on land substances may be absorbed by soil particles, leached out, neutralized or degraded by soil microbes. One might for rough estimates use the water-insoluble materials procedures portion from the Coast Guard Hazard Assessment Tree (page 209, CHRIS Volume 3⁽³³⁾) to



NOTE: Letters correspond to calculations procedures in CG-446-3.

FIGURE 4-1. RAIL OR HIGHWAY ACCIDENT WITH PRODUCT RELEASE

address land spills. Figures 4-1 and 4-2 represent possible modifications for rail or highway incidents in which there is not initial product release and in which there is release, respectively. Figure 4-2 includes another dimension, namely, looking at potential subsequent tank failure and how this would tie into the released product scheme. At the very least, additional basic technical data (e.g., evaporation rates from various solid surfaces, such as sand, rock, metal, blacktop, and clay, etc. and flame characteristics) would be required for the chemicals and propellants not covered in CHRIS Volume 3.⁽³³⁾ The Coast Guard procedures would require further checking and modification to make certain that any weightings or other marine-dependant factors have been eliminated for the land predictive procedures.

From the examination of the Coast Guard,^(31,33-35) EPA,⁽³⁶⁾ AAR/B.E.⁽²⁷⁾ and other guides, handbooks and manuals, it appears concludes that the bulk of the procedures are usable, however, some consolidation is advisable. The EPA Manual⁽³⁶⁾ uses the systems approach and is comprehensive in the areas of containment, collection and treatment of materials spilled in water. There is also some good procedural guidance for land spills. The Spill Handling Thought Guide, found on page 118, Figure 36 of the EPA Manual⁽³⁶⁾ is a good concept and could be utilized in establishing the basic framework for handling land spills of the 12 chemicals and propellants. There is a great deal of information on many procedural aspects and areas of interest, but effectiveness is reduced because it lacks specific indexing like that found in CG-446-3.⁽³³⁾

4.5.1 Additional Recommendations

1. CHRIS Volume 1.⁽³¹⁾ This document could be discontinued because all the information is contained in CHRIS Volume 2.⁽³⁴⁾

2. CHRIS Volume 2.⁽³⁴⁾ This document contains the essential information in a simple, useful format. The information is applicable to land spills as well as to marine spills for the most part. It needs to be updated and expanded to cover all commodities listed in the DOT Emergency Response Guidebook.⁽³⁰⁾ There are also gaps in basic technical data in such areas as evaporation rate and source strengths.

3. CHRIS Volume 3.⁽³³⁾ This document is primarily geared to assessing hazards of chemicals instantly spilled on water rather than continuous releases. The procedures and assessment schematics need to be expanded and modified to accomodate land spills and continuous product releases. Pool spreading behavior on solid or porous surfaces versus spreading on water needs to be established. Data on evaporation rates versus solid surface characteristics are required, as are determinations of vapor-phase behavior, fragmentation and blast overpressure data.

It is rather difficult to determine the Coast Guard Hazard Assessment Code (the sequence of procedures to use) for a specific material. The following are the codes listed for some of the 12 chemicals and propellants.

TABLE 4-11. USCG HAZARD ASSESSMENT CODES

<u>Chemical/Propellant</u>	<u>DOT Hazard Class</u>	<u>Coast Guard Hazard Assessment Code</u>
Ammonia, anhydrous	Nonflammable gas	ABCKLMNO
Butadiene, inhibited	Flammable gas	ABCDEFGGZ
Chlorine	Nonflammable gas	ACIJ
Dimethylhydrazine, unsymmetrical	Flammable liquid	APQRS
Ethylene oxide	Flammable liquid	ABCKLMN
Hydrazine	Flammable liquid	—
Hydrogen, liquefied	Flammable gas	—
Monomethylhydrazine	Flammable liquid	—
Nitrogen tetroxide	Poison	AIJO
Oxygen, Cryogenic liquid	Nonflammable gas	—
Propane, LPG	Flammable gas	ABCDEFGG
Vinyl Chloride	Flammable gas	ABCDEFGGZ

The hydrazines are a case in point to show that the procedures need reworking for land spills. APQRS-type materials involve calculations which have factors related to stream width, flow, etc. Butadiene and vinyl chloride utilize procedure Z, but unfortunately the data and procedures for self-reactive materials are not available. They need to be developed. Having good evaporation rate and source strength data for the liquefied gases and volatile liquids in tabular or nomograph form would simplify calculations and improve the accuracy of assessments. Tables and nomographs for release rates of product and for the product remaining in a container, as a function of container size, physical orientation and type of opening, are needed.

Release or no release are the two basic situations. Release can be essentially instantaneous and complete (gas or liquid), partial until some level of remaining product

remains (liquid) or continuous until all product is released (gas or liquid). Hazard Assessment Trees, similar to the one in CHRIS Volume 3 would be prepared as the framework for hazard assessment procedures.

At the time CHRIS Volume 3⁽³³⁾ was issued, the Hazard Assessment Computer System (HACS) program was not running. However, it is operational and undergoing updating and expansion at the present time.

4. CHRIS Volume 4.⁽³⁵⁾ The response methods are geared essentially for marine spills. With respect to transfer operations (marine terminals), two-way communications are needed continuously between shut-off/flow control points and where the operation is being visually observed. Visual observation should be continuous as well.

Several types of discharges are mentioned but not necessarily what action to take to prevent discharge. A checklist should be required for every operation such as blanking off terminal pipeline flanges; connecting and disconnecting hose lines; and shutting off/locking on controls, pumps, etc.

Improved communications are needed between all concerned parties (e.g., above and below deck personnel and crew and terminal personnel).

Procedures are needed to periodically ascertain storage container and transfer equipment integrity.

There is not a really precise method for predicting downwind concentrations.

Updates in names of agencies are needed (e.g., DCPA is now a part of FEMA, and a new federal agency).

The listed sources of assistance are good. Procedures are needed to establish when and how to contact and alert them and have in writing what assistance will be provided.

Discharges deal only with marine situations. On land, the quantities will be less, and usually only one product will be involved. The basic methods of cargo transfer should have applicability to rail and highway operations as well as marine. Practical means for cargo transfer regardless of tank car or tank truck physical orientation are badly needed.

The described containment procedures are for marine situations. They would be appropriate if the land spill reached water. There is a need to expand procedures to cover land incidents such as the use of dikes, berms, ditches and pits (lined and unlined). The land and marine situations are entirely different and require separate procedures.

Collection and recovery procedures given would be applicable if the land spill reached water. This project is concerned only with gases and liquids, not solids. The 12 chemicals and propellants are a mixture of gases (liquefied and compressed), and liquids with varying solubilities and densities. Procedures for mitigating the hazards from the spilled chemicals and propellants, transferring them, collecting them, suppressing the vapors, treating them or otherwise dealing with them must take into account these varied characteristics.

Pumping techniques may have both land and marine application, except when cryogenics are involved.

The general information given for bulk storage is applicable for land as well as marine spill situations. Temporary storage may be necessary for land spills. Depending upon the particular material involved and if not all product has been released and the container has been satisfactorily plugged, patched, sealed or otherwise rendered intact, the container could be used for temporary storage. To the extent that it is safe and practical to do so, remaining spilled material should be picked up and stored, keeping in mind that it may have to be transported for recovery/recycle or disposal. Choosing storage which will make it easier to load for transport or to treat or dispose at the scene, can do much to simplify operations, reduce costs and improve safety. Procedures need to be based upon the overall system approach and not on a single aspect such as storage. Procedures need to address plastic containers that might be used with attention given to precautions about compatibility, permeability and the like.

Use of tank cars and tank trucks are even more applicable to land spills than marine episodes. Tank trucks are very likely to be utilized in supporting rail spill response activities. Procedures must cover such transfer operations.

If planning has been adequate, temporary storage could be an approved shipping container, thus eliminating the need for additional transfer operations.

Bladders are a convenient, versatile storage and handling means for land spills as well as marine spills.

Dikes, as discussed for marine spills, are applicable to land spills. Berms and pits are commonly used for containment on land. When it is possible to line pits and berms with a impermeable material, soil leaching and potential groundwater contamination can be reduced. It is practically impossible to get a liner under an

instantaneous spill, although it may be possible for continuous ones. Also, it may be possible to drain or divert the product into a lined hole. Procedures need to deal with these situations.

The discussion on the uses of burning and associated procedures in CHRIS Volume 4⁽³⁵⁾ are applicable to land spills. Land spill neutralization may involve a smaller but more highly concentrated total quantity of chemicals and propellants spilled. The land spill pool may spread, but it is not as dynamic as one in water, particularly if there is a current. Neutralization procedures are usually for dilute materials. Procedures need to be developed for dealing with concentrated chemicals and propellants.

The tendency of most of the 12 chemicals and propellants to volatilize rapidly and their other characteristics will limit the opportunities for application of absorption techniques. The strong oxidizing nature of nitrogen tetroxide requires special handling precautions.

5. EPA "Manual for the Control of Hazardous Material Spills."⁽³⁶⁾ This contains a good listing of assistance organizations and how to assess them. The information retrieval systems are of most use in obtaining background information for planning—not emergencies themselves.

The EPA Manual⁽³⁶⁾ is systematic in its approach, but could be much more effective if it were clearly tabbed to show the information contained therein. It has a lot of information, but it is not presented clearly. The Thought Guide concept is useful and a series of these for emergency response, hazard mitigation, product transfer, cleanup and disposal could provide a good framework for procedures. Label and placard information needs updating. The information on tank patching and commonly available safety equipment is helpful. Treatment methods only deal with three of the 12 chemicals and propellants and then only after dilution. Information on equipment, treatment chemicals, supplies, etc., are also useful.

6. AAR Bureau of Explosives Handbook.⁽²⁷⁾ The unique and very useful feature of this document is the 49-STCC numbering system. The procedures on handling leaking LPG tank cars are also very useful.

7. DOT "Hazardous Materials Emergency Response Guidebook."⁽³⁰⁾ This document is a major improvement over the previous emergency action guide. Consideration should be given when future revision is undertaken to incorporate the 49-STCC system⁽³⁹⁾ also.

5. DEVELOPMENT OF SPILL SCENARIOS

5.1 RATIONALE FOR SCENARIO DEVELOPMENT

Spill scenarios have been developed to provide a predictive planning tool for handling the broad range of eventualities and conditions associated with highway and rail transportation accidents involving the 12 chemicals and propellants. The developmental philosophy used was to cover as many of the probable emergency situations posed as possible with the thought that while the broad accident conditions would remain constant, parameters such as temperature and amount released could be varied within these broad conditions. The applicability of any scenario is its ability to provide relatively accurate predictions of what could occur for a given a set of parameters. This is absolutely necessary for adequate contingency planning by communities and emergency response personnel. These scenarios then must be broadly applicable, yet specific enough to provide relatively accurate predictions of attendant conditions and hazards, and be sensitive to changing parameters at the accident scene.

The in-depth analyses of several transportation accidents indicated that severe accidents which have occurred could provide excellent starting points because of the broad range of conditions covered involving the appropriate chemicals and also because these actual occurrences could be modelled by various existing dispersion models to assess their applicability to transportation spills and validate their effectiveness as planning tools for future emergency use.

Thus, in developing these scenarios, attention was paid to actual rail and highway accidents in which these chemicals have been involved. Most of the input data used to execute vapor dispersion models for these scenarios was reviewed and found to be available in actual case files of accidents investigated by the NTSB. A sample listing of the typical input parameters include:

1. Meteorological Information:
 - wind speed
 - ambient temperature
 - atmospheric stability class
 - percent cloud cover
 - presence or absence of an atmospheric inversion layer
 - angle between sun and horizon
2. Type of Spill Information:
 - continuous leak
 - instantaneously-formed liquid pool
 - other, (e.g., stack)

3. Other Pertinent Information:

- area of spill
- total amount spilled
- elapsed time since spill
- elevation of receptors
- emission rate
- concentration of interest in ppm
- stack height above local terrain
- stack gas volumetric flow rate

Of the six scenarios that have been developed they include one multiple release of anhydrous ammonia and chlorine and five single releases, where anhydrous ammonia, butadiene, chlorine, hydrazine and vinyl chloride are involved. Four of these scenarios involve rail accidents and two involve highway accidents.

5.2. Spill Scenarios

Highlights of the spill scenarios are as follows:

The first scenario is a train derailment which occurs early on a clear spring day, involving the multiple release of various hazardous materials including anhydrous ammonia and chlorine. There is a light variable wind from 5 to 20 miles per hour. Visibility is about 7 miles and the temperature is 57°F. The sky is 80 percent overcast with clouds at 20,000 feet. The released anhydrous ammonia and chlorine are dispersed, forming a cloud which increases in size until it threatens a 300 square mile area downwind of the derailment. The released hazardous materials could pose a threat to the health and safety of the surrounding population and wreck-clearing personnel for up to 9 days after the initial release. The hazardous materials are leaking from the tank car at a rate of 300 lbs./minute.

The second scenario is a railyard accident in which two loaded "jumbo" tank cars, each containing approximately 34,000 gallons of butadiene, pass through retarders without being slowed, impacting a stationary tank car. The coupler of the stationary car punctures one of the cars of butadiene resulting in an immediate release of a vapor cloud, which disperses over the area. After two to three minutes the vapor explodes violently. The accident occurs at noon on a summer day, temperature around 87°F, light winds at 11 miles per hour with a 60 percent cloud cover. The accident occurs in an area of high population density. A total of 68,000 gallons of butadiene is released in a period of three minutes.

The third scenario involves a train derailment in which several tank cars containing vinyl chloride are punctured, resulting in an instantaneous release of 100,000 pounds of vinyl chloride — 46 minutes after they were initially punctured. The accident occurs during the early afternoon on a fall day, temperature estimated at 83°F, winds

light at 7 miles per hour and zero percent cloud cover. The accident occurs in the suburbs of a major city.

The fourth scenario involves a highway accident in an area of high population density in which anhydrous ammonia is released. The accident occurs at 11:08 a.m. on a clear spring day. A tank truck transporting 38,820 pounds of anhydrous ammonia impacts a bridge rail on a major interstate highway, overturns and produces an instantaneous release of the entire ammonia contents in three minutes. The temperature is a seasonable 80°F, the winds are light at 7 miles per hour and there is zero cloud cover. This released cargo spreads over a 1,000 ft.² in area.

The fifth scenario involves a train derailment in which chlorine is released. The accident occurs on a clear winter day at approximately 1:55 p.m. The temperature is a moderate 55°F, winds light at 1 mile per hour, 600 feet visibility, and zero percent cloud cover. The accident occurs enroute in a rural density area parallel to a state highway. As the liquefied chlorine escapes from the pressurized tank car, it vaporizes and forms a chlorine gas cloud which floats downwind from the site of the derailment for several miles.

The sixth scenario involves a highway accident of a truck in which hydrazine is spilled. The release is continuous from a 55 gallon metal drum. A total of two gallons are released from the drum into the surrounding area. The accident occurs in late fall. The temperature is 76°F with 70 percent relative humidity, a wind speed of 6 mph and a 50% cloud cover. The accident occurs during the daytime where the angle between the sun and horizon is approximately 70°. The atmospheric stability class is not specified, and there is no atmospheric inversion layer.

In a later task of the project these scenarios will be executed using appropriate vapor dispersion models. A review of these models is included in the next Chapter.

6. APPLICABILITY OF VAPOR DISPERSION MODELS TO TRANSPORTATION SPILLS

6.1 GENERAL OVERVIEW

Several vapor dispersion models have been examined and assessed in terms of their applicability to transportation spills and their availability and feasibility for use in emergency response planning. The models examined include the USCG HACS, Shell R&D SPILLS, DDESB Downwind Chemical Hazard Slide Rule, AFCRL Statistical, and prototype dense gas vapor dispersion models.

6.2 U.S. COAST GUARD HAZARD ASSESSMENT COMPUTER SYSTEM (HACS)

HACS is built on the mathematical models that were created for the CHRIS Hazard Assessment Handbook, Volume 3,⁽³³⁾ together with several specialized models developed specifically for computer application. Subroutines for modeling phenomena such as liquid spread and fire, dispersion of vapor, radiation from fires, and dissolution and dispersion in water for some 900 commonly shipped chemicals are included.

The major subroutines are:

- (A) Venting Rate Model. This computes the rates and time of release, and total quantities released for gases and liquids which are discharging from a punctured tank or container;
- (B) Vapor Flame Size and Thermal Radiation Model. This is used for estimating venting of a flammable gas under pressure from a hole in a tank and is comprised of three segments for computing length and distance of the flame jet (B1); safe separation distances from the flame and whether or not an intact tank containing compressed gas will rupture if exposed to the flame (B2); and how long to tank rupture given fire exposure (B3);
- (C) Vapor Dispersion Model. This computes the dispersion of neutrally bouyant gases in air for either instantaneous or continuous releases of gases or vapors evolving from holes in tanks, evaporating pools of spilled liquid or both;
- (D) Spreading Rate and Movement Model. This is used for spills of liquids less dense than water which are insoluble or slightly soluble in water and have a boiling point less than ambient temperature;
- (E) Liquefied Flame Size and Thermal Radiation Model. This is used for potential or actual ignition of a pool of spilled flammable liquid;
- (I) Boiling Rate Model. This is used to compute time for all discharged

liquid to vaporize and is used for liquids more dense than water, insoluble or slightly soluble, with boiling points less than ambient temperature;

- (P) Mixing and Dilution Model. This computes the concentration of a water-miscible liquid or solid at a specified point and time resulting from a discharge in a lake, river or tidal estuary;
- (R) Boiling Rate Model. This is utilized for volatile liquids soluble in water and having boiling points greater than ambient temperature but less than 100⁰C;
- (T) Spreading Rate and Movement Model. This is applicable to the continuous or instantaneous release of chemicals which are soluble or slightly soluble in water, less dense than water and having boiling points greater than ambient temperature;
- (V) Boiling Rate Model. This computes pool size and area, volume of chemical remaining, temperature of the chemical, and evaporation rate for volatile chemicals which are insoluble in water, less dense than water and having boiling points greater than ambient temperature but less than 100⁰C; and
- (X) Movement in Water Model. This is used for chemicals insoluble or slightly soluble in water, more dense than water and having boiling points greater than ambient temperature.

6.2.1 Basic Assumptions of HACS Vapor Dispersion Model (C)

The model is based on the Gaussian diffusion model and the experimentally determined Pasquill variances of the Gaussian concentration profile. This model is comprised of two sub-models or segments to compute (C1) the downward distance over which a flammable or toxic cloud or plume is hazardous and (C2) the time of arrival, duration and width of the cloud or plume for given concentration at a specified downwind location and time. The wind direction and velocity are assumed to be constant (invariant with height and distance of travel of the cloud or plume). The model also assumes a flat terrain in the direction of travel. The output from these dispersion sub-models is based on values of lower flammable and lower toxic limit concentrations for the spilled chemical.

6.2.2 Interface Capabilities of HACS Vapor Dispersion Model (C)

The basic dispersion model (C) was developed to describe dispersion of gases or vapors released directly from a tank. Vapor dispersion models for releases under other conditions were developed as separate modules interfacing with the basic model. These are:

- Vapor dispersion from insoluble or slightly soluble liquids less dense than water with boiling points lower than the ambient temperature (G). Options are provided to model the vapor release as either instantaneous or continuous.
- Instantaneous or continuous vapor release from insoluble or slightly soluble liquids more dense than water and having boiling points less than ambient temperature (J).
- Vapor dispersion hazards associated with spills of soluble chemicals with boiling points less than ambient temperature (N). This model assumes all vapor is evolved instantaneously and uses estimates of the size and shape of the vapor source.
- Dispersion of vapor from spills of volatile liquids which are soluble in water and have boiling points greater than ambient temperature but less than 100°C. (This chemical type has a considerable vapor pressure at ambient temperature and is miscible in water) (S). The model assumes all of the vapor liberated is generated at the spill origin.
- Dispersion of vapors from spills of volatile insoluble chemicals having a boiling point greater than ambient temperature and which are less dense than water (W). Either instantaneous or continuous vapor release is modelled.

It should be noted that these models do not take into account the disturbances caused by obstructions or wind direction change or wind velocity nor do they include the effects of the vapor being heated by the ground or air and the consequent rise of the plume. Therefore, it is important that the output values be properly interpreted by trained persons as guides for assessing/evaluating hazards and not taken as absolute concentration values.

6.2.3 Accessibility to HACS System

HACS is primarily accessible through the National Response Center under the aegis of the on-scene-coordinator (OSC). In addition, there is a mechanism for helping communities with pre-emergency contingency planning, again through the appropriate OSC in each region.

6.3 SHELL R&D SPILLS VAPOR DISPERSION MODEL⁽¹³⁴⁾

The Shell model can be used to analyze the evaporation and atmospheric dispersion of a chemical spill on land. The unsteady state model estimates vapor concentration as a function of time and distance downwind of the spill.

The model incorporates three options depending on the nature of the spill:

- (1) instantaneously-formed pools of liquids or liquefied gases;
- (2) continuous spills, such as leaks from tank cars, tanks or pipelines; and
- (3) stacks, where the emission rate is assumed to be known.

For options (1) and (2), the thermophysical properties of the 36 chemicals in the system are used to calculate the evaporation rate which then becomes the emission rate for the atmospheric dispersion calculations. The mathematical model for calculating evaporation rate is based on heat and mass transfer mechanisms. The air dispersion model is based on the Gaussian puff model which uses the same approach and assumptions as the Gaussian plume equation. This three-dimensional Gaussian puff model is used to generate the following three different outputs: maximum concentrations and their downward positions at given elevations and elapsed times since the spill; concentrations at given times and positions in space; and constant concentration contour plots (isopleths) for given elevations and elapsed times.

The thermophysical properties necessary for the calculation of evaporation rates are vapor pressures, heats of vaporization, saturated liquid enthalpies and binary diffusivities in air. The properties of air required are thermal conductivity, kinematic viscosity and thermal diffusivity in the temperature range of 0-100°C. The necessary soil properties are thermal conductivity, density and specific heat for dry, unfrozen and frozen soil.

6.3.1 Examples of Three Model Options

The following examples illustrate the three options available with SPILLS, together with the features and capabilities of each:

- Example 1 (Figure 6-1) involves a continuous spill of benzene. The requested output is a calculation of stability class, a maximum concentration and two isopleths.
- Example 2 (Figure 6-2) corresponds to an instantaneously formed pool of acrolein. In this case the outputs are requested for two quantities of spills and include two isopleths, a maximum concentration, and the concentration at a particular point.
- Example 3 (Figure 6-3) involves an unsteady-state emission from an elevated stack. The program is requested to determine plume rise, one isopleth and a maximum concentration. An option was incorporated to allow conventional steady or unsteady state air dispersion calculations. Here the number of emission rates input to the program will determine the type of emission process, i.e., one emission rate is considered a steady-state process, two or more correspond to the unsteady-state process. The unsteady-state emission rate description should start at time = 0 with an emission rate of zero and followed by time increments of 0.00001 minute with corresponding emission rate. The program will take the final specified emission rate as a steady-state value at the corresponding time and thereafter. If a problem involves a ground level source, both the stack height and the plume rise should be set to zero.

6.3.2 Accessibility to SPILLS Vapor Dispersion Model

The computer program is very user-oriented, written in a conversational mode using Fortran V, and designed to run on an IBM 370 computer. In addition, it can be easily accessed on a portable terminal at the time of an accident to assist in mitigation efforts. For example, the input parameters to the model can be varied to predict minimum and maximum isopleths upon which estimates of evacuation zones can be based.

6.4 DDESB DOWNWIND CHEMICAL HAZARD SLIDE RULE⁽¹³⁶⁾

The chemical hazard slide rule was developed to provide simple solutions to the complicated problems of making atmospheric dispersion predictions in the field. This system does not solve mathematical relations, it replots computer-generated solutions to such simulations using recognized procedures. Graphical slide rules are different from conventional logarithmic instruments in two basic ways:

- 1) sets of data are acted upon by constants to arrive at new sets of answers, and
- 2) data and constants may be treated as parameters and not values.

The information required to use the Chemical Hazards Slide Rule to determine downwind hazard predictions are:

CMS

-SPILL SPILLS

SPILLS: A PROGRAM FOR ATMOSPHERIC DISPERSION CALCULATIONS

ENTER THE CODE NUMBER RELATED TO YOUR PROBLEM:

- 1 = CONTINUOUS LEAK (CONSTANT FLOW RATE, E.G. PIPELINE, TANK CAP)
- 2 = INSTANTANEOUSLY-FORMED LIQUID POOL
- 3 = OTHER, E.G. STACK

:1

ENTER THE CODE NUMBER OF THE TYPE OF UNITS YOU WANT TO USE:

- 1 = METRIC SYSTEM
- 2 = ENGLISH SYSTEM

:1

DO YOU NEED THE NAME OF THE CHEMICALS IN THE FILE, Y/N?:N
ENTER CHEMICAL FILE IDENTIFICATION NUMBER (1-36) :6

THE CHEMICAL IS BENZENE

ITS TIME WEIGHTED AVERAGE TLV IS 10.00 PPM (30.00 MG M-3)
ITS SHORT TERM EXPOSURE LIMIT TLV IS NOT AVAILABLE AT THIS TIME

IS THERE AN ATMOSPHERIC INVERSION LAYER, Y/N? :N

IS THE ATMOSPHERIC STABILITY CLASS KNOWN, Y/N? :N

IS IT DAYTIME (BETWEEN SUNRISE AND SUNSET), Y/N? :Y

ENTER PERCENT CLOUD COVER (TO NEAREST 10%) :20

ENTER ANGLE BETWEEN THE SUN AND THE HORIZON IN DEG (0-90) :45

ENTER WIND SPEED IN METERS PER SEC :5

THE STABILITY CLASS FOR THIS CASE = 2

ENTER AMBIENT TEMPERATURE IN DEG C :25

ENTER EMISSION RATE THROUGH PUNCTURE IN KG PER SEC :5

DO YOU KNOW THE ELAPSED TIME FROM THE BEGINNING TO THE END OF FLOW, Y/N? :Y

ENTER TIME IN MIN :150

WOULD YOU LIKE TO CHANGE A PARAMETER, Y/N? :N

DO YOU WANT THE MAXIMUM CONCENTRATION AT A GIVEN TIME, Y/N?:Y

ENTER ELAPSED TIME SINCE SPILL IN MIN :60

ENTER ELEVATION OF RECEPTOR IN METERS :0

ENTER MAXIMUM DOWNWIND DISTANCE FOR SEARCH IN KM :20

THE MAXIMUM CONCENTRATION IS = 5.356 MG M-3 (1.678 PPM)

IT OCCURS AT X = 3120.9 M (10436.1 FT)

ANOTHER MAXIMUM CONCENTRATION, Y/N?:N

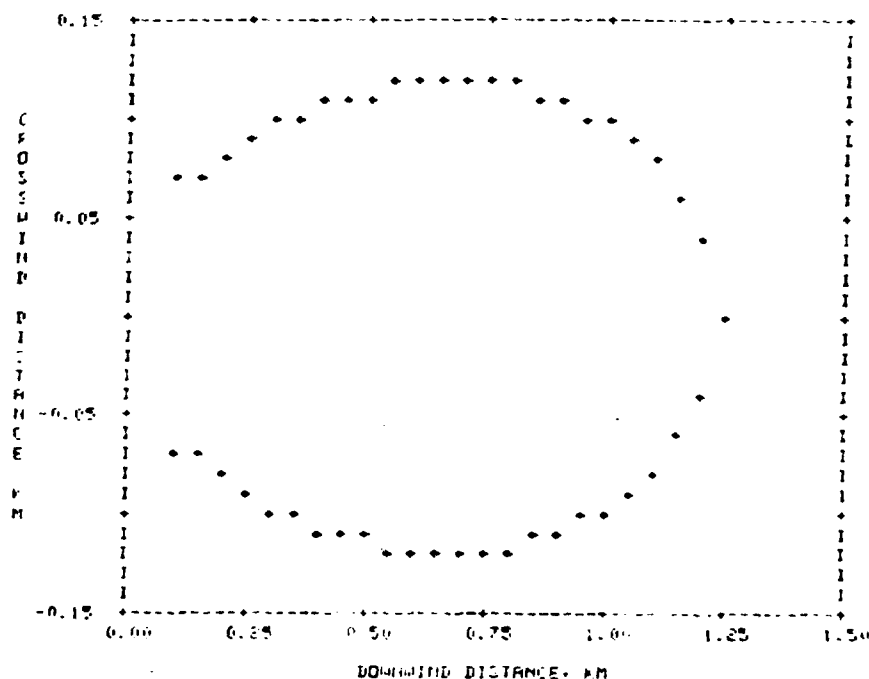
DO YOU WANT AN ISOPLETH PLOT (CONSTANT CONCENTRATION CONTOUR), Y/N?:Y

ENTER ELAPSED TIME SINCE SPILL IN MIN :30

FIGURE 6-1. SPILLS EXAMPLE CASE 1
BENZENE CONTINUOUS SPILL

ENTER THE CODE NUMBER OF THE CONCENTRATION UNIT YOU HAVE:
 1 = MILLIGRAMS / CUBIC METER
 2 = PARTS PER MILLION
 :2

ENTER THE CONCENTRATION OF INTEREST IN PARTS PER MILLION :10
 ENTER ELEVATION OF RECEPTORS IN METERS :0

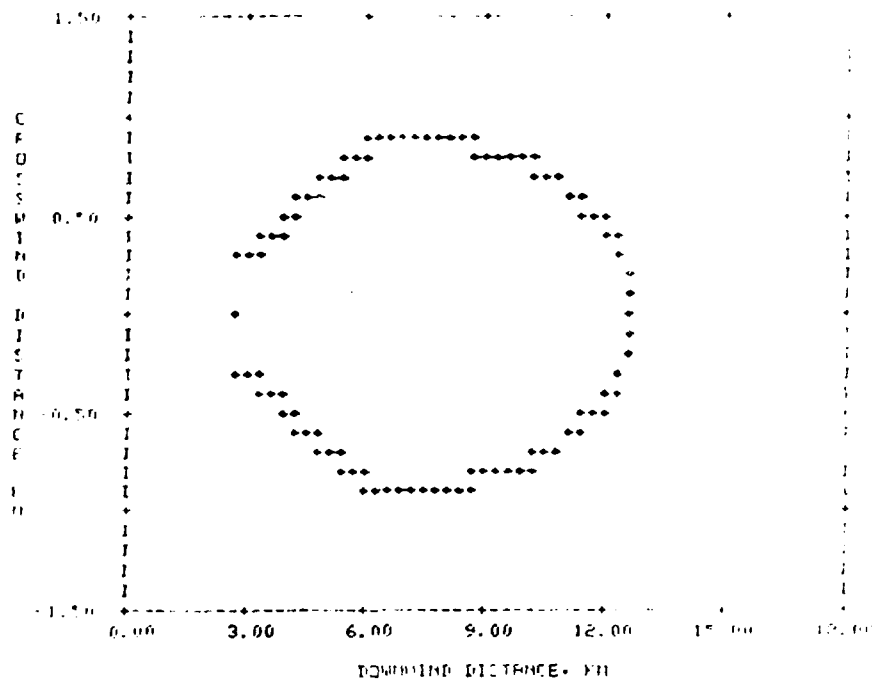


WOULD YOU LIKE TO CHANGE A PARAMETER? Y/N? :N
 DO YOU WANT A GRAPH FOR ANOTHER ELAPSED TIME? Y/N? :N
 ENTER ELAPSED TIME SINCE SPILL IN MIN :60

ENTER THE CODE NUMBER OF THE CONCENTRATION UNIT YOU HAVE:
 1 = MILLIGRAMS / CUBIC METER
 2 = PARTS PER MILLION
 :1

FIGURE 6-1. (CONT'D) SPILLS EXAMPLE CASE 1
 BENZENE CONTINUOUS SPILL

ENTER THE CONCENTRATION OF INTEREST IN MILLIGRAMS / LITER (ENTER 1)
 ENTER ELEVATION OF RECEPTORS IN METERS (0)



DO YOU WANT TO CHANGE A PARAMETER, Y/N? IN
 DO YOU WANT TO CHANGE OTHER CONCENTRATIONS, Y/N? IN
 DO YOU WANT A GRAPH FOR ANOTHER ELAPSED TIME, Y/N? IN
 DO YOU WANT THE MAXIMUM CONCENTRATION AT A GIVEN TIME, Y/N? IN
 DO YOU WANT THE CONCENTRATION AT A PARTICULAR POINT, Y/N? IN

FIGURE 6-1. (CONT'D) SPILLS EXAMPLE CASE 1
 BENZENE CONTINUOUS SPILL

CMS

FILE SPILLS

SPILLS: A PROGRAM FOR ATMOSPHERIC DISPERSION CALCULATIONS

ENTER THE CODE NUMBER RELATED TO YOUR PROBLEM:

- 1 = CONTINUOUS LEAK (CONSTANT FLOW RATE, E.G. PIPELINE, TANK CAR)
- 2 = INSTANTANEOUSLY-FORMED LIQUID POOL
- 3 = OTHER, E.G. STACK

12

ENTER THE CODE NUMBER OF THE TYPE OF UNITS YOU WANT TO USE:

- 1 = METRIC SYSTEM
- 2 = ENGLISH SYSTEM

12

DO YOU NEED THE NAME OF THE CHEMICALS IN THE FILE, Y/N? Y
ENTER CHEMICAL FILE IDENTIFICATION NUMBER (1-56) 13

THE CHEMICAL IS ACROLEIN

ITS TIME WEIGHTED AVERAGE TLV IS

1.000

PPM (1.2500

MG M-3)

ITS SHORT TERM EXPOSURE LIMIT TLV IS

15.000

PPM (18.750

MG M-3)

IS THERE AN ATMOSPHERIC INVERSION LAYER, Y/N? N

ENTER HEIGHT OF THE INVERSION LAYER IN FEET: 5000

IS THE ATMOSPHERIC STABILITY CLASS KNOWN, Y/N? Y

ENTER ATMOSPHERIC STABILITY CLASS (1-6): 4

ENTER WIND SPEED IN MILES PER HOUR: 10

ENTER AMBIENT TEMPERATURE IN DEG F: 175

ENTER TOTAL AMOUNT SPILLED IN POUNDS: 200000

ENTER AREA OF SPILL IN SQUARE FEET: 1300

THE CHEMICAL WILL EVAPORATE IN 1.1037E+05 MIN

WOULD YOU LIKE TO CHANGE A PARAMETER, Y/N? Y

DO YOU NEED THE CHANGE CODE NUMBERS, Y/N? Y

NUMBER PARAMETER

0 = EXIT

1 = STABILITY CLASS AND/OR WIND SPEED

2 = INVERSION LAYER

3 = CHEMICAL NAME

4 = CHEMICAL TEMPERATURE BEFORE THE SPILL

5 = AMOUNT SPILLED

6 = EMISSION RATE

7 = AREA

8 = STACK HEIGHT AND/OR PLUME RISE

9 = AMBIENT TEMPERATURE

10 = SOIL CONDITIONS

ENTER THE CHANGE CODE NUMBER: 17

ENTER AREA OF SPILL IN SQUARE FEET: 15000

FIGURE 6-2. SPILLS EXAMPLE CASE 2
INSTANTANEOUSLY FORMED POOL OF ACROLEIN

THE CHEMICAL WILL EVAPORATE IN 723.5 MIN

WOULD YOU LIKE TO CHANGE A PARAMETER, Y/N? :N
DO YOU WANT THE MAXIMUM CONCENTRATION AT A GIVEN TIME, Y/N?:N
DO YOU WANT AN ISOPLETH PLOT (CONSTANT CONCENTRATION CONTOUR), Y/N?:Y
ENTER ELAPSED TIME SINCE SPILL IN MIN :60

ENTER THE CODE NUMBER OF THE CONCENTRATION UNIT YOU HAVE:
1 = MILLIGRAMS / CUBIC METER
2 = PARTS PER MILLION
:2

ENTER THE CONCENTRATION OF INTEREST IN PARTS PER MILLION :1
ENTER ELEVATION OF RECEPTORS IN FEET :0

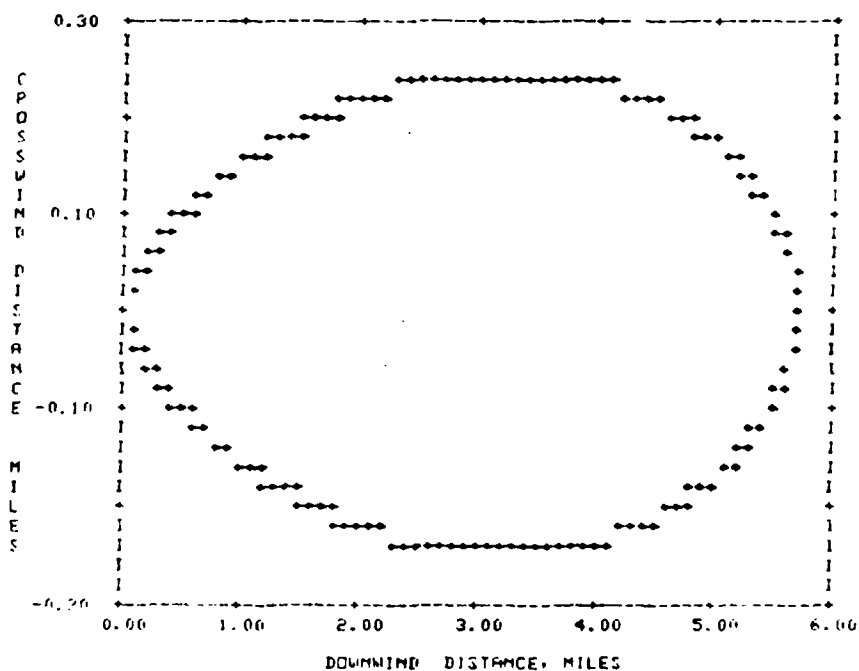


FIGURE 6-2. (CONT'D). SPILLS EXAMPLE CASE 2
INSTANTANEOUSLY FORMED POOL OF ACROLEIN

WOULD YOU LIKE TO CHANGE A PARAMETER, Y/N? :N
 ISOPLETHS FOR OTHER CONCENTRATIONS, Y/N? :N
 DO YOU WANT A GRAPH FOR ANOTHER ELAPSED TIME, Y/N? :N
 DO YOU WANT THE MAXIMUM CONCENTRATION AT A GIVEN TIME, Y/N? :Y
 ENTER ELAPSED TIME SINCE SPILL IN MIN :180
 ENTER ELEVATION OF RECEPTORS IN FEET :10
 ENTER MAXIMUM DOWNWIND DISTANCE FOR SEARCH IN MILES:5

THE MAXIMUM CONCENTRATION IS WITHIN 100 METERS (328 FT) OF THE SOURCE.
 AT 100 METERS THE CONCENTRATION IS = 2056. MG M-3 (492.8 PPM)

ANOTHER MAXIMUM CONCENTRATION, Y/N?:N
 DO YOU WANT AN ISOPLETH PLOT (CONSTANT CONCENTRATION CONTOUR), Y/N?:N
 DO YOU WANT THE CONCENTRATION AT A PARTICULAR POINT, Y/N? :Y
 ENTER ELAPSED TIME SINCE SPILL IN MIN :180
 ENTER ELEVATION OF RECEPTORS IN FEET :10
 ENTER X (DOWNWIND DISTANCE) IN MILES :1.2
 ENTER Y (CROSSWIND DISTANCE) IN FEET :0

THE CONCENTRATION IS = 401.8 MG M-3 (174.7 PPM)

WOULD YOU LIKE TO CHANGE A PARAMETER, Y/N? :N
 ANOTHER POINT, Y/N?:N
 DO YOU WANT THE MAXIMUM CONCENTRATION AT A GIVEN TIME, Y/N?:Y
 ENTER ELAPSED TIME SINCE SPILL IN MIN :800
 ENTER ELEVATION OF RECEPTORS IN FEET :0
 ENTER MAXIMUM DOWNWIND DISTANCE FOR SEARCH IN MILES:20

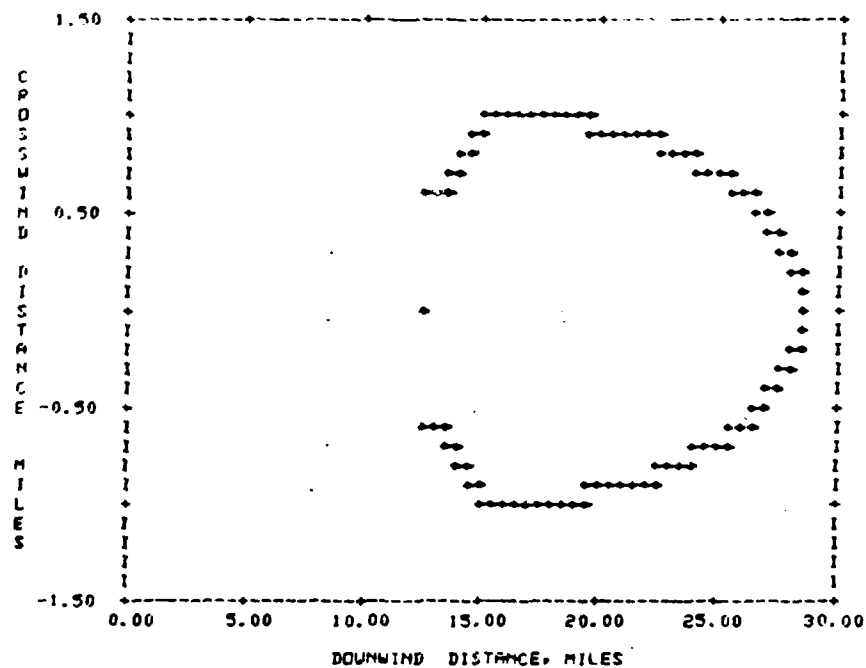
THE MAXIMUM CONCENTRATION IS = .6200 MG M-3 (.2696 PPM)
 IT OCCURS AT X = 22452.3 M (73662.2 FT)

ANOTHER MAXIMUM CONCENTRATION, Y/N?:N
 DO YOU WANT AN ISOPLETH PLOT (CONSTANT CONCENTRATION CONTOUR), Y/N?:Y
 ENTER ELAPSED TIME SINCE SPILL IN MIN :800

ENTER THE CODE NUMBER OF THE CONCENTRATION UNIT YOU HAVE:
 1 = MILLIGRAMS / CUBIC METER
 2 = PARTS PER MILLION
 :2

FIGURE 6-2. (CONT'D). SPILLS EXAMPLE CASE 2
 INSTANTANEOUSLY FORMED POOL OF ACROLEIN

ENTER THE CONCENTRATION OF INTEREST IN PARTS PER MILLION 1.1
 ENTER ELEVATION OF RECEPTORS IN FEET 10



WOULD YOU LIKE TO CHANGE A PARAMETER, Y/N? IN
 1.0PLETHS FOR OTHER CONCENTRATIONS, Y/N? IN
 DO YOU WANT A GRAPH FOR ANOTHER ELAPSED TIME, Y/N? IN
 DO YOU WANT THE MAXIMUM CONCENTRATION AT A GIVEN TIME, Y/N? IN
 DO YOU WANT THE CONCENTRATION AT A PARTICULAR POINT, Y/N? IN
 --

FIGURE 6-2. (CONT'D) SPILLS EXAMPLE CASE 2
 INSTANTANEOUSLY FORMED POOL OF ACROLEIN

-FILED SPILLS

SPILLS: A PROGRAM FOR ATMOSPHERIC DISPERSION CALCULATIONS

ENTER THE CODE NUMBER RELATED TO YOUR PROBLEM:

- 1 = CONTINUOUS LEAK (CONSTANT FLOW RATE, E.G. PIPELINE, TANK CAR)
- 2 = INSTANTANEOUSLY-FORMED LIQUID POOL
- 3 = OTHER, E.G. STACK

:3

ENTER THE CODE NUMBER OF THE TYPE OF UNITS YOU WANT TO USE:

- 1 = METRIC SYSTEM
- 2 = ENGLISH SYSTEM

:1

DO YOU KNOW THE MOLECULAR WEIGHT OF THE SUBSTANCE EMITTED, Y/N?:Y

ENTER THE MOLECULAR WEIGHT :34.08

ENTER AMBIENT TEMPERATURE IN DEG C :20

HOW MANY EMISSION RATES DO YOU HAVE (UP TO 100)? :4

ENTER TIME IN MIN :0.0

ENTER ITS EMISSION RATE IN KG/SEC :0.0

ENTER TIME IN MIN :0.00001

ENTER ITS EMISSION RATE IN KG/SEC :0.5

ENTER TIME IN MIN :30

ENTER ITS EMISSION RATE IN KG/SEC :1

ENTER TIME IN MIN :45

ENTER ITS EMISSION RATE IN KG/SEC :0

IS THERE AN ATMOSPHERIC INVERSION LAYER, Y/N? :N

IS THE ATMOSPHERIC STABILITY CLASS KNOWN, Y/N? :Y

ENTER ATMOSPHERIC STABILITY CLASS (1-6):4

ENTER WIND SPEED IN METERS PER SEC :6

ENTER STACK HEIGHT ABOVE LOCAL TERRAIN IN METERS :50

IS THE PLUME RISE KNOWN (DIST FROM STACK HEIGHT TO PLUME ELEV), Y/N?:N

ENTER STACK GAS TEMPERATURE IN DEG C :200

ENTER STACK GAS VOLUMETRIC FLOW RATE IN CUBIC METERS PER SEC :100

THE EFFECTIVE PLUME HEIGHT IS = 163.35 M

IT OCCURS AT X = 804.3 M

FIGURE 6-3. SPILLS EXAMPLE CASE 3

UNSTEADY STATE EMISSION FROM AN EVATED STACK

IS THIS CASE AN AREA SOURCE, Y/N? :N
 WOULD YOU LIKE TO CHANGE A PARAMETER, Y/N? :Y
 DO YOU NEED THE CHANGE CODE NUMBERS, Y/N? :Y

NUMBER PARAMETER
 0 = EXIT
 1 = STABILITY CLASS AND/OR WIND SPEED
 2 = INVERSION LAYER
 3 = CHEMICAL NAME
 4 = CHEMICAL TEMPERATURE BEFORE THE SPILL
 5 = AMOUNT SPILLED
 6 = EMISSION RATE
 7 = AREA
 8 = STACK HEIGHT AND/OR PLUME RISE
 9 = AMBIENT TEMPERATURE
 10 = SOIL CONDITIONS

ENTER THE CHANGE CODE NUMBER :8
 ENTER STACK HEIGHT ABOVE LOCAL TERRAIN IN METERS :150
 IS THE PLUME RISE KNOWN (DIST FROM STACK HEIGHT TO PLUME ELEV), Y/N?:N
 ENTER STACK GAS TEMPERATURE IN DEG C :120
 ENTER STACK GAS VOLUMETRIC FLOW RATE IN CUBIC METERS PER SEC :100

THE EFFECTIVE PLUME HEIGHT IS = 139.03 M
 IT OCCURS AT X = 684.6 M

IS THIS CASE AN AREA SOURCE, Y/N? :N
 WOULD YOU LIKE TO CHANGE A PARAMETER, Y/N? :N
 DO YOU WANT THE MAXIMUM CONCENTRATION AT A GIVEN TIME, Y/N?:N
 DO YOU WANT AN ISOPLETH PLOT (CONSTANT CONCENTRATION CONTOUR), Y/N?:Y
 ENTER ELAPSED TIME SINCE SPILL IN MIN :40

ENTER THE CODE NUMBER OF THE CONCENTRATION UNIT YOU HAVE:
 1 = MILLIGRAMS / CUBIC METER
 2 = PARTS PER MILLION
 :1

ENTER THE CONCENTRATION OF INTEREST IN MILLIGRAMS / CUBIC METER:10
 ENTER ELEVATION OF RECEPTORS IN METERS :10

CONCENTRATION CALCULATIONS, UP TO 48 KM (29.8 MILES) DOWNWIND FROM THE
 SOURCE, INDICATE THAT THE GIVEN CONCENTRATION OF INTEREST IS TOO HIGH.
 RECOMMENDATION: GET THE MAXIMUM CONCENTRATION FOR THE SAME CONDITIONS

DO YOU WANT THE MAXIMUM CONCENTRATION AT A GIVEN TIME, Y/N?:Y
 ENTER ELAPSED TIME SINCE SPILL IN MIN :40
 ENTER ELEVATION OF RECEPTORS IN METERS :10
 ENTER MAXIMUM DOWNWIND DISTANCE FOR SEARCH IN KM :50

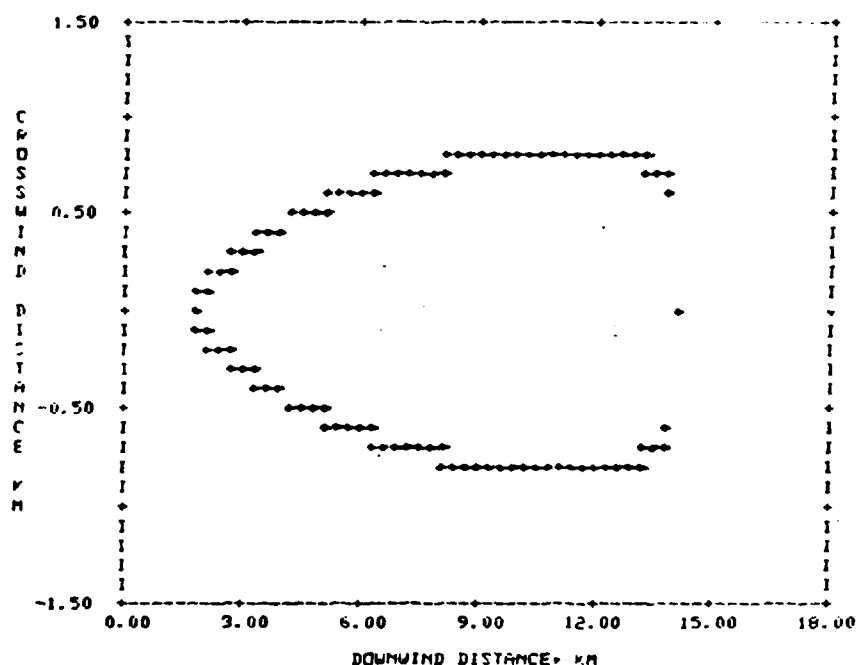
THE MAXIMUM CONCENTRATION IS = .5766 MG M-3 (.4070 PPM)
 IT OCCURS AT X = 4359.9 M (14304.2 FT)

FIGURE 6-3. (CONT'D). SPILLS EXAMPLE CASE 3
 UNSTEADY STATE EMISSION FROM AN ELEVATED STACK

ANOTHER MAXIMUM CONCENTRATION, Y/N? :N
 DO YOU WANT AN ISOPLETH PLOT (CONSTANT CONCENTRATION CONTOUR), Y/N? :Y
 ENTER ELAPSED TIME SINCE SPILL IN MIN :40

ENTER THE CODE NUMBER OF THE CONCENTRATION UNIT YOU HAVE:
 1 = MILLIGRAMS / CUBIC METER
 2 = PARTS PER MILLION
 :1

ENTER THE CONCENTRATION OF INTEREST IN MILLIGRAMS / CUBIC METER :1
 ENTER ELEVATION OF RECEPTORS IN METERS :10



WOULD YOU LIKE TO CHANGE A PARAMETER, Y/N? :N
 ISOPLETHS FOR OTHER CONCENTRATIONS, Y/N? :N
 DO YOU WANT A GRAPH FOR ANOTHER ELAPSED TIME, Y/N? :N
 DO YOU WANT THE MAXIMUM CONCENTRATION AT A GIVEN TIME, Y/N? :N
 DO YOU WANT THE CONCENTRATION AT A PARTICULAR POINT, Y/N? :N
 ::

FIGURE 6-3. (CONT'D) SPILLS EXAMPLE CASE 3
 UNSTEADY STATE EMISSION FROM AN
 ELEVATED STACK

- 1) agent;
- 2) source strength;
- 3) local meteorological data needed to identify the applicable Pasquill Category including wind speed and direction, cloud cover and solar radiation level;
- 4) determination of the source as instantaneous or continuous;
- 5) for a continuous source, length of time of release; and
- 6) level of human activity downwind, which influences breathing rate and therefore, population exposure.

The slide rule uses positive film type acetate overlays to reproduce many graphs. Some parts are fixed over a set of locators and other parts slide to make estimates from many combinations of contributing factors. This assembly may be used to estimate downwind dosages from the accidental atmospheric releases of toxic chemicals near ground level. Two sets of components may be required:

- 1) A set of components to estimate dosages as a function of downwind distances. Slide overlays are provided for both instantaneous and continuous sources.
- 2) The second set of components is used in the estimation of evaporation rate for accidental spills. The evaporation rate and the total quantity spilled are used to estimate the time required for complete evaporation.

General Operating Principles

Precalculated solutions are plotted graphically on a transparent slide so that when proper alignment is made with a base graph, the coordinate axes reflect a valid data set by the intersections of coordinate points on the plotted curves.

A new set of solutions is generated by moving the curve(s) to a new position. Scales are plotted, generally on the slide, to aid in the relocation of the slide at a new position and thus reproduce the precalculated solution for a specific change in a parameter. When more than one parameter is plotted, a cursor is needed to locate the slide properly as two or more parameters are varied.

The functional graphs of this slide rule are plotted on a logarithmic scale in both dimensions.

The user needs to be trained in the use of the system and requires background information on the several input parameters needed. This system was developed for military agents and explosives, and does not have the data necessary to address release of any of the twelve chemicals and propellants in this study. The Chemical Hazard Slide Rule is relatively easy to use and can be applied for field use, however, further development of slides for other hazardous chemicals must be undertaken before the system can be used for across-the-board hazardous material emergency transportation response activities.

6.5 THE AFCRL STATISTICAL VAPOR DISPERSION MODEL⁽¹³⁵⁾

The AFCRL model is a steady-state model representing a ground-level release of vapors from a spill of UDMH-hydrazine fuel or nitrogen tetroxide oxidizer. It was developed to determine the dispersion and toxic vapor levels of these propellants at Titan II installations. Experiments have shown that low-level atmospheric diffusion depends on the following parameters: (1) wind direction fluctuation as an indication of the horizontal rate of mixing or diffusion; (2) vertical temperature gradient as an indicator of the vertical rate of diffusion; (3) mean wind speed as an indicator of the dilution rate of the contaminant as it is emitted at the source; and (4) source strength, the amount of material introduced into the atmosphere per unit time.

The AFCRL dispersion model assumes that: (1) only vertical and lateral mixing occur; (2) steady-state conditions are present; and (3) there are homogeneous horizontal atmospheric conditions. The model was empirically/statistically developed based on the following tracer experiments simulating ground-level continuous point source releases: (1) Prairie Grass at O'Neill, Nebraska in 1956; (2) Ocean Breeze at Cape Kennedy, Florida in 1963; and (3) Dry Gulch at Vandenberg AFB, California in 1963.

The equation developed using these data is as follows:

$$\frac{C_p}{Q} = .000175 X^{-1.95} (\Delta T + 10)^{4.92},$$

where C_p is the peak concentration in gms/cubic meter at a height of approximately 5 feet above the ground at a given downwind travel distance, X in meters

Q is the source strength in gms/second

ΔT is the difference, in $^{\circ}F$, between the temperature at 54 feet and 6 feet above the ground.

ΔT is defined by $T_{54} - T_6$ so that a negative ΔT means a decrease of temperature with height, and a positive ΔT , an increase of temperature with height. The quantity 10 is added to ΔT to avoid raising a negative number to a power. The constants are parameters of fit determined by least-squares regression techniques. The model can be applied only to releases of short duration, 3 minutes or less, and up to a maximum downwind direction of six miles. This model can not be applied to releases that are instantaneous or have elevated sources.

Based on the results of these tests, nomographs and tables have been developed which predict the normalized peak concentration of contaminants as a function of distance downwind and extent of hazard area as defined by a given

concentration and source strength. If an accident was to occur, data necessary to execute this model could be obtained at the meteorologic equipment stations at the missile site.

6.6 OVERVIEW OF DENSE GAS DISPERSION MODELS

The HACS, SPILLS, DDESB Slide Rule and AFCRL vapor dispersion models are not designed to predict the concentration levels and atmospheric dispersion of negatively buoyant or dense gases. Other groups of models are being developed with this purpose in mind but have not been validated by field testing. Dense gases fall into four categories based on either their chemical composition or specialized shipping requirements. These categories are: (1) high molecular weight gases (e.g. Cl_2); (2) pressurized liquefied gases at ambient temperature and elevated pressures (e.g. LPG); (3) refrigerated liquefied gases (e.g. LNG); or (4) refrigerated pressurized liquefied gases.

For predicting the atmospheric dispersion of high molecular weight gases it should be noted that they experience gravity spreading with entrainment and turbulent mixing in the atmosphere. Pressurized liquefied gases stored at ambient temperatures and elevated pressures experience gas releases from two effects: (1) flash evaporation due to reduction of vapor pressure and temperature to reach equilibrium with the atmosphere; and (2) slow pool evaporation resulting from heat transfer to the cold liquid pool. Gravity spreading and dispersion of the cold gas are influenced by surface heating of the cloud, since vapors are emitted at the boiling point of the gas. Thus, cloud mixing is enhanced with heating along the cloud path. Refrigerated liquefied gases emanate from pool evaporation after a spill. The resultant vapor is denser than air and disperses with a gravity spread component until mixing and cloud heating cause the gas to become neutrally or positively buoyant. Atmospheric diffusion of refrigerated pressurized liquefied gases would result from the combination of flash and pool evaporation and cloud heating.

Atmospheric dispersion models for dense gases are typically multicomponent mathematical descriptions of the three phases of gas release. These models can best be defined as:

- source model which describes gas emission to the atmosphere;
- gravity spread model which simulates spreading and dilution of the cloud under the influence of gravity and edge mixing or entrainment; and

- o neutral tracer dispersion model which accounts for final transport and dispersion of the gas from the time the cloud becomes neutrally buoyant with respect to air until it no longer presents hazards.

Two distinct features of source/gas generation models are that pressurized liquefied gas is subject to two components of vaporization upon release as follows: (1) a flash as the liquid vapor pressure goes from pressure vessel environment to ambient air pressure and cools the liquid to its boiling point; and (2) heat transfer to the liquid pool from the substrate (land or water).

Gravity spreading models are based on the understanding that gravity acting on the density difference between the cloud and air results in an outward motion. The outward motion continues until the density difference is eliminated. It should be noted that confined land spill models do not normally include gravity spread submodels. Various gravity spread models consider cloud-air entrainment, convective heating and wind speed.

Dispersion models are of two types as follows: (1) numerical models (based on LNG simulations) developed primarily for Lawrence Livermore Laboratory and; (2) analytical models. In the numerical models, gravity spreading after vaporization and dispersion are coupled in numerical solutions to equations for mass, heat and momentum conservation. Analytical models, however, are empirical solutions to a diffusion equation for neutrally buoyant gases whose fundamental concepts are equated to Gaussian puff (instantaneous) and (continuous) plume solutions derived by Pasquill.

The dispersion parameters used in dense gas models are somewhat controversial because of their temporal and spatial variability. Presently dispersion parameters are empirical relations based on limited measurements over short distances on flat terrain for neutrally buoyant gases which may not be representative particularly over water or varying terrain.

While a comprehensive but usable dense gas model does not presently exist, field experiments are planned to further develop applicable models. Once a comprehensive vapor dispersion model with capabilities of existing models for spills on land and water is combined with dense gas and terrain effects, the emergency response community will have a tool broadly applicable to the wide range of vapor hazards presented at hazardous materials transportation emergencies.

6.7 OVERVIEW OF VAPOR DISPERSION TESTING IN EUROPE

Vapor dispersion testing in European nations is in its infancy. A series of tests were conducted by Koninklijke/Shell-Laboratory in the Netherlands and in Norway in

terms of the vapor dispersion patterns of LNG and LPG to land and water.

Another series of dispersion tests is planned to begin in the middle of 1982. The emphasis of these tests will be on dense gases. These tests will be operated and funded by several nations of the western world. Having an estimated cost for testing of 2 to 2.5 million dollars, funds are still being raised from the international community. To date, no tests have taken place, but preliminary work in setting up testing apparatus has occurred. The tests are planned to occur on an RAF base in England. It is anticipated that the purpose of these tests will be to examine the fundamental principals of freon, carbon dioxide and air.

7. CRITERIA FOR DEVELOPING PROCEDURES FOR MITIGATING HAZARDS ASSOCIATED WITH RESPONSE ACTIVITIES AT AN ACCIDENT

Based on the assessment of present emergency response, hazards mitigation, wreckage removal and cleanup operations reported in sections 4, 5, and 6 it is now necessary to move towards development of improved hazards mitigation and cleanup procedures. (Wreck clearing is handled separately in section 8). An essential part of the development is the identification of criteria for these procedures which will ensure the procedures are comprehensive and meet all requirements for safely handling the emergency. Based on this, criteria for developing procedures for twelve critical operations are derived in the following section.

7.1 CRITERIA FOR TWELVE CRITICAL OPERATIONS

- on-scene methods for identifying hazardous materials in unmarked transport trailer, railcar or shipping container;
- assessment of container integrity after sustaining damage;
- assessment of toxicity, flammability and explosivity hazards or risks relating to mitigation and cleanup operations;
- developing a logical process for formulating a protocol for selecting the hazards mitigation and cleanup methods for single and multiple material spills;
- transfer operations;
- remote sensing of product container temperature and pressure;
- on-scene communication to central computer centers and command posts;
- stopping leaks and accomplishing manual or remote transfer and venting operations;
- training aids for government and industry response teams;
- determining local weather conditions to aid in establishing air dispersion limits for varying conditions of weather and terrain;
- wreckage removal; and
- cleanup and disposal.

The following sections describe the criteria necessary as input to developing procedures for each of these operations.

7.1.1 On-Scene Methods for Identifying the Ingredients of Unmarked Transport Trailer, Railcar and/or Shipping Containers

At a transportation accident it is essential to identify accurately any hazardous materials involved and the various hazards (i.e., toxic, flammable, explosive, corrosive, etc.) associated with them. Response to transportation accidents involving

hazardous materials requires timely identification of the contents of involved containers, tank cars or tank trucks. Several alternatives exist for identifying hazardous materials being transported. These include, but are not limited to, the following:

1. sensing methods using appropriate instruments;
2. waybill, consist or bill-of-lading documentation;
3. use of the DOT placarding system separately or in conjunction with the United Nations or Standard Transportation Commodity Code (STCC) identification numbers;
4. observation of markings, specific coloration, size, shape and appurtenances on containers; and
5. use of such assistance networks as the USCG National Response Center or Chemical Manufacturers Association's CHEMTREC (Chemical Transportation Emergency Center).

Optimally, these various methods can be used in conjunction to positively identify a material involved in an accident. Positive identification is necessary for the responding personnel to properly mitigate hazards associated with a specific accident.

There are many commercially available field sensing devices for identifying hazardous materials and various toxic and flammable vapors. These include gas type detectors, radiation absorption units (IR,UV), colormetric techniques and GC-MS. Methods for remote identification still need to be developed. For maximum efficiency and applicability, such field equipment should have the following characteristics:

1. be easily maintained with long-lived, rechargeable power sources and easily replaced components;
2. be portable (less than 50 lbs.) so they can be carried over obstacles and irregular terrain easily to obtain accessibility;
3. have an equipment readout that does not require technical interpretation or computation and that results in a hard copy;
4. be sensitive to, but not blinded by, a broad range of flammable, toxic and explosive vapor concentrations;
5. be sensitive to immediate, short-term vapor level hazards as well as to longer-term vapor hazards;
6. be real-time, rapid and capable of continual monitoring throughout the entire wreck-clearing operation;
7. be shatterproof and able to withstand shock and other hostile environments;
8. where necessary, be capable of detecting chemical concentration in an aquatic environment;
9. cost-effective; and
10. commodity specific.

Waybill or bill-of-lading documentation is an another important tool for

identifying the contents of a tank truck, tank car or other container involved in a transportation accident. In the highway mode, the bill of lading is carried in the driver's cab. For rail shipments, the train consist and waybill information is usually kept by the conductor in the caboose. These documents identify contents of a rail tank car or highway tank truck as well as providing the quantity and weight of the commodity, the DOT placard(s) required, the DOT description and hazard classification of the material and the National Motor Freight Classification Number (highway) or the Uniform Classification Number (rail) for the specific commodities being transported. Procedures must assure:

1. this information is actually carried;
2. the information is accurate and precisely presented;
3. rail or highway personnel actively seek out representatives of the emergency response community for the identity of the materials involved (i.e., they should remain at the accident site until response teams arrive and assist wherever possible in identifying the contents of a truck or tank car);
4. printed emergency response procedures are provided with the documentation for each commodity being transported; and
5. the rail crew identify not only which cars contain hazardous materials but also their position in the train for possible interaction (This could increase hazards and risks for arriving emergency responders).

The DOT placard is an indicator of the primary hazard associated with specific classes of hazardous materials. At present, nine classes of hazardous commodities are identified. They are: explosives, compressed gases, flammable liquids, flammable solids, oxidizing material, poisonous material, irritating material, corrosive material and radioactive material. Of concern to the present study are flammable, toxic and explosive materials. In the case of an accident involving fire, the placards may either burn or be destroyed. Placards may be useful at accidents where no fire occurs, and particularly if they are still in place on the car and readable. Relevant criteria for an adequate placard system require it be:

1. manufactured from a non-destructive material;
2. easily visible and immediately recognizable;
3. weather and light resistant;
4. the correct placard for the vehicle involved.

A study conducted by Virginia Polytechnic Institute and State University entitled, Virginia Highway Hazardous Materials Flow examined truck traffic in Virginia during 1977 to identify the percentage of highway carriers in the state that comply with DOT placarding requirements for hazardous materials transportation. It was observed

that seventeen percent of the hazardous materials truck traffic requiring placards were in non-compliance with Federal Regulations. Therefore, response groups must exercise additional care to properly identify materials involved.

All DOT-regulated hazardous commodities shipped by highway or rail have been assigned a United Nations number and a Standard Transportation Commodity Code number. If either of these numbers are known, but the commodity name is not known, existing response procedures can be identified by referencing the UN number in the DOT Emergency Response Guidebook⁽³⁰⁾ or the USCG CHRIS^(31,33-35) System; as well as the UN or the STCC number in the AAR guide, Emergency Handling of Hazardous Materials in Surface Transportation.⁽²⁷⁾ Each of these manuals has been designed for a particular type of release on land or water and consequently no manual is applicable for all types of spills. Appropriate response procedures need to be available in a single source document for all hazardous materials emergencies. A problem associated with the UN classification system is that the responses are for generic hazard groupings (although primary, secondary and tertiary hazards have been considered), rather than being commodity specific.

Certain commodities in transportation require that the name be stenciled on the tank car or container. For example, tank cars in anhydrous ammonia, propane, chlorine and butadiene service are stenciled. This stenciling can be a useful identification tool as an indicator of tank contents. Stenciling should be required on both tank ends as well as each side. This will provide greater visibility to on-site personnel. Also, to insure reliability, a check should be made prior to loading the container so that the lading conforms with the tank stencil. Operational procedures may be required to ensure this check prior to loading operations.

Telephonic assistance networks such as the USCG National Response Center and CHEMTREC can assist a caller in identifying a material given some on-scene information such as color, smell, dispersion patterns, etc. Also, these groups recommend information on preliminary handling and firefighting procedures and even evacuation requirements for use at the accident until expert assistance arrives. Computerized systems can further augment data transmission to an accident scene. These systems need to be accessible to personnel in remote areas; use real-time data; have quick turn around time, which will improve on-scene identification methods; and have 24-hour accessibility by personnel to the system. The personnel using these systems need to have knowledge of input parameters used to execute the models and have proper training to interpret the results.

7.1.2 On-Scene Communication to Central Computer Center and Command Post

A properly operated communication system is an essential tool at the accident site, however, a communication network that is over-utilized or unstructured could be detrimental to any operation. Unfortunately, the latter is the typical state of affairs at a transportation accident.

Presently, after an accident has occurred, the engineer, conductor or truck driver will notify the dispatcher. Communication to the dispatcher may be via radio, wayside railroad telephone or by public telephone. The latter two modes imply that the engineer/conductor/driver must leave the scene of the accident to make his report to the dispatcher. Furthermore, he may have to search for a public telephone if he is in a remote area. If he has access to a wayside railroad telephone, he could possibly be closer to the accident scene; but he may not be able to provide accurate, real-time information in terms of the conditions at the accident, damaged vehicles or hazardous chemical spills. Once the dispatcher has been notified of the accident and its location, he will then notify other departments which will, in turn, notify emergency and police units that are in the area of the accident. Also, when hazardous cargoes are involved, specific government agencies must be notified.

For the next several hours, work crews will be arriving at the scene and must coordinate with local fire and police departments and also deal with spectators. As the number of people increase at the scene, communication becomes an extremely important tool for coordinating efforts to mitigate the potential danger of hazardous material releases. Typically, this is the point where communications between groups begins to break down. There are too many independent groups operating at the scene with no overall communication network to knit them into a cohesive work force. This situation is undesirable from the standpoint of safety and effectiveness.

The fire department is usually the first major unit to arrive at the scene. Individuals within these units may or may not have had any formal training in the handling of hazardous materials. There are training programs that are directed towards fire and rescue units so they can aid in handling chemical spills and damaged vehicles at the scene. The more progressive departments have personnel that have some form of this training. These people will have manuals containing information on the methods to be used to mitigate hazards associated with spilled chemicals and/or damaged vehicles on-site. The question is, how current these manuals are. If they are not current, what is the state-of-the-art that is not presented in the outdated manuals which would prove beneficial in handling the on-site hazard?

One can easily surmise that there are two basic communications problems to and from an accident site. First, there is the problem of communication between individuals and/or groups of people at the site and the problem of communicating with organizations not located at the accident. Secondly, a need exists to ensure that field personnel have the most current methodology available for accident mitigation.

At a crash site, the radio communication equipment will typically belong to four different groups:

1. fire department;
2. police department;
3. emergency medical groups; and
4. carrier.

This means that more than likely these groups will not be able to communicate with one another using their radio equipment. A solution for this would be to establish a communication command post (CCP).

The CCP has the potential of solving many of the problems that are inherent in present wreck-clearing operations. It would be responsible for coordinating all communications between each of the rescue groups at the accident including railroad personnel. The CCP would allow easy transfer of command to more experienced personnel as they arrive on-site. The CCP would also be responsible for making and maintaining contact with the National Response Center (NRC). The CCP would pass current real-time data as to the conditions at the crash site to the NRC, which would return to the CCP information concerning the mitigation options available given the hazardous materials involved. The NRC would also be responsible for recommendations on alternative techniques for changing conditions at the crash site.

To protect crews and civilian population in proximity to the accident, the CCP should to furnish the NRC accurate on-scene meteorologic conditions, especially wind speed, ambient temperature and precipitation/condensation information.

To make the command post operational there must be designated radio frequency channels assigned that will be used nationally for emergency operations. The transceivers to be used by field personnel must be portable and can be designed to transmit or receive only from the CCP. The CCP should not be more than one mile from the accident site. The CCP will consist of a transceiver that is capable of transmitting and receiving all of the designated radio frequencies. A receiver scanner could be used to monitor the active channels. The operator would select the channels to use based on the particular needs at the moment.

The CCP must also be capable of relaying information to the NRC. The mechanism to implement this would be to use either a radio link or lay a wire to an acoustic coupler attached to a telephone receiver. This link must be able to transmit voice and data. The data would be transmitted over the telephone using a modem. The output from the modem will be combined with the audio that would be transmitted to and from the NRC. Vapor concentration, temperature and wind speed and direction data would be transmitted to the NRC. The data should be collected from weather monitoring stations strategically placed around the accident site. The sensor stations would transfer their data to the CCP via cable or from small battery-operated transmitters. If transmitters are used, they could all be assigned the same transmission frequency. The weather sensor stations would initiate their data transmissions at random. The probability of two or more sensor stations transmitting simultaneously will be minimized. The CCP will decode the data and determine if the data were contaminated by two or more channels transmitting concurrently. When data proves to be valid, the CCP will forward it to NRC. If the data are not valid, they will be ignored and another transmission from the weather stations will be requested.

Data will also be transmitted by NRC to the CCP. This data will be in conjunction with the voice communication and will consist of information concerning the mitigation of the hazardous materials. Located in the CCP will be a line printer which will reproduce the data transmitted from the NRC into hard copy. The line printer will be capable of making additional copies. These additional copies will then be forwarded to the field crews to minimize misunderstood verbal communication. The hard copy will also be used as reference material. This will minimize the need to carry manuals that cover all types of possible chemical hazard information.

Another function of the CCP is to make announcements to the press and news media concerning the accident, evacuation possibilities and precautionary steps which the public can perform for self-protection.

7.1.3 Assessment of Toxicity, Flammability and Explosivity Hazards or Risks Relating to Mitigation and Cleanup Operations at Accident Scene

At a hazardous materials transportation accident, it is essential to assess the toxic, flammable and explosive hazards or risks relating to mitigation and cleanup operations on-scene. Detailed assessments of toxic and flammable hazards associated with specific hazardous materials can be performed by on-site field sensing analytical methods, mathematical calculations as well as by the experience and knowledge of responding personnel.

Sensing devices (i.e., vapor or gas detectors) for monitoring toxic or flammable vapor concentrations should possess several of the same characteristics as those detectors used for identifying hazardous materials. In fact, much of the equipment used for identifying a material can also be used for monitoring and assessment purposes on-scene. Sensing equipment used in field applications should include the following characteristics:

1. easy maintenance with long-lived, rechargeable power sources and easily replaced components;
2. portable and lightweight (less than 50 lbs.) so it can be easily carried over obstacles and irregular terrain to gain accessibility;
3. readout should not require technical interpretation or computation and a hard copy of the results should be available in a short period of time;
4. detectors should be sensitive to but not blinded by a broad range of flammable, toxic and explosive vapor concentrations (from lower to upper explosive limits and saturation concentrations);
5. detection process should be real-time, rapid and capable of continual monitoring throughout the entire wreck-handling and clearing operation;
6. equipment should have shatterproof housing, be able to withstand shock and other hostile environments;
7. where necessary, an instrument should be able to detect chemical concentrations in an aquatic environment;
8. be cost-effective;
9. instrument components used for measurement of flammable and explosive vapor hazards should be non-sparking;
10. detectors to measure toxic vapor concentrations must be commodity specific; and
11. during immediate response and site stabilization, product transfer, wreckage removal and cleanup and disposal operations, the optimal number of detectors should either be strategically located or carried by adequately protected personnel to obtain the most accurate and representative measurements.

Mathematical calculations using equations, slide rules or nomographs can also be used to assess the toxic, flammable and explosive hazards at an accident site. Here the amount of material being shipped and the amount spilled over a given time period can be used to estimate the source strength. Once the source strength is known, meteorologic conditions such as wind speed and direction, and ambient temperature can be used to plot mean vapor dispersion estimates for evacuation or other operational risk analysis purposes. Even though it can be used to assess gross hazards, this method requires prior technical knowledge concerning the hazardous material and its thermophysical properties as well as more technical and interpretive capability by the personnel on-scene to perform the calculations, plot the curves and interpret the results.

Clearly, another way to assess a material's flammable, toxic or explosive hazards is to have personnel on-site familiar with the physical, chemical and thermal properties of the hazardous commodity itself. For example, in accidents involving ethylene oxide or propane, a person familiar with either would know that the vapors can be detonatable in unconfined space and pose additional personnel safety risks in wreck clearing and other operations. However, only an expert could take such information and make sound decisions based on knowledge and experience with the material. On the other hand, there are serious problems associated with depending solely on technical expertise viz:

1. experts are not always available to respond in a timely fashion, although this could be done over the telephone;
2. because of the very large number of hazardous commodities being shipped, it is often difficult to locate an expert other than specific shipper personnel for a particular chemical; and
3. as a sole detection and assessment method, the varying conditions and combinations of hazardous materials involved at different accidents often leads to differing opinions and ideas even among the experts on the optimum course of action to mitigate hazards.

7.1.4 Determining Local Weather Conditions and/or Forecasts to Aid in Establishing Air Dispersion Limits For Varying Conditions of Terrain and Weather

To identify the procedural criteria for determining local weather conditions or forecasts to aid in establishing air dispersion limits for varying conditions of terrain and weather, two issues must be considered. First, what types of data need to be collected on-site for input to an air dispersion model for evaluation of evacuation needs and secondly, how appropriate are various air dispersion models in accurately describing behavior of releases of specific hazardous materials.

Input required for determining air dispersion limits include on-site meteorologic conditions and topography as well as data on the material, amount spilled and source strength.

If possible, meteorologic data should be collected at the accident site, but if an accident occurs in a remote area of rugged terrain, the set-up of mobile meteorologic monitoring equipment may be unrealistic. However, when the topography is rather flat, mobile meteorologic monitoring equipment should be established at the accident site with resultant data being forwarded to the command post and NRC/CHEMTREC.

Local meteorologic forecasts expected to impact an accident area will be important where the accident is of such magnitude that the response operations take several days. When required, forecasted meteorologic information can be obtained through contact with a local weather service or the National Weather Service.

Contingency plans should have a provision which requires immediate contact with these groups to obtain the required weather information.

The types of data which should be collected either by the mobile equipment or through the weather service include ambient temperature, wind speed and direction, atmospheric pressure, presence or absence of temperature inversion, and location of nearest cold front (precipitation or condensation activity).

The collection of these data will require sensing devices which should meet the following requirements:

1. be able to function over a wide range of temperatures;
2. be able to withstand shock and hostile environments;
3. be easily maintained with replaceable parts;
4. require only simple input and output, used with a minimum of training;
5. have non-sparking components;
6. provide real-time monitoring capabilities;
7. be portable, easily carried;
8. have a long-lived, rechargeable power source;
9. provide a written record of the data; and
10. be cost-effective.

Meteorologic monitoring should be conducted continuously throughout the entire unstabilized hazards period of the accident. In conjunction with on-scene monitoring, any released material should be tracked by radar or aerial surveillance methods.

Based on meteorologic conditions and the toxic and flammable vapor hazards associated with the released material, decisions can be made concerning; (1) whether the hazardous condition has been stabilized enough to allow work in the area, and (2) whether downwind population ought to be evacuated and to what distance. These decisions are critical in cases where the released material presents toxic or flammable vapor hazards.

There are several approaches to establishing air dispersion limits for releases of hazardous materials. The first is a general approach which uses as input parameters source strength, wind conditions and ambient temperature for predicting concentration levels, either TLV (toxic lethal values) or LEL (lower explosive limits) downwind at a distance from the accident site. This estimation is based on mathematical calculations and is more general than computerized air dispersion models.

Generally, there are four classes of air dispersion models: Gaussian, numerical, statistical/empirical and physical. Several specific computerized models have been developed, such as the USCG HACS and Shell R&D SPILLS.

The major problem in the field application of air dispersion models to predicting vapor behavior for the chemicals and propellants in our study is that most existing models do not account for terrain effects nor are they descriptive of the behavior of dense gases. When a dense gas is dispersed, it first stays on the ground and travels from the source by gravity spreading until the edges of the cloud become diluted due to turbulence induced by air entrainment. The diluted cloud eventually disperses as a neutrally or positively buoyant gas.

Currently, the only operational air dispersion model which accounts for variations in landforms was developed and is operated by Lawrence Livermore Laboratories. This model, however, uses Gaussian dispersion which is not adequate for dense gases. Thus, an air dispersion model is needed which will both account for varying terrain and be descriptive of dense gases.

Optimally, the vapor dispersion model should:

1. be descriptive of actual conditions;
2. have a data base of commodity specific thermophysical information for all chemicals both neutrally and negatively buoyant;
3. be applicable to releases that are instantaneous or continuous;
4. be applicable to releases on land and water;
5. use as input real-time meteorologic parameters;
6. be available to on-scene personnel either using telephonic or other computer terminal hookups through state civil defense office or USCG National Response Center/CHEMTREC;
7. contain submodels which can describe potential environmental impact of contamination to water resources;
8. provide hard copy of results readily available on-site; and
9. present unambiguous results which are directly usable to evaluate evacuation necessities as well as indicating vapor levels in areas where wreckage removal is to take place.

The final issues to be addressed include deciding when the use of a vapor dispersion model is appropriate, determining when a model is the most applicable to a given situation involving specific hazardous material(s) and developing an effective way to utilize the results. These problems have yet to be solved, but are of major concern for maximum efficiency in protecting both the public and workers at the accident site. Compilation of information about the various air dispersion models available in matrix form could be used by emergency responders in the selection of an appropriate model and by detailing the data input required. This tool is not yet as widely used as it could be with appropriate procedures for its application.

7.1.5 Handling Leaks

One can approach the problem of leaks or product releases from containers punctured or otherwise damaged in transportation accidents from three options:

1. stopping the leak;
2. leaving the leak as is; or
3. further opening up the car or tank (venting) and disposing of the lading (burning).

Depending on the size, shape, and orientation of a hole in a container, a leak may be patched or plugged. If the leak is from damaged or loosened car fittings (gauging devices, valves, safety vents, thermometer well cap, etc.), they may be tightened or repaired. Often, leakage from fittings can be stopped by tightening mounting nuts and closure plugs. However, if the mounting gaskets or valves have deteriorated, tightening nuts will not stop the leak. Replacement may be possible by specially trained personnel with special equipment.

The following criteria for performing any such procedures are essential:

1. patching or plugging materials must be compatible with the hazardous material;
2. only "non-sparking" tools must be used when making emergency repairs;
3. a leaking container is approached only after monitoring for and assuring safe toxic or flammable vapor levels;
4. response personnel use appropriate protective gear and equipment;
5. if the container has a fire at the safety relief valve or from a tank puncture, no attempt be made to extinguish;
6. all sources of ignition such as mechanical refrigeration units, lamps, stoves, markers, etc. must be extinguished;
7. trains are not permitted to pass on adjacent tracks; and
8. moving of leaking tank cars is not attempted.

In cases where a container is inaccessible, or the damage too severe, or where fire impingement has reached dangerous proportions, or the container is punctured and its contents burning, trying to stop a leak may not be feasible or desirable. There may, in fact, be times when a tank car or other container may need to be emptied of its contents because of critical damage precluding moving, rerailing or even off-loading. In the past few years there have been a few successful attempts (i.e., Claxton, Kentucky; Molino, Florida) at "venting" tank cars and "burning" contents using explosives. These procedures are still at very preliminary stages and thus must be used with extreme caution and only when conditions indicate no other solutions. The following issues must be addressed in developing this technology:

1. assessment of critical shell damage to container precluding moving or an in-field transfer;
2. the decision to utilize explosives for "vent" and "burn" must be one mutually arrived at and agreed upon by the experts who have critically assessed the situation;
3. the area must be sufficiently remote to reduce exposure of public and property;
4. experts must be located to perform the operation;
5. explosive materials such as shaped charges, thermite grenades, etc. must be available;
6. the accident scene must be sufficiently stabilized to permit access to place charges and other equipment as required;
7. there must be adequate prior assessment of impact and expected results;
8. the public and all non-essential response personnel must be removed to a safety perimeter beyond the site;
9. if any liquid release is expected, dikes, dams or containment pits must be constructed; and
10. after fire has subsided the container be checked for presence of flammable or other vapors in order to allow safe resumption of wreck-clearing operations.

7.1.6 Assessment of Container Integrity After Sustaining Damage

When tank cars, tank trucks or other containers are mechanically stressed in a hazardous materials transportation accident, an analytical monitoring tool is needed to assess structural integrity. When the structural integrity of containers is not adequately known or improperly assessed after an accident and a sudden increase occurs in pressure and temperature of the material, the potential for a BLEVE increases sharply. In an effort to minimize the risk to responding personnel, innovative methods of remote structural assessment must be examined for application to on-site assessment of tank car integrity.

The present state-of-the-art of structural assessment of damaged tank cars, tank trucks or other containers at an accident site is mainly visual and based on personal experience with little or no analytical tools being available.

As a general rule all dents, scores or gouges ought to be examined and the radius of curvature estimated. Dents with scores or gouges and those crossing tank seam welds are considered the most dangerous. Dents in the cylindrical section of the tank parallel to the longitudinal axis are considered the most serious. When dents have a minimum radius of curvature of 4 inches or less (2 inches or less for AAR M-128 steel) have a crack anywhere, cross or weld seam, or include a score or gouge, the tank ought not be moved and immediate field transfer considered. Head dents are not generally as

serious unless accompanied by gouges or cracks. Small dents in heads not exceeding 12 inches are marginal if they show a radius of curvature less than 4 inches (2 inches for AAR M-128 steel).

Cracks, scores and gouges are critical when crossing weld seams or in conjunction with dents. A score or gouge in excess of 1/16 inch for a 340W tank or 1/8 inch for a 400W tank is usually be considered critical.

Wheel burn is a damage mode similar to a gouge and has the same safety considerations.

With only these general visual guidelines based on accident experience, it is clear that there is room for considerable improvement in the assessment of the tendency of tank cars to rupture following damage in an accident. Acoustic emission (AE) technology is an existing method which appears to have significant potential application to the on-site assessment of damaged container structural integrity.

The greatest number of AE applications to date have been made on pressurized systems including nuclear reactor vessels and piping systems, chemical/petroleum vessels, storage tanks and rocket motor cases. The large number of AE signals produced by a pressure vessel poses a problem, although impressive progress has been made in identifying signals from different types of sources including plastic deformation, microscopic cracking, friction between mating parts (due to heat up and cool down or expansion under load), fluid flow, leaks (either external or through valves and pumps), low quality welds, etc. In almost all cases significant increases in AE activity were associated with the bursting of pressure vessels, at levels sufficiently below the burst pressure to serve as an adequate basis for safety alerts. It is hoped that use of this type of technology at the time of lifting damaged tank cars would be effective to warn of impending fracture. (See Appendix L).

Adequate sensing and data analysis equipment is available from several suppliers and AE systems can be configured with varying degrees of sophistication. These range from a simple transducer, signal conditioner, and output device to multiple detectors connected to a minicomputer which can perform real-time data processing, signal identification and source location with reasonable accuracy for a large structure. Installation can be made by simple magnetic attachment with or without a couplant (usually some type of grease), electrical tape or other mechanical hold-downs.

Criteria for acoustic emission technology should:

1. be able to detect and locate the origin of acoustic signals from any point in the structure;
2. distinguish between interference and tank emission signals;

3. distinguish between significant and insignificant flaws, and other pertinent sources of acoustic emissions such as leaks;
4. function on structures with complicating features such as vessels with nozzles and other penetrating fixtures, stainless steel cladding, internal structures, large wall thickness and inaccessibility to some parts of the structure;
5. produce continuous records; and
6. display and reduce data for timely interpretation.

7.1.7 Remote Sensing of Container Temperature and Pressure

Along with methods for assessing mechanical/structural integrity of damaged loaded containers, procedures are needed to assess and monitor as closely as possible the temperature and pressure in both damaged and undamaged containers throughout wreck clearing operations. These data are of particular importance when a loaded tank car is being uprighted, moved, rerailed or off-loaded. The tragic results of Waverly, Tennessee point up how important an internal monitor of temperature and pressure in conjunction with a structural integrity assessment could have been to those involved in transfer and other wreck-clearing operations.

While technology exists for temperature/pressure sensing, no widespread technology is available for remote sensing on-scene of pressure and temperature following a highway or rail accident. One of the potential techniques which could be adapted for this purpose is infrared radiometry. This method uses thermal radiation from a heated surface which is measured by an infrared radiometer. The heating can be either active or passive. The radiation pattern reveals heat flow anomalies caused by imperfect structural properties and flaws and is a highly refined technique. This technique could be adapted for remote sensing of non-jacketed containers by giving a close approximation of the temperature of the contents and the container. Knowing the volume of liquid and specific vapor pressure data, the internal pressure could be calculated and monitored as a function of temperature. This would not be applicable to jacketed containers because only the outer shell temperature could be ascertained.

Many tank cars have gauging systems to determine liquid levels and some have thermometer wells for measuring the temperature of the contents. These devices are used in loading and unloading of tank cars. To be of any use in monitoring temperature/pressure of a car following an accident, the car would have to be approached for initial visual assessment and then perhaps a readout could be attached for remote monitoring.

Monitoring of internal car pressure could be facilitated by including pressure gauges in the tank car body at manufacture with externally mounted readout dials.

There are currently a few tank cars with these external pressure indicators in service for cryogenics. However, the car still must be physically approached to read the pressure. Also this kind of system is not cost-effective for all cars in hazardous materials service.

To be applicable to accident site needs, a remote temperature/pressure monitoring system should:

1. be portable for reaching remote sites;
2. be easily maintained with a rechargeable power source and available components;
3. be sensitive to temperature fluctuations of a container and its contents;
4. have constant monitoring capabilities;
5. be capable of being remotely attached to a container and monitored from a safe distance;
6. be insensitive to weather fluctuations;
7. cause no sparking or buildup of static electricity;
8. present data quickly and flag any large or sudden changes in container or lading temperature, indicating potential problems; and
9. require a minimum of technical training to operate.

Such a system coupled with an acoustic emission system could provide real-time monitoring of structural integrity as well as temperature and pressure changes in a tank car being moved or undergoing transfer. This could give responders a margin of safety as yet unequalled in emergency response.

7.1.8 Transfer Operations for Safe Removal of Hazardous Materials to Another Portable Container

At a hazardous material accident site, it is often necessary to transfer materials from a damaged container to an intact one prior to removing the material from the accident scene. Procedures are needed for transferring lading and for providing adequate personnel safeguards during the transfer operation. There are three major methods used to transfer materials from one container to another—gravity flow, pressure flow and pumping. The criteria for these procedures should ensure:

1. proper transfer equipment and receiving containers are available;
2. ambient conditions are stable with no hazardous flammable or toxic vapor concentrations in the area;
3. an inert atmosphere is available as needed;
4. pump is durable, resistant to corrosion, compatible and non-sparking; a centrifugal pump is recommended over a piston pump because of greater pumping capacity and limited pressure potential;
5. fittings should be compatible and readily obtainable;

6. transfer system components (i.e., piping, hoses, valves, fittings) are compatible, available and easy to set up;
7. transfer team (shipper provided or contracted) is available within a reasonable response time;
8. commodity incompatibilities do not exist (i.e., no greases when transferring liquefied oxygen);
9. closed system of transfer is used;
10. equipment used in transfer operation is properly grounded to reduce static electricity buildup;
11. continuous monitoring for leaks as well as changes in container temperature and pressure is carried out;
12. rate of transfer is not too rapid to cause static electricity buildup;
13. receiving container has adequate capacity, meets DOT specifications if the specific hazardous material are to be transported, or meets EPA requirements for disposal;
14. is pressure-flow transfer, the external pressure is minimized to prevent any increase in internal container pressure; and
15. a snorkel-type or some similar device is available to reach liquid level through the vapor space in a tank

7.1.9 Removal of Wreckage From the Scene (Railroad and Highway)

Methods need to be developed for safe, economical, and rapid removal of wreckage at railroad and highway accidents involving hazardous materials. These methods will involve improved procedures and equipment for lifting derailed rail cars and overturned highway tank cars. A detailed analysis of criteria for these methods is given in Section 8. A major criterion for safe removal of damaged railroad and highway tank cars is the verification and monitoring of tank car structural integrity. An innovative application of acoustic energy technology can possibly satisfy this criterion. A detailed discussion of this technology and its application to assessing tank car structural integrity is presented in Appendix L. The main criteria for developing improved methods of wreckage removal are listed below:

1. reduction of hazards to wreck-clearing personnel by monitoring area for toxic and flammable vapors and assuring use of proper personal protective clothing and equipment;
2. safe off-loading and transfer of damaged containers carrying hazardous materials;
3. assessing and monitoring the structural integrity of tank cars prior to and during wreckage removal;
4. decoupling and isolating derailed cars from wreckage prior to their removal. (cutting torches should not be used on tank cars, either empty or loaded).

5. determining priority for removal of rail cars involved in accident, taking into account such factors as hazardous versus non-hazardous material cars, overturned versus upright cars, location of cars, and relative damage to cars;
6. establishing method of transporting a given rail car i.e., whether on its own trucks, spare trucks, or loaded onto a flatcar or gondola;
7. providing adequate rigging (cranes, hooks, slings, etc.) available for moving and lifting derailed rail cars and overturned highway trailers;
8. establishing optimum locations for attaching hooks and slings to derailed railcars and overturned highway trailers in order to upright, move, and lift these vehicles;
9. determining proper procedures for uprighting, moving, and lifting derailed railcars and overturned highway trailers, including maximum force levels that can be safely exerted in various directions;
10. providing safety precautions to be followed during vehicle moving and lifting to prevent accidents to wreck-clearing personnel; and
11. identifying equipment modifications, including lifting lugs on rail cars, to facilitate safe, economic, and rapid wreckage removal of derailed rail cars and overturned highway trailers.

7.1.10 Cleanup and Disposal of Spilled Materials And Contaminated Soils and Water

In the case of the chemicals and propellants specified in this study, the cleanup and disposal may not be as much of a problem as it could be with a number of other hazardous materials. Nevertheless, certain of them are toxic and could also adversely affect the environment. Procedures are required for picking up the material which has been; (1) spilled and remains, or (2) has been treated by vapor suppression, neutralization or dilution techniques. Procedures are also required for deciding whether or not to recover the residual or contaminated materials, dispose of them on-site or transport them to an off-site disposal facility. Whichever choice is made must be backed up with procedures for the particular cleanup and disposal methods employed. Procedures must assume continuous monitoring of the scene for toxic and flammable vapors for the protection of the personnel engaged in cleanup and disposal operations.

Cleanup personnel need to select the proper tools, equipment and materials for picking up, handling, packaging and disposing of the spilled material or residual contaminated product. Procedures are required for optimal on-site disposal procedures such as burning, neutralization, venting/evaporation, burying or dilution. Deciding if or how to recover spilled product is an increasingly attractive option as economic and regulatory requirements dictate resource recovery. Cleanup of spilled materials may have to precede cargo transfer and wreckage removal operations in many cases. Special precautionary as well as decision-making procedures are required in this regard. Disposal procedures in particular must meet EPA requirements and when contaminated hazardous

materials require shipment off-site, it must be done in approved containers in accordance with DOT hazardous materials shipping regulations. Procedures are required to assure personnel have proper protective clothing, gear and breathing apparatus, continuous communications within the group and with the OSC and adequate supervision. Equipment and materials used must be compatible with the hazardous commodity involved. Prior approval and arrangement must be obtained for shipping a material to a particular disposal site under new RCRA regulations. The disposal method is often that suggested or designated by the shipper whose recommended procedures should be strictly followed.

7.1.11 A Logic Process for Establishing a Protocol for Selecting the Hazards Mitigation and Cleanup Methods for Single Material Spills and Multiple Materials Mixing

In developing a logic process for establishing a protocol for selecting hazard mitigation and cleanup methods for single and multiple material spills, the accident site must be viewed in its entirety and the interdependence of the materials involved, mitigation techniques used, and cleanup and disposal operations must be assessed. Several criteria need to be met in developing a decision-making protocol:

1. the hazardous materials involved must be identified along with their physical, chemical and thermal properties;
2. assessment of toxic, flammable and explosive vapor hazards associated with the particular hazardous material(s) involved in the accident must be carried out; and
3. accident site conditions must be detailed.

In determining the accident site conditions, procedures must be established to handle the following situations:

1. hazardous material(s) on fire resulting in toxic or corrosive combustion products (i.e., burning vinyl chloride yields hydrochloric acid);
2. releases resulting in either a massive liquid pool or a small continuous leak as a result of loose, damaged or unseated fittings or valves; and
3. situations where no release occurs but there is fire impingement on intact tanks containing hazardous material(s).

Given both the hazardous materials involved and other accident conditions such as release, fire involvement, location and weather, hazards mitigation options can now be identified. In deciding which hazard mitigation option to use, personnel must be aware of the available alternatives, personnel and equipment requirements and appropriate specific applications for each method. Procedures need to be developed which will ensure that available options are known to on-scene decision-makers so that the optimum solution considering both safety and cost-effectiveness is reached. The

options also ought to be developed in an integrated form so that the total scene will be considered at every step in the wreck-handling process. The following items need to be integrated into a system for selecting hazard mitigation techniques:

1. vapor suppression by foam or other suppressants;
2. liquid containment on land by dikes, dams, berms, pits, gels, sorbents, etc.;
3. stopping leaks if possible;
4. using firefighting techniques to cool intact tanks impinged by fire if the water supply is sufficient or to extinguish fire if source of leaks can be quickly and adequately secured to prevent reignition and flashing of flammable vapors;
5. evacuation considerations including dispersion of toxic and flammable vapors in the immediate accident area and downwind, and explosive (BLEVE) potential with blast overpressure, radiant heat and fragments;
6. introducing turbulence into release of dense gases in an attempt to increase air entrainment at the edges of the cloud, thereby diluting it for more rapid dispersion; and
7. cataloging and assessment of the availability of resources (equipment, materials and personnel) at the accident site.

The selection of wreckage removal operations depends upon:

1. an assessment and evaluation of the structural integrity of cars and containers mechanically stressed in an accident;
2. analytical capabilities (i.e., acoustic emission, infrared radiometry) for monitoring structural integrity and container pressure and temperature during wreck-clearing operations;
3. selection of handling options including rerailing, moving, lifting, uprighting or off-loading of cars and containers in the field;
4. possibility of sufficient tank damage, fire or inaccessibility in the case of compressed flammable gases like propane, butadiene or vinyl chloride to warrant emptying the car and disposing of its contents (vent and burn); and
5. availability of equipment, adequate containers, compatible materials and trained personnel with appropriate protective gear and equipment.

Cleanup and disposal procedures selected will depend on:

1. the particular materials involved in the accident and their resulting condition (for example, pooled liquids with foam blanket would require removal while a gas release would require monitoring until it was adequately dispersed);
2. mitigation options selected and used on-scene (for example, gelled residue from liquid containment; foam residue from vapor suppression; contaminated, corrosive runoff from firefighting or tank cooling; and residues from neutralization of corrosives); and

3. regulatory mandates such as the EPA/USCG requirements under the Clean Water Act limiting spills of hazardous materials and indicating pollutant levels for cleanup of such spills and disposal requirements as delineated under the Resource Conservation and Recovery Act for hazardous spill residues.

7.1.12 Training Aids for Government (Federal, State and Municipal) and Industry Response Teams

There are a number of training courses available which are taught by government, industry, educational institutes and consulting organizations aimed specifically at responders to hazardous materials incidents. These courses vary from formal academic class session to slide-tape presentations, with an instructor's guide and student workbook, to the home-study (correspondence) course. The slide-tape courses run from five to twenty hours of class time. They may or may not be modular (i.e. deal with topic areas such as HM identification, decision-making and seeking technical assistance).

Hazardous material training courses stress planning but also present some basic information concerning the nature of hazardous materials; how to identify spilled/leaking material, where to find technical help, danger assessment, decision-making and to a certain extent some general procedures for on-scene actions such as controlling access to the area, evacuation, surveillance of vapor clouds, firefighting, rescue and communications. In some instances, there is hands-on training such as use of polyurethane foam for sealing holes in drums or diking liquid pools, applying metal patches to tank car holes by means of bolts, or stopping leaks with wooden plugs. These are useful techniques, but have limited application in specific situations. Heavy reliance must still be placed on the specialists from the various disciplines involved. These specialists operate and make decisions based predominately on their own experience and knowledge and, with few exceptions, perform tasks without the benefit of written procedures, particularly with respect to cargo transfer, wreckage removal, cleanup and disposal. Although these courses give some attention to restoring the scene to normal, there is a lack of procedural training in these four activities.

There are many training aids available in addition to the courses themselves. Examples are nomographs, slide rules, pocket manuals, checklists, brochures, guides, films, video tapes, slide-tape combinations, reference books, data bases, resource lists and charts. The U.S. Department of Transportation's Materials Transportation Bureau provides, free-of-charge, quantities of a number of hazardous materials training aids to emergency service organizations. Others can be purchased from private companies. Rail

carriers in conjunction with the Chemical Manufacturers Association are putting on HM transportation emergency training courses in communities where chemical shippers are located or through which rail lines run.

Regardless of the type of activity, immediate response, hazard mitigation, cargo transfer, wreckage removal, cleanup and disposal or the specialist discipline involved, training must assure that procedures are understood and utilized to accomplish the following four items:

1. provide effective communications;
2. evaluate/assess the situation, hazards and actions;
3. make decisions; and
4. take appropriate actions.

These are discussed in succeeding paragraphs.

7.1.12.1 Effective Communications

An incident must be recognized and promptly reported to the proper authority. It is very important that certain essential information about the accident be given in this report so that the response network may be activated and those involved can have a reasonable idea of the nature of the incident and HM's involved. Training in how, when, what and to whom to report a HM incident is the first criterion. It involves the ordinary citizen, as well as those who might become involved as professionals who happen upon an accident scene. Communications within a particular response discipline, between groups and with the on-scene coordinator (OSC) are complex but vital. Therefore, training is required in the proper use of communications equipment. Also, the assignment of proper frequencies and responsibility for coordination of communications must be clearly spelled out in the emergency action plan. The persons responsible for coordinating communications need training for such purposes as the following:

1. to understand the interface between different communication modes, frequencies and equipment;
2. to understand, interpret and relay facts and requests being made by or sent to the numerous groups and individual specialists involved in the emergency;
3. to recognize and expedite priority communications;
4. to deal effectively with the news media, by providing appropriate factual information and by utilizing the news media as a means of mitigating hazards to the public such as preventing panic and providing proper instructions or warnings; and
5. to know how to use communications to coordinate effectively the many activities taking place on-scene and as backup, so that such activities do not interfere with or jeopardize safety of each group and that resources are used most effectively.

The various response groups and individual specialists need communications training in order to know proper procedures for maintaining constant contact within their particular groups so that everyone is always accounted for, prompt escape action may be taken if the need arises, and the OSC can be provided with the latest facts on conditions, progress, problems and needs.

The public needs training in such areas as simple self-protection (i.e., stuffing cracks in windows or doors) actions in the event of a HM spill; getting and keeping away from the scene; obeying evacuation orders; and, as previously mentioned, reporting an incident.

The news media can be a real help or can compound the problem. Making the news media aware of and where possible, a participant in HM spill response training, can make it a strong positive force in a real emergency. Training courses need to contain a portion showing how the news media can assist in the event of an accident.

All persons concerned with a spill must have further training in evaluation/assessment methods, decision-making, the procedures required in their specific activities and awareness of how their actions impact others.

7.1.12.2 Evaluation and Assessment

A chemical, propellant or other HM transportation accident requires initial and continued assessment of the situation and evaluation of the requirements and effectiveness of corrective actions. Essentially, these involve obtaining facts and analyzing them. Training is vital to assure that those involved with the emergency know what information is necessary, how it may be obtained and how to analyze it for determining the existing hazards, potential dangers, what damage has been sustained, the magnitude of the spill, who and what are exposed, what resources exist and how they can be used most effectively, what additional resources are required, and the effectiveness of corrective actions. Such training should involve how to:

1. identify at a safe distance any HM's involved or that have been released;
2. determine the integrity of the HM containers;
3. establish the danger perimeter;
4. predict the downwind toxic or flammable vapor concentration versus distance as well as cloud size and travel rate;
5. use resources most effectively;
6. determine the applicability and effectiveness of corrective actions;
7. use remote sensing/detection/analytical equipment;
8. interpret data;
9. spot changing conditions which pose additional dangers;

10. assess risks;
11. determine hazards; and
12. monitor the scene for toxic or flammable vapor levels and for evidence of personnel exposure.

Such training includes teaching formalized methodologies where appropriate (i.e., risk/hazards analysis).

7.1.12.3 Decision-Making

Decisions are made by people, and methodologies are tools which can be used to help organize and present information to assist the decision-maker in this task. Decisions are made at every level by every person responding to or coming upon a transportation accident involving hazardous materials. The decision may be as simple as turning a car around and heading the other direction, if one spots what appears to be a train wreck five miles across the valley. Decisions must be made as to whether the wreckage can be safely approached or not. What types of response equipment and personnel need to be deployed, when and how, are decisions that have to be made. Another involves whether to order an evacuation or not, what area should be evacuated and when. Should an attempt be made to stop the leak, do nothing, or further open a damaged container to dispose of its contents are critical decisions which must be made. Others involve whether or not to transfer hazardous cargo or attempt to move or upright overturned cars or tank trucks containing hazardous materials, and which should be done first. The train crew must decide if the engine and remaining cars should be moved away from the wreckage. A decision must be made each time a person or piece of equipment is deployed. Appropriate cleanup procedures must be chosen. Someone must decide if residual material is to be neutralized, burned, vented, recovered on-site or disposed of off-site, as well as what methods to use. For every action that is taken a decision must be made. It is imperative that training be designed to meet the needs of all decision-makers. Depending upon the individual responsibilities and the particular types of activities involved, training can range from checkoff lists to computer-simulated decision-making methods. Essential to all decision-making is consideration of the situation or problem, the alternative courses of action, how the action will be accomplished, when and by whom, and what will be the expected impact or results of each.

7.1.12.4 Response Activities

Training is required to assure effective and safe performance of all the on-scene and support activities in handling hazardous material transportation spills. This fourth aspect of the training criteria deals with the actual field operations and what type

of procedural training is appropriate to each of the specialized groups and individual experts involved. This training involves ways to select, use and identify the limitations of equipment and materials (i.e., use only transfer equipment which is compatible with the particular HM or use gravity flow, pressure flow or pumping as cargo transfer means).

Training can help train crew members and truck drivers:

1. to understand the HMs aboard, their hazards and the precautionary procedures they can use in the event of an accident;
2. assist them in seeking response help;
3. convey HM information to response personnel; and
4. otherwise cooperate with authorities on-scene.

There are continued hazards at chemical and propellant spill scenes and the degree or nature may change. Training for on-scene personnel needs to include procedures for recognizing the actual and potential hazards and the eventuality of a significant change. Their training needs to assure that each person understands not only how to perform his own task efficiently, but to recognize the absolute necessity for safety and accomplishing the task without jeopardizing the safety of others at the scene or creating problems for them, while at the same time protecting the environment and property. Training on the selection and use of proper protective gear, tools, equipment and materials is vital to personnel safety and the successful handling of the spill. Training is needed in the techniques, limitations and safety precautions for cargo transfer, wreckage removal, cleanup and disposal operations. Hazard mitigation involves any means for reducing or eliminating the hazard or threat, so it cuts across the full spectrum of on-scene activities. Training needs to concentrate on the use of common sense coupled with good information and sound technical analysis.

8. STATE-OF-THE-ART MEANS FOR LIFTING DERAILED CARS AND OTHER CONTAINERS

8.1 INTRODUCTION

The history of wreck-clearing operations in railroad and highway accidents involving hazardous materials indicates a need for improvements in equipment, procedures, and above all, safety. Criteria must be developed for optimal procedures and equipment modifications that will enable economical and rapid removal of wreckage with minimum risk to personnel. Some of the severe safety problems in wreck clearing are illustrated in Appendix K.

8.2 CURRENT PRACTICES

There is a scarcity of definite guidelines for wreck-clearing operations involving rail cars and highway trailers containing hazardous materials. There are several reasons for this. One is the wide variety of hazards posed by different toxic, flammable or explosive materials. This is further compounded by the need to assess car (trailer) damage after the accident and possible dangers associated with movement of the car (trailer) during wreck-clearing operations. Expertise for these procedures is almost always provided verbally by a supervisor at the scene, whether from the carrier or wreck-clearing firm. The concern over liability undoubtedly plays a large part in the lack of specific written procedures for wreck-clearing of rail cars (trailers) carrying hazardous material.

Some general guidelines for such wreck-clearing operations are included in the Bureau of Explosives Pamphlet No. 1, "Recommended Practice for Handling Incidents Involving Hazardous Materials."⁽²⁷⁾ Excerpts pertaining to railroad tank cars containing flammable gas are given below:

Wrecking operations or transfer of contents of tank cars of flammable gas should not be attempted until all vapors in that vicinity are dispersed. Cutting torches must not be used on tank car tanks, either empty or loaded.

If leaks are expected in handling, transfer contents to other car or container. Transfer of flammable gas cars involved in derailments should not be undertaken by carrier employees. Contact the shipper, consignee, or experienced contractor for transfer of lading.

Do not allow trains to pass on adjoining tracks as long as the explosimeter shows readings at or above the lower explosive limit.⁽²⁷⁾

For railroad tank cars containing flammable liquid, the applicable guidelines from this pamphlet are as follows:

Wrecking operations or transfer of contents of tank cars of flammable

liquid should not be attempted until all vapors are dispersed. Cutting torches must not be used on tank car tanks either empty or loaded. Many liquids regarded as safe under ordinary conditions and transported as combustible or non-regulated materials should be treated as dangerous in handling a wreck. An empty or partially empty tank car, with or without placards, is very liable to contain a vapor-air mixture which may ignite. Fumes in any empty tank car should be considered as injurious to a person entering it. An empty tank should not be entered before it has been cleaned by steaming and checked for residual vapors. When using cutting torches, care must be exercised to avoid contact with leakage or ground saturated with even such materials as lubricating oils, asphalts, or other petroleum products, vegetable oils, and animal fats, for they can be ignited and will burn as do flammable liquids.

Move to safety the least damaged cars, avoiding sudden shocks or jars that might produce sparks or friction. No unnecessary attempt should be made to move a damaged tank car from which flammable liquid is leaking. Short movements may be made by attaching a bucket under small leaks to prevent spread of flammable liquid over tracks. Cover tracks at intervals in rear of a moving car with fresh earth to control the spread of liquid and vapors.

Only as a last resort, to meet an emergency, should a derailed car be moving by dragging, and then on a bed of foam when possible but in any event all persons should be kept at a safe distance. When leaks are expected in handling, empty the car first, by transfer of contents to another car or container.

Do not allow trains to pass on adjoining tracks as long as the explosimeter shows readings at or above the lower explosive limit. ⁽²⁷⁾

A derailment of a railroad tank car in a tunnel, involving release of flammable liquid or gas, requires special precautions if fire does not occur at the time of the derailment:

Rescue injured persons. Close attention must be given to the risk of suffocation, and the fire and explosion hazard in the tunnel. Self contained breathing apparatus must be used, as gas masks equipped only with a filtering device are not designed for service in areas where insufficient oxygen is available.

Remove all possible sources of ignition as soon as possible (turn off power if railway is electrified) and keep unauthorized persons away.

If the wreckage is on fire, the heat of the fire will tend to vaporize the leakage and carry its fumes upward. If the car is not leaking, every effort should be made to extinguish the fire or to move the tank car away from it. ⁽²⁷⁾

As noted above, the hazards from leakage are dependent on the material and are described in B.E. Pamphlet No. 2 ⁽²⁷⁾ for a wide variety of hazardous materials. For toxic, nonflammable gases such as anhydrous ammonia and chlorine, the recommended protection for personnel (including wreck-clearing personnel) is as follows:

Personnel Protection:

1. Avoid breathing vapors
2. Keep upwind
3. Wear self-contained breathing apparatus
4. Avoid bodily contact with the material
5. Wear boots, protective gloves and safety glasses
6. Do not handle broken packages without protective equipment
7. Wash away any material which may have contacted the body with copious amounts of water or soap and water
8. If contact with the material anticipated, wear full protective clothing. ⁽²⁷⁾

With regard to vehicles other than railroad tank cars, specifically those carrying explosives, B.E. Pamphlet No. 1 contains the following recommendations applicable to wreck-clearing:

If the accident does not cause the immediate ignition or explosion of the explosives, the first and most important precaution is to prevent fire. The area should be guarded to keep away all unauthorized persons. Before beginning to clear a wreck in which a vehicle containing explosives is involved, all unbroken packages should be removed to a place of safety and broken packages and contents gathered up and removed for destruction or repacking and any remaining explosive material rendered inert. Many explosives are readily fired by a blow or by the spark produced when two pieces of metal or a piece of metal and stone come violently together. In clearing a wreck, therefore, care must be taken not to start fire with tools. With most explosives, thorough wetting with water practically removes the danger of explosion by spark or impact; but with the dynamites, wetting does not make them safe from impacts. If initiating explosives such as fulminates or azides have been scattered by a wreck, after a wreck has been cleared, the wet surface of the ground should be removed, and after saturating the area with fuel or lubricating oil, be replaced by fresh earth. ⁽²⁷⁾

When it comes to specific guidelines for moving the railcar (trailer) during wreck clearance, there is very little to go on. In the case of railroad and highway tank cars containing hazardous material, it is necessary to assess tank car damage and

structural integrity before any movement is initiated. In fact, it may not be safe for personnel to be in the vicinity of a stationary, damaged tankcar, as is evident from the tragic accident at Waverly, TN. Current methods for assessing tank car damage are strictly visual. Even when damage is noted, the determination of the severity of the damage, i.e., how badly it has affected the structural integrity of the tankcar, is strictly a matter of judgment by the supervisor at the scene. As was evident at Waverly, these methods are inadequate for assessing the danger. Some recent techniques involving acoustic emission have the potential for more accurate assessment of tankcar damage and structural integrity and for providing some warning of incipient structural failure. This technology is discussed in detail in Appendix L.

Assuming that it is safe to initiate wreck clearance of the railcar (trailer), the question arises as to how this movement is to be carried out safely and expeditiously. As has been noted previously, there are few, if any, written procedures for clearing wrecks involving railcars (trailers) containing hazardous material. Obviously, all aspects of rigging come into play including cranes, cables, hooks, slings, and methods of hoisting and moving loads. In addition, there are special considerations involved in the wreck clearance of railcars (trailers) containing hazardous material. For example, consider a derailed railroad tankcar that is to be moved. If it is still coupled to other cars and the coupler is inoperative, how is the car to be uncoupled? If overturned, how is the tankcar to be righted? Where can hooks and slings be attached? What are the permissible levels of force that can be exerted in various directions for uprighting, moving, and lifting the tankcar?

There are no written procedures for answering such questions and this obviously is an area requiring further investigation and definition. For the time being, it is useful to consider rigging practices in general since much of these would be applicable to wreck clearance of railcars (trailers) containing hazardous materials. The only comprehensive guide to rigging that has been identified is the Handbook of Rigging,⁽¹⁸⁾ Third Edition, by W. E. Roosenagel, for construction and industrial operations.

Wire rope, or steel cable as it is frequently called, is generally preferred for hoisting heavy loads such as those encountered in wreckage removal. The wire rope is used in all aspects of rigging including slings, hoisting cables and crane cables. It is essential that all wire ropes be inspected periodically for wear and broken wires to

determine when a wire rope has reached the limit of its safe usage and must be discarded. It is dangerous, particularly in wreckage removal, to continue its use beyond a certain stage.

The safe working loads for various types of wire rope slings are shown in Table 8-1. The braided sling is made up of a number of smaller size wire ropes that form a continuous, uniform spiral throughout the entire length of the sling. The spiral braiding gives a much lower modulus of elasticity than a single cable of the same capacity. This greatly reduces the stress on the individual wires when a load is applied suddenly, permitting its safe use with a smaller factor of safety as indicated in Table 8-1. Braided slings are also constructed so as to be almost flat in the general cross-section, these being used particularly for basket-type hitches. These slings may have application in lifting railroad tankcars since their flat cross-section would minimize stress on the tankcar body.

Type of sling	Nominal size, in.					Total load on two-leg slings (For three-leg sling multiply by 1½. For four-leg sling multiply by 2)			Weight per ft. (exclusive of hook, ring, thimble, or splice), lb
		Single sling, lb	Choker sling, lb	U sling, lb	Basket sling, lb	 60-deg bridle, lb	 45-deg bridle, lb	 30-deg bridle, lb	
6 X 19 improved plow steel rope (Federal spec. RL-R-571)	½	1,350	1,010	2,700	2,360	2,330	1,910	1,350	0.23
	¾	1,840	1,380	3,680	3,220	3,180	2,600	1,840	0.31
	1	2,420	1,815	4,840	4,240	4,180	3,420	2,420	0.40
	1½	2,900	2,175	5,800	5,080	5,000	4,110	2,900	0.51
	2	3,800	2,850	7,600	6,650	6,570	5,400	3,800	0.63
Factor of safety = 8	½	5,260	3,940	10,520	9,200	9,100	7,450	5,260	0.90
Splice efficiency = 80%	¾	7,000	5,250	14,000	12,250	12,100	9,900	7,000	1.23
	1	9,000	6,750	18,000	15,750	15,550	12,750	9,000	1.60
Rope diameter →	1½	11,200	8,400	22,400	19,600	19,400	15,900	11,200	2.03
	2	13,800	10,350	27,600	24,200	23,900	19,550	13,800	2.50
8-part braided wire strand sling	½	1,540	1,150	3,080	2,700	2,670	1,630	1,540	0.18
	¾	3,420	2,560	6,840	5,980	5,920	4,850	3,420	0.42
	1	6,500	4,870	13,000	11,380	11,300	9,220	6,500	0.80
Factor of safety = 5	½	10,800	8,100	21,600	18,850	18,700	15,300	10,800	1.28
Splice efficiency = 100%	¾	14,120	10,600	28,240	24,650	24,400	20,000	14,120	1.84
	1	18,820	14,150	37,640	33,000	32,600	26,600	18,820	2.48
Strand diameter →	1½	24,200	18,150	48,400	42,300	41,900	34,300	24,200	3.20
	2	30,240	22,700	60,480	53,000	52,300	42,900	30,240	4.08
Use factor		1.000	0.750	2.000	1.750	1.732	1.414	1.000	

TABLE 8-1 . SAFE WORKING LOADS ON VARIOUS TYPES OF SLINGS

A significant improvement in the lifting and moving of derailed freight cars would be available through the use of lifting legs that were incorporated into the car structure during manufacture. This aspect of equipment modifications to facilitate wreck clearance will be discussed in section 8.3.11.

Finally, wreck clearance requires the use of mobile cranes. Some types suitable for use in railroad wreck clearing operations are the locomotive crane and the crawler crane, shown in Figures 8-1 and 8-2, respectively. For highway wreck clearing, the automotive truck crane shown in Figure 8-3 is appropriate. Prior to their use at an accident site, these mobile cranes should be inspected to insure their safe operation. Standard inspection procedures include the following:

To inspect these cranes, have the operator lower the boom nearly horizontally or until the load block rests upon the ground; then stop the engine. Examine the boom carefully, both from the ground and by walking out on it. Strike all rivet heads with a machinist's hammer to detect any loose ones. Note all bent structural members (legs, lattice members, gusset plates, etc.) and any parts worn by the cables. Check for excessive corrosion. Also inspect the structural members that form the anchorage for the boom hoist cable. Note any loose bolts.

Strike each sheave with the hammer to detect any cracks. Of course, check the cables, anchorages, etc. Inspect the crane engine and hoist mechanism, paying attention to loose or worn pins, keys, cotter pins, broken gear teeth, etc. Check the running gear, including wheels, crawler treads, axles, gears, sprockets, turntable, rollers, center pin, and other vital parts. Make sure that the rail clamps and/or out-riggers are in good condition.

Have the operator start up the engine and raise the boom to the normal operating position, then pick up a fair-size load and test the brake and frictions. Check the latch (if provided) on the foot brakes to ensure positive holding. (18)

Some precautions that should be followed during crane operation include the following:

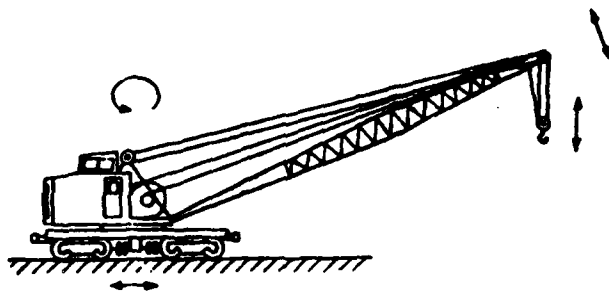


FIGURE 8-1. LOCOMOTIVE CRANE

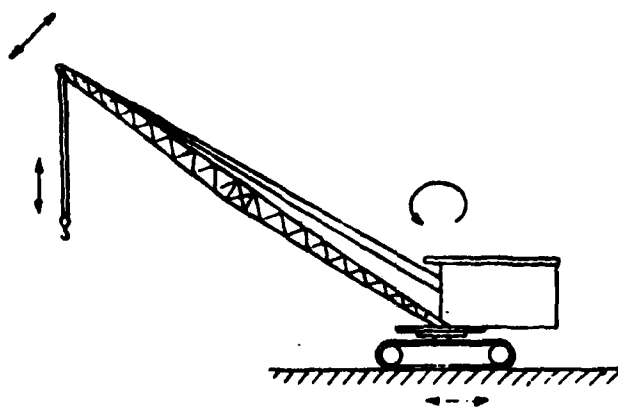


FIGURE 8-2. CRAWLER CRANE

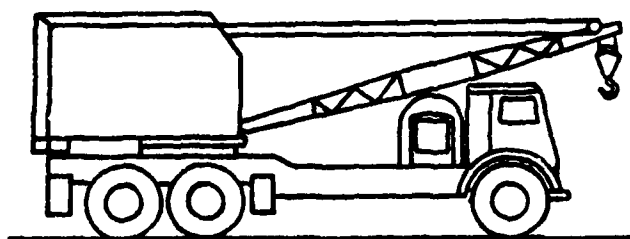


FIGURE 8-3. AUTOMOTIVE TRUCK CRANE

When operating a boom crane, always make certain that the chassis is on an even keel; in other words do not have the treads or wheels on one side higher than on the other side, particularly if the load is picked up with a high boom. When the crane is out of level, there is a side bending on the boom under certain conditions, and failure to recognize this has resulted in fatal accidents. Do not slew the crane too rapidly while carrying a load, for not only is there danger of striking persons but there is also the possibility that the centrifugal force thus developed may upset the crane. (18)

When cranes are used for wreck clearing on highways, additional dangers are present from overhead electric wires.

A serious hazard to the crane operator and to those riggers working with him is the ever-present danger, when operating in a city street, of the boom or cables coming into contact with live overhead electric wires. The operator is not exposed to electric shock unless he attempts to leave the crane, especially if it is mounted on rubber tires. If he is holding onto the crane when his foot touches the ground he may be killed. Likewise, a rigger on the ground may be killed if he attempts to pick up a tool from the crane chassis.

Some states have labor laws requiring that all automotive cranes that operate on city streets or highways be equipped with a grounding wire which is attached to the crane chassis and to a steel plate which the crane operator lowers like an "anchor" onto the ground or pavement, even though they be perfectly dry. Those crane operators, or the riggers in charge of the job, may take safety more seriously and they may try to get a better electrical ground by connecting the wire to a fire hydrant or to a pipe driven into the earth. However, even such grounding is of questionable value, and may offer a false sense of security. (18)

In clearing of wrecks involving hazardous materials, remote operated mobile cranes would seem to offer improved safety to personnel. However, discussions held with experts in the field indicate that this is impractical. Both the rigger and the crane operator need to be close to the railcar (trailer) being moved in order to assure precise and careful movement during wreck clearance. Areas with more promise for improving safety during wreck clearance are in developing techniques for assuring the structural integrity of the tankcar and in equipment modifications such as lifting lugs to facilitate lifting and movement of the tankcar. These areas will be discussed in the next section.

8.3 CRITERIA FOR IMPROVED EQUIPMENT AND PROCEDURES

The preceding sections on wreck-clearing operations have identified safety problems that have occurred in the past as well as deficiencies in current practices. This leads naturally to the delineation of areas where improved equipment and procedures are required in order to facilitate safe, economic, rapid removal of wreckage involving hazardous as well as non-hazardous materials. These general areas are as follows:

1. Reduction of hazards to wreck-clearing personnel from toxic, explosive

leads naturally to the delineation of areas where improved equipment and procedures are required in order to facilitate safe, economic, rapid removal of wreckage involving hazardous as well as non-hazardous materials. These general areas are as follows:

1. Reduction of hazards to wreck-clearing personnel from toxic, explosive and flammable vapors;
2. Safe removal and transfer of contents of rail cars carrying hazardous materials;
3. Assessing the structural integrity of tank cars prior to and during wreckage removal;
4. Decoupling and separating derailed rail cars from wreckage prior to their removal;
5. Establishing a safe sequence for the removal of rail cars involved in an accident taking into account such factors as hazardous versus non-hazardous material cars, overturned versus upright cars, location of cars and relative damage to cars;
6. Determining how to transport a derailed rail car (i.e., whether on its own truck, spare trucks, or loaded onto a flatcar or gondola);
7. Identifying characteristics of rigging equipment (cranes, hooks, slings, etc.) required for moving and lifting derailed rail cars and overturned highway trailers;
8. Establishing optimum locations for attaching hooks and slings to derailed railcars and overturned highway trailers in order to upright, move, and lift these vehicles;
9. Determining proper procedures for uprighting, moving and lifting derailed rail cars and overturned highway trailers, including maximum force levels that can be safely exerted in various directions;
10. Precautions to be followed during vehicle moving and lifting to prevent accidents to wreck-clearing personnel; and
11. Identifying equipment modifications, including lifting lugs on railcars, to facilitate safe economic and rapid wreckage removal of derailed rail cars and overturned highway trailers.

8.3.1 Reduction of Hazards from Vapors

Reduction of hazards from toxic, explosive and flammable vapors is applicable to all personnel (including wreck-clearing personnel). Criteria for accomplishing this are discussed in Sections 7.2.3, 7.2.5 and 7.2.10. With regard to wreck-clearing personnel, the following excerpts from these sections are particularly relevant.

1. detectors should be sensitive to a broad range of flammable, toxic, and explosive vapor concentrations (from lower to upper explosive limits and saturation concentrations);
2. detectors to measure toxic vapor concentrations must be commodity specific;
3. detection process should be real-time, rapid and capable of continual monitoring throughout the entire wreck-handling and clearing operation;

4. prior to wreckage removal, all discharges from damaged tank cars and containers must be stopped and all vapors dispersed; and
5. procedures are required to assure personnel have proper protective clothing, gear and breathing apparatus, continuous communications within the group and with the OSC and adequate supervision.

8.3.2 Hazardous Material Transfer

The transport of hazardous materials by rail is accomplished either via bulk containers such as tank cars or by means of smaller containers carried inside box cars. Examples of containers shipped in box cars are packages of explosives, packages of various solid hazardous materials and cylinders or small tanks of hazardous liquids or gases. Although these containers were intact and secured to the inside of the box cars at the time of shipment, their condition and degree of constraint after car derailment are suspect. Before wreck clearing is initiated, all unbroken, hazardous material containers in box cars should be removed to a place of safety. The contents of broken containers must be disposed of safely, in a manner that is commodity-specific.

With regard to derailed tank cars containing hazardous material, the question of whether or not to transfer contents prior to wreck clearing depends on many factors. These include damage to the tank, whether damage to trucks and car underframe would prevent retrucking, orientation of the derailed tank car, accessibility to transfer equipment, capacity of wreck-clearing equipment, etc. If leaks are expected during tank car movement, the contents should be transferred prior to wreck clearing. Criteria to be followed during such transfer are given in Section 7.2.5.

8.3.3 Structural Integrity of Tank Cars

In the case of derailed or overturned tank cars containing hazardous materials, the structural integrity of the tank cars must be assessed prior to, and during, wreck-clearing operations. Visual methods for accomplishing this are insufficient as evidenced by the tragic occurrence at Waverly, where rupture of the LPG tanker occurred below the safety valve pressure release setting of 300 psig. This was well below the nominal tank bursting pressure of 1000 psig. To avoid such dangers in the future, it is necessary to meet the following criteria:

1. establish whether relief valve is operable, and
2. determine that structural integrity of tank car is sufficient to withstand a bursting pressure much greater than the nominal relief valve setting.

The first criterion is normally satisfied visually by determining that there is no evidence of mechanical damage to the relief valve, that the relief valve is not buried in the ground, and that the orientation of the derailed or overturned tank car is not such as to place the relief valve below the level of liquid in the tank.

The second criterion regarding tank car structural integrity is much more critical and difficult to satisfy. Visual indications are not adequate for this critical area. A promising new method has been investigated with the potential for assessing structural integrity of tank cars, namely acoustic emission (AE) technology. This technology is discussed in detail in Appendix L. Some highlights from this section, as it relates to assessment of tank car structural integrity, are presented in the following paragraphs:

Acoustic emission (AE) is the name given to the stress waves produced in a material by various sources and which propagate at speeds in the acoustic range. All structures emit AE signals which are characteristic of the material used, the fabrication process employed, and the manner in which the structure is loaded. These signals are detected by special transducers (microphones) attached to the surface.

AE equipment and technology has been used for many purposes including in-process weld monitoring, proof testing, leak detection and location, and mechanical property testing and characterization. Of particular interest to this study is the large number of applications that have been made to pressurized systems including nuclear reactor vessels and piping systems, chemical/petroleum vessels, storage tanks, and rocket motor cases.

A survey of the state-of-the-art in AE technology has been conducted with primary emphasis on the use of AE signals as a precursor of burst failures in pressurized vessels. Discrimination between passive, active and critically active AE signals was also emphasized. Passive signals are those associated with sources that are non-critical. Active signals are those associated with potentially critical phenomena such as cracking, plasticity, etc. And finally, critically active AE signals are those indicative of imminent structural failure.

While much remains to be done before AE technology can be used as a tool in the assessment of tank car structural integrity, there is no doubt that the potential is there. A laboratory-scale test plan has been prepared to gain experience with AE technology as it applies to the assessment of flaws in pressurized containers. In a later stage, tests will be conducted on existing and damaged railroad tank cars to determine their AE "signatures". These will be analyzed and compared with data from other damaged tank cars in order to derive criteria and methodology for the assessment of the structural integrity of derailed tank cars. This work can be extended to cover overturned highway tank trucks as well.

8.3.4 Separating Derailed Rail Cars

The wreckage in a derailment is frequently in a jumbled, partially interlocked condition. Some rail cars may still be coupled together with the couplers inoperative. Damaged trucks may be intertwined with other parts of the wreckage. Even after hazards from vapors have been minimized and hazardous materials transferred, removal of damaged rail cars should not be initiated until these cars have been detached or mechanically separated. Otherwise movement of the rail cars would be subjected to unexpected jolts and banging together of wreckage. Moreover, in the case of a hazardous material tank car, such banging could breach the integrity of the car with possibly disastrous results.

If possible, mechanical separation of the rail cars should be accomplished by gentle moving and lifting of juxtaposed portions of the wreckage. If portions are inextricably tied together, as for example in coupled rail cars where the couplers are inoperative, then the use of cutting torches may be required. Extreme caution must then be used, particularly in the case of tank cars that contain flammable liquids or gas. Cutting torches must not be used on tank car tanks either empty or loaded. When spilled flammable liquid, is in the vicinity, further precautions are required as per B.E. Pamphlet No. 1. "When using cutting torches, care must be exercised to avoid contact with leakage or ground saturated with even such materials as lubricating oils, asphalts, or other petroleum products, vegetable oils and animal fats, for they can be ignited and will burn as do flammable liquids."⁽²⁷⁾

8.3.5 Sequence of Wreckage Removal

A freight train derailment very often leaves cars still intact on the track at the front and/or rear of the train. These cars should be pulled to safety as soon as possible, particularly if some of the derailed rail cars contain hazardous material.

After the accident scene has been stabilized, it is necessary to establish a sequence for wreckage removal that minimizes hazards to personnel. The wreckage may contain a mixture of hazardous and non-hazardous material laden cars with various degrees of damage. It is not possible to state fixed rules for the sequence of wreckage removal because it depends on the particular accident configuration. In general, non-hazardous material cars should be removed first, if they are readily accessible and their removal does not endanger the integrity of hazardous material tank cars. (It is assumed

that hazardous material containers in box cars have been removed to a place of safety, and the contents of broken containers disposed of safely, after which these cars can be treated as non-hazardous.)

Next comes the removal of hazardous material tank cars. This must be done with extreme caution, avoiding any banging or jolts to the cars. As noted earlier, if any leaks are likely during movement of these cars, their contents should be transferred first. Upright intact tank cars should probably be removed first, in order to reduce the number of hazardous material laden cars at the accident scene as quickly and safely as possible. Damaged and/or overturned tank cars containing hazardous material are probably the last to be removed. Their structural integrity should be continually monitored, both before and during wreckage removal. After uprighting of these cars, their contents would normally be transferred before proceeding in their removal.

In the last analysis, the decision on the safest sequence of wreckage removal, as well as on all other aspects of wreckage removal, must depend on the expertise of the wreck supervisor at the accident scene.

8.3.6 Transporting Derailed Rail Cars

If a derailed rail car has not suffered appreciable damage to its underframe, including the car body bolster, then the car can be retrucked and transported by rail in the normal manner. Its own trucks can be used if these are available and in operable condition. Otherwise spare trucks should be brought in to the accident scene for this purpose. In the case of a derailed tank car carrying a hazardous material, it is also necessary to assess the structural integrity of the tank shell before retrucking and transport by rail. If a leak is considered likely during transport, the car contents should be transferred first.

If the derailed rail car cannot be safely retrucked, then transport on a flat car or gondola is usually the only alternative. The car body should be blocked and securely tied down in such transport to avoid further damage. The contents of a hazardous material tank car should be transferred before the car is transported in this manner.

8.3.7 Rigging Equipment Used in Wreck Clearing

As discussed in Section 8.2, wreck clearance requires the use of mobile cranes. The automotive (truck) crane shown in Figure 8-4 is typically used for highway wreck clearing involving overturned tank car trailers. For railroad wreck clearing, the locomotive crane and the crawler crane, shown in Figures 8-1 and 8-2, are appropriate. In addition, the side boom tractor shown in Figure 8-4 is frequently used in railroad wreck clearing. Side boom tractors are commonly used in pairs, on opposite sides or opposite ends of a rail car, for lifting and moving the car.

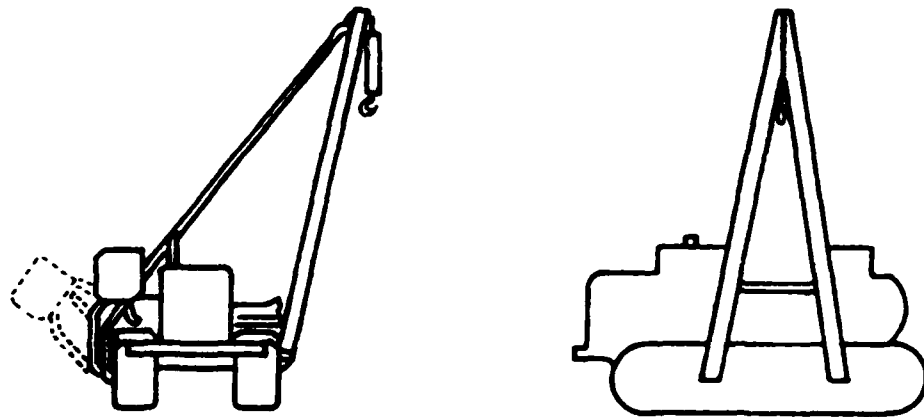


FIGURE 8-4. SIDE BOOM TRACTOR

As in other rigging operations, wreck clearing requires the use of hooks, cables and slings. For the heavy loads involved, cables and slings are typically made of wire rope. The characteristics of various wire rope slings are given in Section 8.2 (Table 8-1). Figure 8-5 shows the tension on a sling rope (or chain) depends upon its angle as well as the load to be lifted. As noted in that section, the braided wire rope sling can be made almost flat in general cross section, which would minimize the stress on tank cars during lifting. Another sling with a flat cross section is the chain mesh sling, shown in

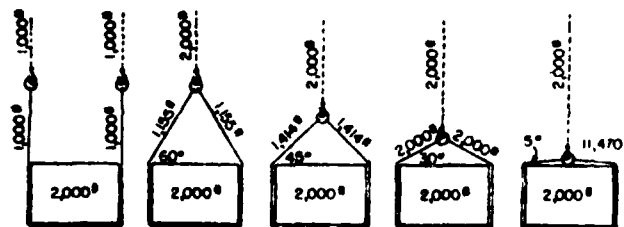


FIGURE 8-5. VARIOUS ANGLES AND TENSIONS ON SLING ROPES

Figure 8-6. This type of sling would be very effective in reducing the stress on tank cars during lifting. It could also be used to advantage in minimizing the damage to the jacket of insulated tank cars.

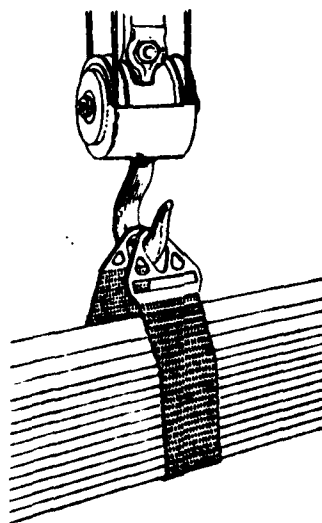


FIGURE 8-6. CHAIN MESH SLING

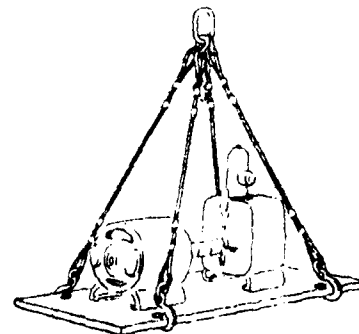
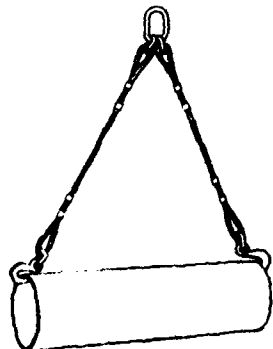
Some typical sling configurations used in lifting are shown in Figure 8-7. When lifting lugs or holes are available on the rail car, the bridle sling or four-leg sling with hooks would be very effective for lifting the cars.

8.3.8 Attachment of Hooks and Slings to Vehicles

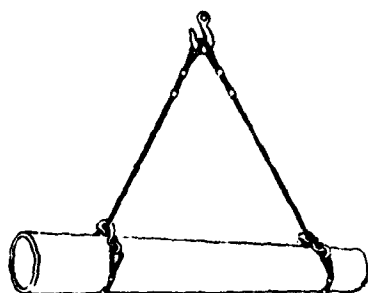
As is evident from the fatal rigging accidents noted in Section 8.3.10, the attachment of hooks and slings to the vehicle is of critical importance. The slipping of hooks or slings while lifting or the tearing away of the vehicle structural member to which the hook or sling is attached can have disastrous results. Hooks and slings are often applied to freight car members that are not designed to withstand the lifting forces involved. Even when these structural members hold, they are badly distorted, which only adds to the damage caused by derailment.

Basket slings, either single or double, are sometimes used for lifting one end or all of a derailed car. These types of slings can slip during lifting, if the direction of force exerted by each sling deviates too much from vertical. The car can drop as a result, endangering personnel as well as causing further damage.

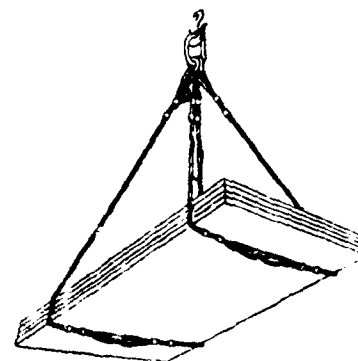
Bridle Sling



Four-leg sling with hooks for use when lifting holes or eyebolts are provided



Double choker sling with hooks attached for more readily attaching and detaching



Double Basket Sling

NOTE: In using the double basket sling, watch that one part does not tend to slip along the load and allow it to tilt and drop

FIGURE 8-7. TYPICAL SLING CONFIGURATIONS AND THEIR USES

Slings that contact sharp edges of the car during lifting can be cut and can fail, again with potentially disastrous results. Slings should be padded where passing over sharp edges of the car to avoid this possibility.

From the foregoing it is clear that the wreck supervisor must have a good knowledge of the construction of the freight cars involved in the derailment in order to avoid injury to personnel and further damage to the cars during wreck clearing. This is especially true in the case of hazardous material laden cars where a mishap during wreck clearing can have grave consequences. It would be very helpful if design drawings of the derailed cars were made available at the accident site as part of the accident response procedures.

A basic improvement in wreck clearing of derailed freight cars would be to have information available from car manufacturers on the best locations for attachment of hooks and slings, both for uprighting and lifting of the derailed cars. It is recognized that car manufacturers could be reluctant to provide this advice because of liability considerations, yet the history of wreck clearing indicates an urgent need for improved procedures. Having information on the best places for attachment of hooks and slings would advance this goal.

8.3.9 Procedures for Moving Vehicles

The uprighting and lifting of derailed freight cars should follow basic rigging procedures used in handling heavy loads. For example, uprighting a rail car involves rigging procedures similar to turning a load over on its side. Some correct and incorrect hitches for accomplishing this are shown in Figures 8-8. The objective naturally is to

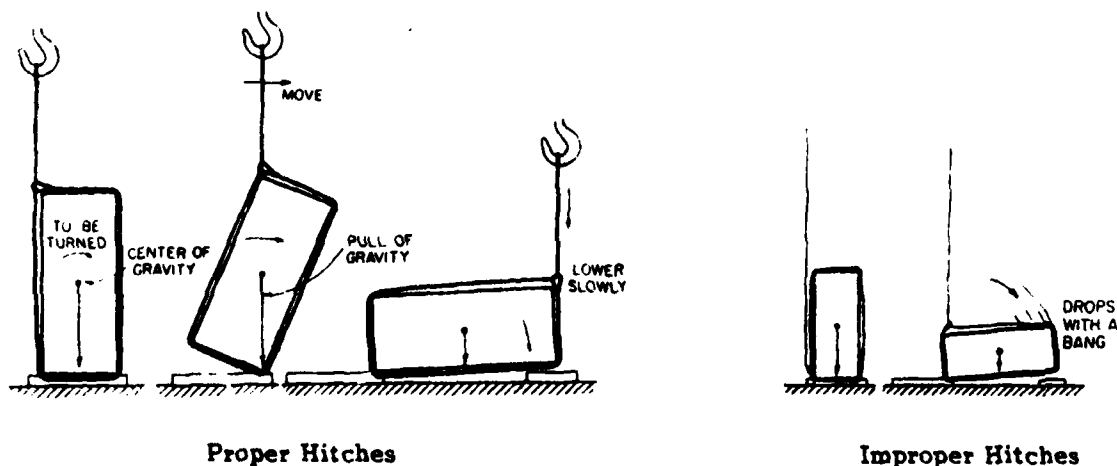


FIGURE 8-8. PROPER AND IMPROPER HITCHES

upright the car without banging or jolting it particularly when loaded with hazardous materials. When slings are used as spreaders for lifting the rail car, it is important that the sling angle be such as to not overload the sling cable. This is illustrated in Figure 8-9.

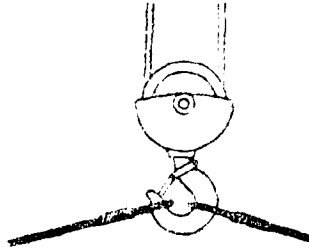


FIGURE 8-9. IMPROPER SLING ANGLE

Often times, it is unsafe or impractical to attach hooks or slings to the underframe of a derailed car because the car is buried in mud, water or chemicals. A safe procedure may be to first drag the car longitudinally to a better location via hook and sling attached to the coupler or draft gear which can withstand longitudinal forces. In the case of hazardous material cars, dragging should be done only on a bed of foam to minimize dangers from jolts and sparking.

The danger of load slippage on basket slings, due to poor angles of applied force, has been mentioned in Section 8.3.8. Another danger is the instability of some high center of gravity cars such as tank cars. This type of car can roll during lifting and cause the crane to topple. Where there is a possibility of car rolling a steadying line should be attached to the car during lifting.

The corners of freight cars are strongest in the vertical direction. Lifting forces at these locations should therefore, be in a vertical or near vertical direction. Appreciable lateral forces at these locations are to be avoided. Movement of an upright car laterally can be done by lifting and moving the entire car or else by lifting and moving one end of the car while the other end serves as a pivot. In the latter mode, care must be exercised to avoid additional stresses on an already damaged car, particularly in the case of hazardous material tank cars. It may be useful to lay down a bed of foam under the pivot end prior to such movement.

In all movement and lifting of rail cars during wreck clearing, care must be exercised to avoid force levels and directions for which the car was not designed. Again, as is the case of hook and sling attachment, making car drawings quickly available at the

accident site would be helpful. Also, the advice of car manufacturers should be solicited as to the maximum force levels in various directions than can be safely applied to derailed freight cars during wreck clearing.

8.3.10 Accident Prevention During Rigging Operations

In addition to the dangers of working around hazardous materials, wreck-clearing workers are subject to the considerable hazards associated with rigging operations in general. Recently, according to industry sources, a wreck-clearing worker was killed when a rail car collapsed on him after a rigging cable snapped. This accident was preventable by following a basic safety maxim in rigging, namely, no persons should be allowed below a suspended load. There have been other fatalities in wreck-clearing operations resulting from improper safety practices. In March, 1978 on the Union Pacific Railroad, an employee was killed between two couplers while the car was being pushed onto another car.⁽⁹⁶⁾ In May, 1978, also on the Union Pacific, a cable hook slid along the side of the car with the result that the car fell down on and killed the employee.⁽⁹⁶⁾ In February, 1978 on Santa Fe, while a hopper car was being erected, the lifting hook was applied to the bolster cover plate which tore away and fell on a man killing him.⁽⁹⁶⁾ These last two fatalities are indicative of the hazards associated with the improper attachment of hooks and/or application of lifting forces, which are discussed in Section 8.3.8.

The following are general safety criteria, for rigging operations in wreck-clearing, to minimize danger to personnel:

1. Prior to their use at an accident site, mobile cranes must be inspected using standard procedures to insure their safe operation.
2. All wire ropes must be inspected periodically for wear and broken wires to determine when a wire rope has reached the limit of its safe usage and must be discarded.
3. Hooks, chains, and eyebolts should be inspected periodically for cracks or other flaws and any faulty equipment removed from service. Hooks should be checked for signs of spreading (caused by overloading).
4. Boom cranes should not be slewed rapidly while carrying a load. During operation of these cranes, the chassis should be on an even keel and properly stabilized.
5. Avoid a very wide angle in a basket or bridle sling even strong enough to carry the load, since one sling may readily slip off the crane hook (see Figure 8-9).
6. All wreck-clearing personnel should wear safety shoes and hard fiber safety helmets and appropriate protective clothing.
7. No persons should be allowed below a suspended load
8. No persons should be allowed between portions of wreckage that are being moved.

9. During car movement, no persons should be allowed between crane and point of attachment to car (to avoid injury in event of failure of cable, hook or car attachment point).
10. Extreme caution must be used during crane operations near overhead electric lines, to avoid contact between electric lines and any part of crane or load (particularly applicable to wreck-clearing on highways).

8.3.11 Equipment Modifications

A number of equipment modifications have been considered, including those listed in the Statement of Work, to facilitate safe, rapid and economical removal of wreckage in railroad and highway accidents involving hazardous materials. At present, only one modification is considered worthy of implementation, namely the lifting lug or lifting provision outlined in AAR Standard S-234-78. This provision would allow a freight car to be lifted by hooks attached to the lugs or reinforced holes incorporated in the freight car design. This standard is shown in Figure 8-10.

The DOT/FRA Special Safety Inquiry on Lifting Lug Requirement, of October 31, 1978, presented the views of numerous industry representatives with regard to this standard. The representatives of tank car manufacturers, the Manufacturing Chemists Association, and DuPont were against this modification, while representatives of AAR, the railroads and wreck-clearing firms were strongly in favor of modification.

The arguments raised against the requirement for lifting lugs are as follows:

- o It is not safe to use these lugs beyond a lifting angle of 15 degrees from the vertical, because the corners of freight cars are strong only in a vertical or near vertical direction, with regard to applied forces
- o It is not possible to limit the use of these lugs to applied forces within 15 degrees of vertical, therefore, this lifting provision will be subject to abuse in practice, with resulting damage to the lifting lug and its attachment to the car.
- o Misuse of lifting lugs during the lift of a freight car and the subsequent failure of the lugs on their attachment to the car, could cause the car to fall and injure wreck-clearing personnel.
- o In the case of a hazardous material tank car, failure of the lifting lugs or their attachment to the car during lifting could result in puncture or rupture of the tank with release of hazardous material.
- o On tank cars, the breakaway weld in the bolster attachment to the tank reinforcement plate could be overstressed from the accident, and thus fail under lift by lugs attached to the bolster.

PROVISION FOR LIFTING FREIGHT CAR

Standard

S-234-78

Adopted 1977

Effective: Cars Ordered New After July 1, 1978

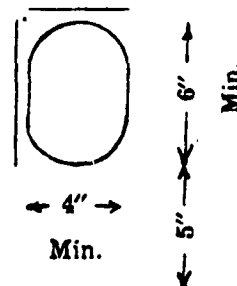
1. The purpose of this provision is to provide a means to vertically lift a loaded upright car. This provision is for new cars to facilitate rerailling operations and to improve the method of handling derailed cars.

2. The provision shall be made available at four places, preferably in or near the body bolster at the side sill.

3. The design force at each provision for the upright car must be 40% of the gross rail load applied within 15 degrees of the vertical axis of the upright car. Each connection zone must be designed to support the above load without exceeding the yield strength of the material except that local deformation is permitted to achieve hook bearing area.

4. The provision may be similar to that shown below and should have rounded ends and provide sufficient opening to accommodate lifting means.

Longitudinal Centerline of Car



Outboard Vertical Surface of Side Sill

Typical Arrangement When Opening
is Utilized in Horizontal Structure

FIGURE 8-10. PROVISIONS FOR LIFTING FREIGHT CAR

- On insulated tank cars that have been derailed, the possible damage to these lugs and/or attachment to the car would be concealed in the case of lugs attached to the tank, adding to the danger in their use.
- The use of such lifting lugs would not be cost-effective
- Wreck-clearing techniques are best left to the discretion of the railroads and wreck-clearing firms.
- Risk of liability for misuse of a lifting provision intended only for accident situations should not be imposed on innocent parties (such as the carrier or car manufacturer).

In response to the foregoing objections to lifting lugs, the following counter-arguments were made:

- The use of lifting lugs as per the AAR Standard would eliminate most of the hazards and equipment damage associated with conventional lifting methods that use hook and sling attachments to the car.
- Personnel would not have to crawl under the derailed car to attach hooks and slings to the carbody underframe, with all of the attendant hazards. Even under the best of conditions, this procedure results in frequent injuries to hands and/or fingers of the person holding the hook and sling attachment in place as the cable slack is taken up.
- Crawling under the car to attach hooks and slings is extremely difficult and hazardous when the car is buried in mud, water and even chemicals.
- Under current methods of lifting, hooks and slings are often attached to car body structural members that are not designed for lifting forces. These structures can tear away during lifting, with disastrous results.
- Slippage of hooks and slings during car lifting often occurs under current rigging methods. This can result in severe car damage and injury to personnel.
- With current lifting methods, cables and slings are often damaged where they contact sharp edges of the car body, and can fail during car lifting.
- On insulated tank cars, the use of slings for lifting causes damage to the jacket.
- On uninsulated tank cars, the use of slings for lifting causes added stress in the tank shell. This can be dangerous in the case of a pressurized tank car that was already damaged during derailment.
- There are many box cars now in use that have holes in the bottom of their bolster flanges to provide for wrecking hook application. There have been no reported difficulties or accidents in the use of these lifting holes.
- Some 200 tank cars now in operation were built with lifting lugs or holes incorporated in the bolster reinforcing plates. There is no history of misuse of these lifting provisions.
- On tank cars, lifting lugs need not be attached to the tank shell but lifting lugs or holes can be incorporated in the car body bolster, which can readily withstand car lifting forces.

- The provision for lifting as per the AAR standard is not restrictive and can be applied to every freight car's design with a minimum of modification. The preferred location is the body bolster which is the strongest segment of a freight car.
- The design forces and lifting angles of the AAR Standard are reasonable and can be conservatively implemented in the freight car design. There is already a safety factor in the lifting provision which allows for some deviation in its use in the field.
- The safety of wreck-clearing operations rests with the expertise of the Wreck Master. If lifting lugs were available, his expertise could be counted on in utilizing that tool or not as the situation warranted.
- The economic consequences of lifting lug misuse are sufficient to assure necessary precautionary measures.
- The addition of reinforced holes or lifting lugs would be a many-fold improvement in safety and ease of wreck clearing, compared to no special lifting provisions at all.
- Lifting lugs are applicable to all cars, carrying both hazardous and non-hazardous material. Restricting lifting lug requirements to certain types of cars would limit interchangeability and add confusion.
- The decision on transfer of hazardous materials is not affected by the presence or absence of lifting lugs.
- The availability of lifting lugs would speed up wreck clearing, return of the track to normal, and return of derailed cars for repair. It would increase the safety and reduce the cost of wreck clearing.
- With regard to liability for lifting lug misuse, it should be pointed out that non-installation of a known safety aid (such as lifting lugs) could also cause liability to car manufacturers.

A consideration of the foregoing arguments, both pro and con leads inevitably to the conclusion that the implementation of the AAR Standard for provision for lifting freight cars would greatly reduce the hazards of wreck clearing, reduce the likelihood of equipment damage, and expedite the entire operation including return of the track to normal and return of derailed cars for repair. It is also evident that the main reason for the objection to this provision by car manufacturers and others is their concern over liability in the event of lifting lug misuse. While such concern is understandable, it is not a valid reason for delaying the implementation of this proven technique for increasing the safety and reducing the cost of wreck-clearing operations.

9. USER'S MANUAL FORMAT

9.1 INTRODUCTION

Several user's manual formats have been considered and reviewed resulting in a recommended format for the final procedures manual to be developed in Task 4. The format of this manual will be designed so it is compatible with the formats of the Association of American Railroads, Environmental Protection Agency, U.S. Coast Guard and DOT response manuals currently being used. The manual will also be compatible with requirements of the NRC so it can be easily integrated into its planned expanded operations.

In considering the several possible formats for the chemicals and propellants spill handling procedures manual, careful consideration has been given to such things as: integrating the "best" aspects of available documents; assuring optimal safety-benefits will be maintained without significantly changing the format of familiar documents; being compatible with the NRC operations; being cost-beneficial; utilizing the state-of-the-art in safety technology; and striving for a system which would be nationally recognized and accepted by all segments of industry, the emergency services and government. Several possible manual formats have been considered and are detailed below.

9.2 CANDIDATE FORMATS

There are three basic formats which were considered which could serve as procedural user's manuals to handle a hazardous materials transportation accident. The following primary candidate approaches include a Five-Volume Series on Spill Response Procedures, a Commodity-Specific Procedures Manual and an Organizational Guide Series.

9.2.1 Five-Volume Guidelines Series on Spill Response Procedures.

This approach envisions a modification and expansion of the four-volume CHRIS series into the following five-volume system:

- Volume 1 - General Guidelines. Consolidate general precautionary information from the CHRIS,^(31,33-35) AAR,⁽²⁷⁾ EPA⁽³⁶⁾ AND DOT⁽³⁰⁾ documents. Preventive procedures could be included. Specific listings of equipment, protective clothing, information sources, etc., should be included as appendices.

- o Volume 2 - Emergency Response Guidelines and Hazardous Chemical Data. Include DOT P-5800.2, "1980 Hazardous Materials Emergency Response Handbook"⁽³⁰⁾ as the primary document. Expand and update CHRIS Volume 2 "Hazardous Chemical Data"⁽³⁴⁾ to cover all materials found in the DOT Emergency Response Guidebook.⁽³⁰⁾ The CHRIS Volume 2⁽³⁴⁾ and the AAR/Bureau of Explosives Handbook⁽²⁷⁾ should be utilized as back-up documents for additional detail on specific commodities. CHRIS Volume 1 entitled, "Condensed Guide to Chemical Hazards",⁽³¹⁾ is not recommended for further consideration because the identical information appears in Volume 2⁽³⁴⁾ of the CHRIS series. It might be claimed that CHRIS Volume 1 is all that the firefighters, law enforcement and other emergency services personnel require and that additional information would only confuse them. This argument can be refuted simply by highlighting the appropriate sections in the miniaturized reproductions found in Volume 2⁽³⁴⁾ of CHRIS.
- o Volume 3 - Hazard Assessment Guidelines. Use CHRIS Volume 3⁽³³⁾ entitled, "Hazard Assessment Handbook", with update and expansion to provide for land spills in addition to marine episodes. Additional procedures and dispersion model(s) should be included, if necessary, and technical data tables and figures for their use should be provided. Data on fragment dispersion, blast overpressure (container rupture/vapor-phase explosion), evaporation rates, source strengths and self-reacting materials behavior (polymerization and decomposition) calculation procedures are needed. Hazardous materials identification and container integrity assessment procedures also need to be addressed in this volume.
- o Volume 4 - Hazard Mitigation Guidelines. This volume should include cautionary response indices and methods and the corrective response methods (stopping discharges and containment) portion from CHRIS Volume 4,⁽³⁵⁾ made applicable to land spills and expanded to cover the chemicals and propellants. Chapters 4 and 5 from the EPA Manual⁽³⁶⁾ could be utilized on controlling discharges and containment techniques. CHRIS Volume 4⁽³⁵⁾ must be updated and expanded, particularly with respect to land spills. The spill handling thought guide concept from the EPA document should be utilized.
- o Volume 5 - Wreckage Removal, Transfer, Cleanup and Disposal Guidelines. This volume should have a section on product transfer procedures when material remains in a container. This section must consider the location, positioning and condition of the container, as well as if, when, and how to

transfer cargo or discard of lading in place. Wreckage removal precautionary procedures are needed. The collection, recovery and treatment (chemical and physical) sections of CHRIS Volume 4⁽³⁵⁾ must be expanded to include spills on land. This revised section should be consolidated with the appropriate portions from the EPA Manual⁽³⁶⁾ on collection, removal, dilution, disposal and treatment.

In summary this approach takes advantage of the benefits of existing major systems and serves the useful purpose of consolidating the various procedures and backup information into one source. Inasmuch as the NRC is fully operational and being expanded to cover hazardous materials (HM) emergencies in all transport modes, it is a logical focal point for a national response system. The NRC is operated by the U.S. Coast Guard, an element of the Department of Transportation, as part of its joint responsibilities with EPA under the Clean Water Act. NRC is also tied into CHEMTREC, so there is the added advantage of chemical industry involvement. CHEMTREC is recognized and utilized by the HM transport industry and emergency services personnel in responding to HM incidents, so this approach does not introduce some confusing new concepts to those persons having to deal with HM emergencies. The five volume set would be the support documentation for the expanded system centered at the NRC and CHEMTREC, with linkups to the scene as well as having interaction with shipper and carrier. The expansion performed in this study would be limited to information pertaining to the 12 chemicals and propellants.

The one problem with this proposed approach is that it does not provide the individual responders/organizations with procedures. Basically the approach is an overall management tool to be utilized by individuals with decision-making powers. Also, comprehensive technical data (e.g., chemicals and propellants evaporation rate, source strength and self-reaction data) are limited and would have to be developed through future laboratory/field tests. Appendix M is a preliminary outline of the contents for each of the indicated volumes.

9.2.2 Commodity-Specific Procedures Manual

9.2.2.1 Option A

This option would be patterned after the JANNAF manual entitled, "Chemical/Rocket Propellant Hazards, Volume III"⁽¹⁰¹⁾ and provide response procedures and other related information for each of the 12 chemicals and propellants in somewhat more detail than currently is found. This would amount to expansion of the propellants and development of data for the additional chemicals. Inasmuch as the JANNAF document contains certain aspects (e.g., transportation regulations, materials

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POST ACCIDENT PROCEDURES FOR CHEMICALS AND PROPELLANTS

3/5

(U) SYSTEMS TECHNOLOGY LABS INC ARLINGTON VA

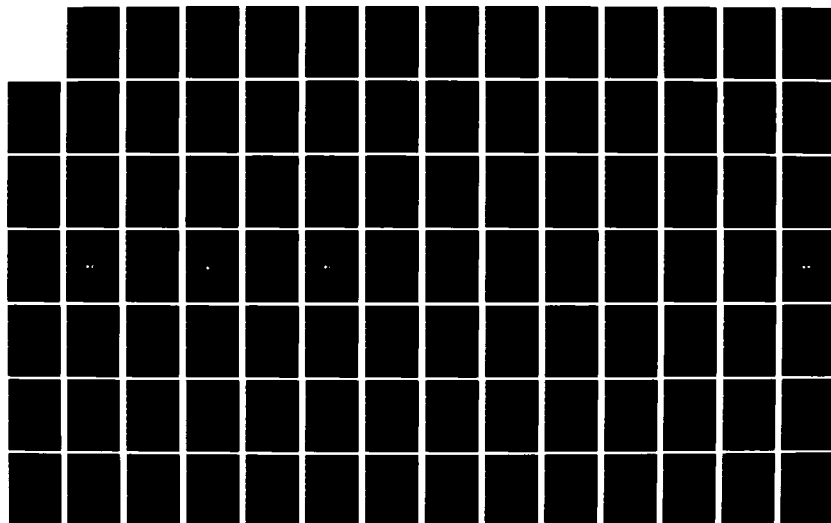
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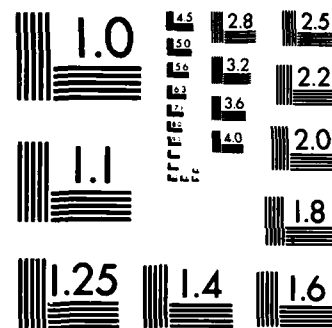
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

compatibility and other technical data) beyond the scope of the current project; complete documentation could not be provided. Updating the JANNAF⁽¹⁰¹⁾ manual may well be necessary to provide the Air Force with the latest propellant technology and doing so would not be prohibitive because of the relatively small number of bulk propellants. This approach has very definite implementation problems, if one considers undertaking documentation on a commodity-specific basis for the thousands of hazardous materials shipped. Since the procedures manual must be compatible with the Coast Guard, (31,33-35) EPA⁽³⁶⁾ and AAR⁽²⁷⁾ documentation, the JANNAF⁽¹⁰¹⁾ hazards manual approach cannot be recommended. However a sample table of contents for such a manual is shown in Appendix N.

9.2.2.2 Option B

This option represents a combination of the AAR/B.E. response manual entitled "Emergency Handling of Hazardous Materials in Surface Transportation"⁽²⁷⁾ and the Department of Transportation's "Hazardous Materials Emergency Response Guidebook".⁽³⁰⁾ The AAR manual is commodity-specific, while the DOT Guidebook assigns one of several generic responses to specific commodities. The recommended format would be to assign a series of responses for each hazardous material being transported. The principal problem with this option is that it would require several thousand mini-guides to cover each of the more than 1,700 regulated hazardous materials being transported. Appendix N also illustrates the possible contents for such a commodity-specific guide.

9.2.3 Organizational Guide Series

These guides would be developed for each individual responding group, organization or specialist in terms of immediate response, hazard mitigation, wreckage removal, and cleanup and disposal activities. Appendix J details organizational activities at a hazardous materials transportation emergency for 19 of the groups responding to an accident. The individual guides would also be compiled into a master set of overall emergency response procedures. One of the positive aspects of such a format is that each group would have specific responsibilities identified and outlined so that important on-scene needs do not get overlooked in the proliferation of activities surrounding an accident. However, a drawback is the tendency to isolate group actions rather than foster and promote cooperation and coordination during the emergency. On the other hand, this approach could be developed in conjunction with the overall spill response procedures manual as a useful complement. Appendix O illustrates the possible content for such an organizational guide series for the train crew segment of the emergency response community.

9.3. RECOMMENDED FORMAT

Based on a preliminary evaluation the Five-Volume Guideline Series on Spill Response Procedures is recommended, because it can be accomplished with the minimum perturbation of existing systems; foster the consolidation of separate organizational approaches; is practical; appears to be cost-effective; and provides the required product. It is also suggested that an organizational guide for one of the responding groups (other than firefighters) be prepared for experimental evaluation.

PARAMETERS OF OHMTADS

SEGMENT RATIONALE

The following lists segment numbers, mnemonics and segment title, as well as the basic considerations which were made in collecting data for the OHM-TADS file.

Segment No.	Mnemonic	Segment Title	
1.	ACC	<u>OHM-TADS Accession Number</u> : A unique, computer assigned, identifier for the data file.	14. CON
2.	CAS	<u>Chemical Abstracts Service Registry Number</u> : A unique, international, identifier for material of interest.	15. STO
3.	SIC	<u>Standard Industrial Code</u> : Industry-employed codes which can be used to identify manufacturers of material.	16. HND
4.	MAT	<u>Material Name</u> : Generally, the common name for the materials.	
5.	SYN	<u>Synonyms</u> : Alternate identifiers of similar isomers for which the data is valid.	
6.	TRN	<u>Company Trade Names</u> : Lists commercial trade names and the associate manufacturer whenever possible.	17. PRD
7.	FML	<u>Chemical Formula</u> : Gives most common formula or describes nature of materials included in the general heading such as components of an industrial blend or mixture.	18. HYD
8.	SPC	<u>Species in Mixture</u> : Identifies typical product purity in cases of single constituent materials, or specific major components of heterogeneous mixtures.	19. ADD
9.	USS	<u>Common Uses</u> : Enumerates common uses of materials.	20. BIN
10.	RAL	<u>Rail (%)</u> : Percentage shipped by rail (estimate).	21. COR
11.	BRG	<u>Barge (%)</u> : Percentage shipped by barge (estimate).	
12.	TRK	<u>Truck (%)</u> : Percentage shipped by truck (estimate).	22. SGM
13.	PIP	<u>Pipeline (%)</u> : Percentage shipped by pipeline (estimate).	23. ANT

Containers: Lists type of shipping containers normally used or required by law. Typical shipment size when available.

General Storage Procedures: Relates to precautions to be taken when storing the material. Rationale for these measures varies from safety considerations to precautions designed to prevent degradation of the materials.

General Handling Procedures: States the precautions to be taken when handling the material. Information relates to both safety considerations and practices designed to prevent degradation of the material.

Production Sites: Lists major producers and their plant locations.

Hydrolysis Product of: Lists hazardous materials which decomposes to the material of reference when contacted with water.

Additive (%): Lists typical stabilizers and inhibitors added to the base material.

Binary Reactants: Lists materials known to react when put in contact with the material of reference.

Corrosiveness: General statement of observations on corrosive action to materials commonly used for packaging or equipment that might be required at a spill site.

Synergistic Materials: Lists other materials and water quality parameters whose presence can increase the toxicity of the material of interest.

Antagonistic Materials: Lists other materials and water quality parameters whose presence can reduce the toxicity of the material of interest.

PARAMETERS OF OHTADS (CONTINUED)

24.	FDL	Field Detection Techniques. Limit (ppm). Ref. A three part segment listing potential field detection techniques, the lower sensitivity limit, and the literature reference where more data can be obtained. Field test generally refers to any gross identification method that can be used at the spill site without elaborate or non-portable equipment. It normally assumes that the material or the chemical class has been identified so that general tests for aldehydes or phenols, etc. are applicable. The two major types of tests listed are inorganic colorimetric reactions and organic spot tests.	32	FLP	Flash Point (°C): Listed open cup value when available, otherwise closed cup.
			33.	AIP	Auto Ignition Point (°C): Listed value at which auto ignition occurs in the presence of adequate air.
			34.	EXP	Explosiveness: Summarizes potential for violent rupture or vigorous reaction at a spill site.
			35.	LEL	Lower Explosive Limit (%): Listed value is % of material in air which is the lower explosive limit.
			36.	UEL	Upper Explosive Limit (%): Listed value is % of material in air which is the upper explosive limit.
			37.	MLT	Melting Point (°C): Accepted value under standard conditions unless otherwise noted below in segment 38.
25.	LDL	Laboratory Detection Techniques. Limit (ppm). Ref. Follows format of previous segment for specific tests that can be used for positive identification of material. These tests are generally reliant on sophisticated laboratory analysis equipment, such as atomic absorption units and gas chromatographs.	38.	MTC	Melting Characteristics: Decomposes, ignites, etc.
			39.	BLP	Boiling Point (°C): Accepted value under standard conditions unless noted below in segment 40.
			40.	BOC	Boiling Characteristics: Reduced pressure, etc.
			41.	SOL	Solubility (ppm 25°C): Typically the listed value for standard reference conditions.
26.	STD	Standard Codes: Enumerates the National Fire Protection Association codes for materials as well as pertinent transportation codes.	42.	SLC	Solubility Characteristics: Slightly and moderately are used when a specific value is not given.
27.	FLM	Flammability: Summarizes potential for fire at a spill site. Uses the NFPA ranking system described by one of the following modifiers: very quite moderate slight non-flammable	43.	SPG	Specific Gravity: Listed value for material in the state it is most often shipped. For materials whose boiling point is near ambient temperatures, the liquid state was usually referenced.
			44.	VPN	Vapor Pressure (mm Hg): The pressure characteristic (at any given temperature) of a vapor in equilibrium with its liquid or solid form.
28.	LFL	Lower Flammability Limit (%): Listed value is % of material in air which is the lower limit of flammability.	45.	VPT	Vapor Pressure Text: Indicates conditions under which measurement is made.
29.	UFL	Upper Flammability Limit (%): Listed value is % of material in air which is the upper limit of flammability.	46.	VDN	Vapor Density: A value derived by dividing the mass of the vapor by its volume and measuring at a specific temperature. A value <1 indicates that the vapor is lighter than air, >1 is heavier than air and will give the appearance of a fog, hugging the ground.
30.	TCP	Toxic Combustion Products: Occasionally lists specific materials or classes of materials released when compound of concern is burned or heated to decomposition.	47.	VDT	Vapor Density Text: Indicates temperature and any other conditions under which measurement is made.
31.	EXT	Extinguishing Methods: Notes fire fighting techniques and outlines unique precautions to be taken if any.	48.	BOX	Biochemical Oxygen Demand (BOD lb/lb): Describes relative oxygen requirements of wastewaters, effluents, and polluted waters. Lists

PARAMETERS OF OIMTADS (continued)

49.	BOD	biochemical oxygen demand of pure substance on a lb/lb, or % of theoretical demand basis.	59.	CAT	<u>Chronic Aquatic Toxicity Limits (ppm)</u> : Maximum level in ppm found to be safe for extended exposure of fish to the material of interest.
50.	PER	<u>Biochemical Oxygen Demand Text</u> : Displays same information listed in segment 48 and includes duration of the test and source of information.	60.	CAR	<u>Reference for Chronic Aquatic Toxicity</u> : Source of information.
51.	PFA	<u>Persistence</u> : Interprets BOD and chemical data to estimate material life span in a free aquatic system. When possible degradation products are specified.	61.	STX	<u>Salt Water Toxicity</u> : Indicates toxicity to estuarine or marine animals in parts per million.
52.	FOO	<u>Potential for Accumulation</u> : Recounts data on ability of various organisms to accumulate a material and the specific organs in which concentration is most pronounced.	62.	STB	<u>Salt Water Toxicity Text</u> : Follows same general format as segment 58.
53.	EDF	<u>Food Chain Concentration Potential</u> : Indicates potential for material to be concentrated to toxic levels while it is passed up the food chain. Where possible, data is given on findings in predator species.	63.	ATX	<u>Animal Toxicity</u> : Displays doses reported in milligrams of material per milligram of body weight of the test animal (unless otherwise noted).
54.	CAG	<u>Etiological Potential</u> : Enumerates diseases and ailments initiated or accelerated by exposure to the material of interest.	64.	ATB	<u>Animal Toxicity Text</u> : <u>Column 1</u> —Doses in mg of Material per mg body weight of test animal. <u>Column 2</u> —Time of exposure. <u>Column 3</u> —Species, lists animal of reference—typically lab animals—rats, guinea pigs, mice, pigs, dogs, and monkeys.
55.	MUT	<u>Carcinogenicity</u> : Relates results of work directed to isolating carcinoma in test animals. Human data is used when available.			<u>Column 4</u> —Parameter, description of exposure. Terms indicate whether dose caused death or other toxic effects, and whether it was administered as a lethal concentration, or toxic concentration in the inhaled air. Refer to Appendix for abbreviations.
56.	TER	<u>Mutagenicity</u> : Cites finding of tests for mutagenicity.			<u>Column 5</u> —Route, lists mode of application. Refer to Appendix for abbreviations.
57.	FTX	<u>Teratogenicity</u> : Cites finding of tests for teratogenicity.	65.	ATL	<u>Column 6</u> —Reference, source of data.
58.	FTB	<u>Freshwater Toxicity Number (ppm)</u> : This segment indicates the concentration in parts per million at which test results were reported.			<u>Chronic Animal Toxicity Limits (ppm)</u> : Maximum level reported in ppm thought to be the threshold for extended use on livestock.
		<u>Freshwater Toxicity Text</u> : <u>Column 1</u> —Concentration in ppm at which test results were reported.	66.	ATR	<u>Reference for Chronic Animal Toxicity Limits</u> : Source of information.
		<u>Column 2</u> —Time of exposure expressed in hours.	67.	LVN	<u>Livestock Toxicity (ppm)</u> : Lists recommended or safe levels of concentration in ppm for use on livestock.
		<u>Column 3</u> —Species tested, usually a common name.	68.	LVR	<u>Reference for Livestock</u> : Source of information.
		<u>Column 4</u> —Effect on organism tested often given as TLM or LD 50.	69.	WAN	<u>Acute Waterfowl Toxicity (ppm)</u> : Concentration in ppm considered to be hazardous to waterfowl upon acute exposure.
		<u>Column 5</u> —Test environment, includes data on water quality and other controlled conditions.			
		<u>Column 6</u> —Source of information.			

PARAMETERS OF ORNTADS (continued)

70	WAR	Reference for Acute Waterfowl Toxicity Source of information:	87	NS	General Sensation: Designed to identify some of the reactions people might have as symptoms and effect on body) when exposed to the designated material, sensation upon breathing the vapors, vapor concentration levels at which noticeable reactions occur, warning properties, and miscellaneous toxicological observations.
71	CWF	Chronic Waterfowl Toxicity Limits (ppm): Concentration in ppm considered to be maximum permissible in water inhabited by waterfowl.	88	LOI	Lower Odor Threshold (ppm): Listed value in ppm.
72	CWR	Reference for Chronic Waterfowl Toxicity Source of information:	89	LOR	Lower Odor Threshold Reference: Source of information.
73	AON	Aquatic Plants (ppm): Concentration in ppm found to be injurious to aquatic flora listed.	90	MOT	Medium Odor Threshold (ppm): Listed value in ppm.
74	AOR	Reference for Aquatic Plants: Source of information.	91	MOR	Medium Odor Threshold Reference: Source of information.
75	IRN	Irrigable Plants (ppm): Concentration expressed in ppm found to be injurious to crop listed.	92	UOT	Upper Odor Threshold (ppm): Listed value in ppm.
76	IRR	Reference for Irrigable Plants: Source of information.	93	UOR	Upper Odor Threshold Reference: Source of information.
77	CPT	Chronic Plant Toxicity Limits (ppm): Threshold level expressed in ppm for extended use as irrigation water.	94	LTT	Lower Taste Threshold (ppm): Listed value in ppm.
78	CPN	Reference for Chronic Plant Toxicity Limits: Source of information.	95	LTR	Lower Taste Threshold Reference: Source of information.
79	TRT	Major Species Threatened: This segment was originally designed to spotlight individual species especially susceptible to the material of interest. Data such as this is very rare. Consequently, the segment includes specific data on tests run with different species.	96	MTT	Medium Taste Threshold (ppm): Listed value in ppm.
80	TIC	Taste Imparting Characteristics (ppm): Level in ppm at which material will impart a taste to the flesh of fish living in the affected waters.	97	MTR	Medium Taste Threshold Reference: Source of information.
81	TIR	Reference for Taste Imparting Characteristics: Source of information.	98	UTT	Upper Taste Threshold (ppm): Listed value in ppm.
82	INH	Inhalation Limit (Value): Generally the accepted threshold limit value (TLV) which is that level acceptable for industrial exposure over an eight hour period. May sometimes be the LC50 for inhalation.	99	UTR	Upper Taste Threshold Reference: Source of information.
83	INT	Inhalation Limit (Text): Units and source of information for the above segment.	100	DHI	Direct Human Ingestion (mg/kgwt): Note toxic dose levels via human consumption in milligrams toxicant per kilogram body weight.
84	IRL	Irritation Levels (Value): Level at which skin and mucous membrane irritation occurs.	101	DHR	Reference for Direct Human Ingestion: Source of information.
85	IRT	Irritation Levels (Text): Reference and explanatory comments for above segment.	102	DRK	Recommended Drinking Water Limits (ppm): Cites Public Health Service Drinking Water Standards whenever available.
86	DRC	Direct Contact: Summary statement indicating corrosiveness or irritation value of material in direct contact with skin, mucous membranes, or eyes.	103	DRR	Reference for Recommended Drinking Water Limits: Source of information.
			104	BCU	Body Contact Exposure (ppm): States about contact threshold limits in water where available.
			105	BCR	Reference for Body Contact Exposure: Source of information.

PARAMETERS OF OMTADS (continued)

106	PHC	<u>Prolonged Human Contact (ppm)</u> : States safe level for bathing and swimming (prolonged) in parts per million.	
107	PHR	<u>Reference for Prolonged Human Contact</u> : Source of information.	
108	SAF	<u>Personal Safety Precautions</u> : Lists equipment to be employed when working in a spill area. Refers to disaster conditions and as such often presupposes fire or intense heat. Response teams should use their own judgment in deciding when stated precautions are no longer necessary. For most circumstances, eye protection, hard hats, and gloves are recommended.	
109	AHL	<u>Acute Hazard Level</u> : Attempts to indicate level of hazard resulting from a spill. Relates to inhalation, ingestion and contact with material. Also lists specific water use hazard level such as fish toxicity and irrigation water toxicity.	114. AML
110	CHL	<u>Chronic Hazard Level</u> : Interprets chronic toxicological-biological hazard to life forms subjected to material of interest for extended periods of time.	115. SHR
111	HEL	<u>Degree of Hazard to Public Health</u> : Interpretive summary of data from previous segments. This segment focuses on those toxicological chemical hazards directly affecting public health.	116. AVL
112	AIR	<u>Air Pollution</u> : Summarizes degree of hazard to people in the vicinity of a spill. May refer to fumes, vapors, mists, or dusts of the material spilled or its combustion and/or decomposition products.	117. DIS
113	ACT	<u>Action Levels</u> : An interpretive segment designed to aid in initiating response activities. Suggests notification of fire and air authority if material poses flammability or air hazard. Recommends alerting Civil Defense if explosion hazard exists. When explosion or severe air pollution exists, evacuation is indicated. If the material in question is highly corrosive or can be absorbed through the skin at toxic levels, affected waterways should be restricted from public access. When flammable materials are involved, ignition sources should be removed. Air contaminants require entry from upwind. If the spill involves solids, attempts should be made to prevent suspension of dusts in the air. If	118. DSN 119. IFP 120. WTP

the material is one that will form a slick on water before dissolving, early attempts at containment will be quite beneficial.

It is assumed that these actions will be complemented by general defensive responses. These include, notifying downstream water users of the spill, stopping all leaks or diverting their flow from reaching surface waters, and removing all bags, barrels and/or other containers that may still be leaking to the water body.

In Situ Amelioration: Lists potentially effective treatment methods which could be applied to the body of water for removal of the spilled material. Methods deemed to include hazards equal to or greater than that of the contaminant were systematically excluded. The term carbon refers to activated carbon in granular or powdered form.

Beach and Shore Restoration: This segment is used mainly to indicate if material can be safely burned off beaches. Occasionally, a recommendation is made to wash affected area with a neutralizing solution.

Availability of Countermeasures: Material Lists major materials required for countermeasures recommended in segment 114 (in situ amelioration) and possible local sources for those materials.

Disposal Methods: Describes recommended techniques for disposing of spilled materials.

Disposal Notification: Lists local authorities who should be notified before disposal methods in segment 117 are initiated.

Industrial Fouling Potential: Relates potential problems from use of water contaminated by the material of interest. Generally refers to use in boiler feed and cooling water. Materials with flash points below 50° C are listed as potential rupture hazards when included in boiler feed or cooling water.

Effect on Water Treatment Process: Describes potential interaction with typical water and wastewater treatment facilities. Most frequent entries concern effect of chlorination on the aesthetic properties of contaminated water, and the effect of high concentration on sewage organisms.

PARAMETERS OF ORITADS (continued)

121. WAT Major Water Uses Exhausted: Lists water uses imperiled by a spill and consequently indicates what type of downstream water users should be notified of the spill.
122. LOC Probable Location and State of the Material. This is an interpretive segment of physical data designed to assist personnel in identifying the material spilled and its whereabouts. The data attempts to describe the physical appearance of the material as shipped (i.e., a dark red powder, etc.) and its probable location if the spill occurs in or near surface water.
123. DRT Soil Chemistry: A general description of the behavior and exchange capacity of various cations and ions in soil.
124. HOH Water Chemistry: A general description of the behavior of the material of interest in aqueous solution.
125. COL Color in Water: Identifies the color or appearance of concentrated solutions of the material of interest. In many cases, dilution and material coloring will minimize the visibility of the color listed here.
126. DAT Adequacy of Data: A simple classification was used to indicate the availability of data.
 Poor—indicates toxicological data is sparse if it exists at all.
 Fair—indicates toxicological data was found but no aquatic toxicities are listed.
 Moderate—indicates toxicological data was found along with some information on toxicity towards fish.
 Good—indicates both toxicological and aquatic toxicity data was found.
 Limited References—identifies those materials for which a complete literature survey was not run.

OPTION? MAT/AMMONIA

FILE: 1 COUNT: 1

OPTION? TYPE 1/2

FILE 1: ENTRY 1

(1) TECHNICAL ASSISTANCE DATA SYSTEM: 72T16584

(2) CAS REGISTRY NO: 7664417

(3) SIC CODE: 3872; 2892; 2824; 2819

(4) MATERIAL: \$\$\$AMMONIA\$\$\$

(5) SYNONYMS: ANHYDROUS-AMMONIA

(7) CHEMICAL FORMULA: NH_3

(8) SPECIES IN MIXTURE: 99.5% NH_3

30% SOLUTION:

(9) COMMON USES: FERTILIZER 2872/ EXPLOSIVES SYNTHETIC FIBERS
NITRIC ACID

(10) RAIL TRANSPORT (%): 58.7

(11) BARGE TRANSPORT (%): 13.2

(12) TRUCK TRANSPORT (%): 24.7

(13) PIPE TRANSPORT (%): 03.4

(14) CONTAINERS: TANK CARS, TANK TRUCKS, BARGES AND STEEL CYLINDERS.
CYLINDERS UNDER 165 POUNDS CAPACITY ARE NOT REQUIRED BY THE
INTER-STATE COMMERCE COMMISSION TO HAVE BURSTING DISCS, FUSIBLE PLUGS OR
PRESSURE RELIEF VALVES. TANK BARGES. PRESSURIZED STEEL TANK CARS,
BOTTLE-TYPE STEEL CYL., TUBE-TYPE STEEL CYL

(15) GENERAL STORAGE PROCEDURES: PROTECT AGAINST PHYSICAL DAMAGE AND
EXCESSIVE HEATING OF CONTAINERS: STORE IN COOL, WELL-VENTILATED PLACE.
FIRE RESISTIVE STORAGE RECOMMENDED: SPRINKLER PROTECTION RECOMMENDED FOR
STORAGE IN COMBUSTIBLE CONSTRUCTION. SEPARATE FROM OTHER CHEMICALS,
PARTICULARLY OXIDIZING GASES, CHLORINE, BROMINE, IODINE, AND ACIDS. TO
KEEP GAS IN LIQUID STATE AT ROOM TEMP. A PRESSURE OF 175 PSI IS
REQUIRED.

(16) GENERAL HANDLING PROCEDURES: WATER SPRAY EFFECTIVE IN
DISPERSING VAPORS - DO NOT PUT WATER ON FROZEN AREAS OR LIQUID AMMONIA

COMPUTER RUN OF OHTADS FOR NH_3

(17) PRODUCTION SITES:

AIR PRODUCTS AND CHEMICALS, INC., NEW ORLEANS, LA.
ALLIED CHEMICAL CORP., HOPEWELL, VA.; SOUTH POINT, OHIO; LA PLATTE,
NEB.

AMERICAN CYANAMID CO., FORTIER, LA.

AMERICAN OIL CO., TEXAS CITY, TEXAS

AMMONIA, INC., BONNIE, FLA.

APACHE POWDER CO., BENSON, ARIZ. APPLE RIVER CHEMICAL CO., EASTMAN,
ILL.

ARKLA CHEMICAL CORP., HELENA, ARK.

ARMOUR AGRICULTURAL CHEMICAL CO., CRYSTAL CITY, MO.; CHEROKEE, ALA.

ATLANTIC REFINING CO., PHILADELPHIA, PA.

CALIFORNIA CHEMICAL CO., FORT MADISON, IOWA; RICHMOND, CA.

CALUMET, NITROGEN PRODUCTS CO., HAMMOND, IND.

CARIBE NITROGEN CO., GUANICA, PUERTO RICO

CENTRAL NITROGEN, INC., TERRE HAUTE, IND.

CITIES SERVICE OIL CO., LAKE CHARLES, LA.; TAMPA, FLA.

COASTAL CHEMICAL CO., INC., PASCAGOULA, MISS.

COLLIER CARBON AND CHEMICAL CORP., EREA, CALIF.

COLUMBIA NITROGEN CORP., AUGUSTA, GA.

COMMERCIAL SOLVENTS CORP., STERLINGTON, LA.

CONSUMERS COOPERATIVE ASSOC., FORT DODGE, IOWA; HASTINGS, NEB

CONTINENTAL OIL CO., BLYTHEVILLE, ARK.

COOPERATIVE FARM CHEMICALS ASSOC., LAWRENCE, KAN.

DEERE, JOHN, CHEMICAL CO., PRYOR, OKLA.

DIAMOND ALKALI CO., DEER PARK, TEXAS

DOW CHEMICAL CO., FREEPORT, TEXAS; MIDLAND, MICH.; PITTS-BURG,
CALIF.; PLACQUEMINE, LA.

E.I. DU PONT DE NEMOURS & CO., INC., BELLE, W. VA.; GIBBSTOWN, N.J.

VICTORIA, TEXAS

EL PASO NATURAL GAS PRODUCTS CO., ODESSA, TEXAS

ESCAMBIA CHEMICAL CORP., PENSACOLA, FLA.

FMC CORPORATION, SO. CHARLESTON, W. VA.

FARMERS CHEMICAL ASSOCIATION, INC., TYNER, TENN.

FEL-TEX, INC., FREMONT, NEB.

FRONTIER CHEMICAL CO., WICHITA, KAN.

W.R. GRACE AND CO., MEMPHIS, TENN.; BIG SPRING, TEXAS

HAWKEYE CHEMICAL CO., CLINTON, IOWA

HERCULES POWDER CO., INC., HERCULES, CALIF.; LOUISIANA, MD.

HODGER CHEMICAL CORP., TACOMA, WASH.

ILLINOIS NITROGEN CO., MARSEILLES, ILL.

KETONA CHEMICAL CORP., KETONA, ALA.

LONE STAR PRODUCING CO., KERENS, TEXAS

MISSISSIPPI CHEMICAL CORP., YAZOO CITY, MISS.

MONSANTO CO., EL DORADO, ARK.; LULING, LA; MUSCATINE, IOWA
 NATIONAL DISTILLERS AND CHEMICAL CORP., TUSCOLA, ILL.
 NEW JERSEY ZINC CO., PALMERTON, PA.
 NITRIN, INC., CORDOVA, ILLINOIS
 NORTHERN CHEMICAL INDUSTRIES, INC., SEARSPORT, ME.
 OCCIDENTAL PETROLEUM CO., LATHROP, CALIF.; PLAINVIEW, TEXAS
 ODESSA NATURAL GASOLINE CO., ODESSA, TEXAS
 OLIN MATHIESON CHEMICAL CORP., LAKE CHARLES, LA.
 PENNSALT CHEMICALS CORP., WYANDOTTE, MICH.; PORTLAND, ORE.
 PHILLIPS CHEMICAL CO., ETTER, TEXAS; PASADENA, TEXAS; BEATRICE, NEB.
 PHILLIPS PACIFIC CHEMICAL CO., PASCO, WASH.
 PITTSBURGH PLATE GLASS CO., NATRIUM, W. VA.
 PURE OIL CO., WORLAND, WYOMING
 RESERVE OIL AND GAS CO., NEW HANFORD, CALIF.
 RDAM AND HAAS CO., DEER PARK, TEXAS
 ST. PAUL AMMONIA PRODUCTS, INC., PINE BEND, MINN.
 SHAMROCK OIL AND GAS CORP., DUMAS, TEXAS
 SHEL Chemical CO., PITTSBURG, CALIF.; VENTURA, CALIF.
 J.R. SIMPLOT CO., POCATELLO, IDAHO
 SMITH-DOUGLASS CO., INC., HOUSTON, TEXAS
 SOLAR NITROGEN CHEMICALS, INC., JOPLIN, MO.; LIMA, OHIO
 SOUTHERN FARM SUPPLY ASSOC., PLAINVIEW, TEXAS
 SOUTHERN NITROGEN CO., INC., SAVANNAH, GA.
 SOUTHWESTERN NITROCHEMICAL CORP., CHANDLER, ARIZ.
 SPENCER CHEMICAL CO., PITTSBURG, KAN.; HENDERSON, KY.; VICKSBURG,
 MISS.
 SUN OIL CO., MARCUS HOOK, PA.
 TECHNE CO., PLAINVIEW, TEXAS
 TENNECO CHEMICAL CO., HOUSTON, TEXAS
 TENNESSEE VALLEY AUTHORITY, WILSON DAM, ALA.
 TEXACO, INC., LOCKPORT, ILL.
 TULOMA GAS PRODUCTS, WOOD RIVER, ILL.
 UNION CARBIDE CORP., BROWNSVILLE, TEXAS CITY, TEXAS
 U.S. STEEL CORP., GENEVA, UTAH; CLAIRTON, PA.
 VALLEY NITROGEN PRODUCERS, INC., HELM, CALIF.
 WESTERN AMMONIA CORP., DIMMITT, TEXAS
 WYCON CHEMICAL CO., CHEYENNE, WYO.
 (24) FIELD DETECTION LIMIT (PPM), TECHNIQUES, REF: .2, SP. EL.,
 BNU, 100193
 (25) LAB DETECTION LIMIT (PPM), TECHNIQUES, REF: .01, SP. EL.,
 BNU, 100193
 (26) STANDARD CODES: EPA 311; NFPA - 3,1,0; ICC - NONFLAMMABLE;
 COMPRESSED GAS, GREEN LABEL, 300 LBS; USCG - LIQUIFIED COMPRESSED GAS;
 IATA - NONFLAMMABLE GAS, GREEN LABEL, NOT ACCEPTABLE PASSENGER, 140 KG
 CARGO

FLAMMABILITY: WILL BURN AT HIGH CONCENTRATION. AT 1290 F OR IN PRESENCE OF ELECTRIC SPARK DECOMPOSES INTO N AND H₂ FORMS FLAMMABLE MIXTURES WITH AIR. PRESENCE OF COMBUSTIBLES INCREASES HAZARD.

(28) LOWER FLAMMABILITY LIMIT (%): 16.
(29) UPPER FLAMMABILITY LIMIT (%): 25.
(30) TOXIC COMBUSTION PRODUCTS: EXTREME DANGER. ENTER WITH CARE
(31) EXTINGUISHING METHODS: FIRE FIGHTING PHASES: STOP FLOW OF GAS. USE WATER TO KEEP CONTAINERS COOL. DO NOT EXTINGUISH UNLESS NECESSARY TO EFFECT AN IMMEDIATE SHUTOFF OF FLOW. DRY CHEMICAL, CARBON DIOXIDE, AND WATER SPRAY CAN BE USED TO EXTINGUISH AMMONIA FIRES. WEAR FULL PROTECTIVE CLOTHING.

(33) AUTO IGNITION POINT (DEG C): 651.
(34) EXPLOSIVENESS: STABLE REACTIVE ONLY UNDER EXTREME CONDITIONS:
(35) LOWER EXPLOSIVE LIMIT (%): 16.
(36) UPPER EXPLOSIVE LIMIT (%): 25.
(37) MELTING POINT (DEG C): -77.7
(39) BOILING POINT (DEG C): -33.4
(41) SOLUBILITY (PPM): 25 DEG C: 1000000.
(43) SPECIFIC GRAVITY: 0.6
(44) VAPOR PRESSURE (MM HG): 4.238
(45) VAPOR PRESSURE TEXT: 4.238 ATMOSPHERES OR 3221 MM HG AT 0 DEGREES CELSIUS;

(46) VAPOR DENSITY (AIR=1): .597
(50) PERSISTENCY: BOD CURVE FOR AMMONIA BEGINS AFTER SEVERAL DAYS. AT THIS TIME BACTERIA WILL CONVERT IT TO NITRATES.

(51) POTENTIAL FOR ACCUMULATION: NEGATIVE;

(52) FOOD CHAIN CONCENTRATION POTENTIAL: NEGATIVE;

(57) FRESHWATER TOXICITY NUMBER (PPM): .3; 3.6; .6; .50; .7; .20; 1; 13.3; 7; .06; 2; .28; 2.9; .42; 3.1; .44; 3.4; .50; 5; .66; 6; 133.9; 420; 320; 420; 410; 350; 28; 0.41

(58) FRESH WATER TOXICITY TEXT: CONC. (PPM)/EXPOS. (HR)/SPECIE/EFFECT/TEST ENV/REF

.3-.4/ /TROUT FRY/TOXIC OR LETHAL/ /C-1
3.6/10/BROWN TROUT FRY/LC50/ /R-73;
.6/ 1.5/RAINBOW TROUT/TOXICOR LETHAL/ /C-1
.50/24/RAINBOW TROUT/LC50/ /R-73;
.7/6.5/RAINBOW TROUT/TOXIC OR LETHAL/ /C-1
.20/ /RAINBOW TROUT/THRESHOLD LC50/ /R-73;
1-2/ /FISH/TOXIC OR LETHAL/ /C-1
.22/3 MONTHS/RAINBOW TROUT/15% LETHAL/ /R-73;
1.2/3.2/SQUALIUS CEPHALUS/TOXICOR LETHAL/ /C-1
.06-.11/3 MONTHS/RAINBOW TROUT/5% LETHAL/ /R-73;
2-2.5/24 TO 96/GOLDFISH/TOXIC OR LETHAL/ /C-1
.28/24/ATLANTIC SALMON SMOLT/LC50/ /R-73;
2.9/13/CICHLAOCCELLARIS/TOXIC OR LETHAL/ /C-1
.42/ /ROACH/THRESHOLD LC50/ /R-73;
3.1/96/SINIFISH/TUMOR/NET 30000

133.9/96/SNAIL/TLM/HARD 20DEG./C-1
 94.5/96/SNAIL/TLM/SOFT 30 DEG./C-1
 133.9/96/SNAIL/TLM/HARD30 DEG./C-1
 420/120/DIATOM/50% RED GROWTH/SOFT 22 DEG./C-1
 420/120/DIATOM/50% RED GROWTH/HARD 22 DEG./C-1
 320/120/DIATOM/50% RED GROWTH/SOFT 28 DEG./C-1
 420/120/DIATOM/50% RED GROWTH/HARD 28 DEG./C-1
 410/120/DIATOM/50% RED GROWTH/SOFT 30 DEG./C-1
 350/120/DIATOM/50% REDGROWTH/HARD 30 DEG./C-1
 8/ /DAPHNIA/LETHAL/ /C-1

0.41/48/RAINBOWTROUT/TLM/CONT. FLOW/E-30

(63) ANIMAL TOXICITY VALUE: 2000; 7338; 10066; 4837

(64) ANIMAL TOXICITY TEXT: 408 PPM 8 HR MAC, 3000 PPM 1 HR MAC, 408 PPM LEAST CONCENTRATION CAUSING IMMEDIATE EYE IRRITATION, 1720 PPM LEAST LEVEL CAUSING COUGH RESPONSE, 5000; 10000 RAPIDLY FATAL FOR SHEEP SHORT EXPOSURE, 2.3% BURNS ON WET SKIN.

VALUE/TIME/SPECIES/PARAM./ROUTE/REF. NUMBER

2000 PPM/ /RAT/LCLO/INH/R-1;

7338 PPM/1 HR/RAT/LC50/INH/R-46;

10066 PPM/1 HR/CAT, RBT/LC50/INH/APD;

4837 PPM/1 HR/MUS/LC50/INH/R-46;

(67) LIVESTOCK TOXICITY (PPM): 0000170;

(68) REF FOR LIVESTOCK: 6N C-11

(69) WATERFOWL TOXICITY (PPM): 0000120;

(70) REF FOR WATERFOWL: INHIBITS GERMINATION, E-101

(79) MAJOR SPECIES THREATENED: 1. ADULT TO LIFE PLANTS MAY BE INJURED

IF EXPOSED FOR 24 HRS TO MORE THAN 3 PPM IN AIR. (R-170)

(82) INHALATION LIMIT (VALUE) 10/250

(83) INHALATION LIMIT TEXT: 18 M5/M3

(86) DIRECT CONTACT: STRONG IRRITANT TO EYES, SKIN, RESP. TRACHEA

PURSENT ODOR. LIQUID PRODUCE SEVERE EYE IRRITATION (E-101)

CONCENTRATIONS CAUSES VIOLENT COUGHING. SEVERE EYE IRRITATION

PULMONARY EDEMA AND DEATH CAN RESULT IF RAPID EXPOSURE IS NOT POSSIBLE.

SHALLOWING LIQUID IS CORROSIVE TO MOUTH, THROAT, STOMACH. NOT A

SYSTEMIC POISON.

(87) GENERAL SENSATION: EXPOSURE TO HIGH CONCN. CAN CAUSE TEMP.

BLINDNESS AND EYE DAMAGE. 46.8 PPM RECOGNITION ODOR IN AIR. GOOD

WARNING PROPERTIES: DIRECT CONTACT WITH LIQUID CAUSES SEVERE EYE

BURNS AND SKIN BURNS. DOSE EFFECT RELATIONSHIP 100 PPM 8 HR MAC, 3000

PPM 1 HR MAC, 408 PPM LEAST; CONCENTRATION CAUSING THROAT IRRITATION

1720 PPM LEAST CONCENTRATION CAUSING IMMEDIATE EYE IRRITATION, 1720 PPM

LEAST LEVEL CAUSING COUGH RESPONSE, 5000; 10000 RAPIDLY FATAL FOR SHEEP

SHORT EXPOSURE, 2.3% BURNS ON WET SKIN.

(88) LOWER ODOR THRESHOLD (PPM): 00000.32

(89) LOWER ODOR THRESHOLD REFERENCE: E-64

(90) MEDIUM ODOR THRESHOLD (PPM): 000000.5

(91) MEDIUM ODOR THRESHOLD REFERENCE: E-64

(92) UPPER ODOR THRESHOLD (PPM): 000002.6

- (93) UPPER ODOR THRESHOLD REFERENCE: E-64
 (94) LOWER TASTE THRESHOLD (PPM): .037
 (95) LOWER TASTE THRESHOLD REFERENCE: Q-10;
 (96) MEDIUM TASTE THRESHOLD (PPM): 0000034.
 (97) MEDIUM TASTE THRESHOLD REFERENCE: C-1 (IN COFFEE)
 (102) REC DRINKING WATER LIMITS (PPM): 00000.05
 (103) REF FOR REC DRINKING WATER LIMITS: E-92
 (104) BODY CONTACT EXPOSURE (PPM): 0000001.
 (105) REF FOR BODY CONTACT EXPOSURE: E-92
 (106) PROLONGED HUMAN CONTACT (PPM): 0002500.
 (107) REF FOR PROLONGED HUMAN CONTACT: C-11
 (108) PERSONAL SAFETY PRECAUTIONS: MAC 100 PPM. EYE PROTECTION, RESPIRATORY APPARATUS, AND COTTON CLOTHING. BE SURE EQUIPMENT IS NOT ALUMINUM, COPPER, LEAD OR TIN. PROTECTIVE CLOTHING OVER A COTTON LAYER IS RECOMMENDED.
 (109) ACUTE HAZARD LEVEL: HIGH. TOXICITY IS DIRECTLY RELATED TO THE LEVEL OF UNIONIZED AMMONIA; CONCENTRATIONS OF 1 PPM DECREASES THE ABILITY OF THE HEMOGLOBIN TO COMBINE WITH OXYGEN IN FISH CONCENTRATIONS OF 2.5 PPM IN PH RANGE 7.4 TO 8.5 ARE CONSIDERED HARMFUL. SOLUTIONS CONTAINING MIXTURES OF AMMONIA AND CYANIDE IRONS INCREASE THE TOXICITY TO FISH. ALGAE IS HARMED OR INHIBITED WHEN CONTACTED WITH AMMONIA. THRESHOLD CONCENTRATIONS FOR FISH: 5 PPM FREE NH3 (E-188).
 (110) CHRONIC HAZARD LEVEL: SOME CHRONIC IRRITATION PROBLEMS CAN OCCUR. RABBITS FED 50-80 MGS OF .5% NH3 (80-130 MG/L) FOR 17 MONTHS SUFFERED CHRONIC ACIDOSIS AND TISSUE CHANGES. (Q-19);
 (111) DEGREE OF HAZARD TO PUBLIC HEALTH: IN EXCESS OF .1 PPM IN WATER RENDERS THE WATER SUSPECT OF RECENT POLLUTION. UNTINNED COPPER SHOULD BE USED IN TUBING FOR DRINKING WATER IF THE AMMONIA CONTENTS EXCEEDS 5 PPM. HIGH LOCAL INHALATION, INGESTION, AND IRRITATION HAZARDS.
 (112) AIR POLLUTION: HIGH
 (113) ACTION LEVELS: NOTIFY AIR AND FIRE AUTHORITY. BE SURE EQUIPMENT IS NOT SUSCEPTABLE TO AMMONIA CORROSION. ENTER FROM UPWIND SIDE. REMOVE IGNITION SOURCES.
 (114) IN SITU AMELIORATION: POSSIBLE TO SPONSOR VOLATIZATION WITH AIR SPONGING. CLINOPTILOLITE AND OTHER NATURAL ZEOLITES ARE AMMONIUM SELECTIVE.
 (116) AVAILABILITY OF COUNTERMEASURE MATERIALS: AIR SPONGING EQUIPMENT MAY BE PRODUCED FROM PIPING, IRRIGATION LINE AND CONSTRUCTION COMPRESSORS. ZEOLITES MAY BE FOUND AT LOCAL DEPOSITS OR ORDERED FROM THE SUPPLIER.
 (117) DISPOSAL METHODS: PUMP INTO LARGE TANK OF WATER, NEUTRALIZE AND ROUTE TO SEWAGE PLANT.
 (118) DISPOSAL NOTIFICATION: LOCAL SEWAGE AUTHORITY.
 (119) INDUSTRIAL FOULING POTENTIAL: IND USE REC. LEVEL 1 PPM AS NITROGEN VOLATILE AND CORROSIVE NATURE WILL CAUSE PROBLEMS IN BOILER WATER AND

(120) EFFECTS ON WATER TREATMENT PROCESS: CHLORINATION WILL PRODUCE CHLORAMINES WHICH ARE MORE READILY DETECTED BY TASTE AND ODOR.
 (121) MAJOR WATER USES THREATENED: ALL USES
 (122) PROBABLE LOCATION AND STATE OF MATERIAL: WILL DISSOLVE IN NH_3 OR NH_4^+ FORM. IS SHIPPED IN SOLUTION OR AS GAS.
 (124) WATER CHEMISTRY: AMMONIA IS SOLUBLE TO 100,000 PPM AND QUICKLY FORMS AMMONIA HYDROXIDE RAISING THE SOLUTION PH AND GENERATING HEAT. THE HYDROXIDE DISSOCIATES PARTIALLY AT PH 6 WITH THE $\text{NH}_4^+/\text{NH}_3$ RATIO AT 1800. AFTER PH 8 THIS RATIO IS 18. IN NEUTRAL SOLUTIONS OR UNDER PHYSICAL CONDITIONS, NH_3 GAS WILL VOLATILIZE AND ESCAPE. AMMONIA UNDERGOES SLOW BIODEGRADATION.
 (125) COLOR IN WATER: COLORLESS
 (126) ADEQUACY OF DATA: GOOD

LOCATION OF HAZARDOUS WASTE DISPOSAL SITES

*BFI - Chemical Services Division
 Mobile, Alabama
 (205) 661-1036

Services:

Collection/haulage,
 processing/treatment,
 storage, lab analysis,
 recovery, reclamation,
 disposal

Waste Handled:

Processing:

Most wastes considered
 Chemical fixing, neutra-
 lization, oxidation/
 reduction

Disposal:

Landfill

*Chancellor and Ogden, Inc.
 3031 East I Street
 Wilmington, California 90744
 (213) 432-8461

Collection/hauling,
 lab analysis, storage,
 disposal

Most wastes considered
 Secure landfill (CA,
 Class I)

Services:

Wastes Handled:

Disposal:

*County of Los Angeles Site
 1955 Workman Mill Road
 P.O. Box 4998
 Whittier, California 90607
 (213) 699-7411

*Palos Verdes Landfill

Services:

Wastes Handled:

Wastes Excluded:

Disposal:

Disposal, lab analysis
 Oil wastes, various wastes
 considered
 Highly flammable,
 mixed loads, magnesium, wastes
 with 4-11pH range
 Secure landfill
 (Class I)

LOCATION OF HAZARDOUS WASTE DISPOSAL SITES (cont'd)

*BFI - Chemical Services Division
Mobile, Alabama
(205) 661-1036

Services:

Collection/haulage,
processing/treatment,
storage, lab analysis,
recovery, reclamation,
disposal

Waste Handled:
Processing:

Most wastes considered
Chemical fixing, neutralization, oxidation/
reduction

Disposal:

Landfill

*Chancellor and Ogden, Inc.
3031 East I Street
Wilmington, California 90744
(213) 432-8461

Services:

Collection/hauling,
lab analysis, storage,
disposal
Most wastes considered
Secure landfill (CA,
Class I)

Wastes Handled:
Disposal:

*County of Los Angeles Site
1955 Workman Mill Road
P.O. Box 4998
Whitter, California 90607
(213) 699-7411

*Palos Verdes Landfill

Services:

Wastes Handled:

Wastes Excluded:

Disposal:

Disposal, lab analysis
Oil wastes, various wastes
considered
Highly flammable,
mixed loads, magnesium, wastes
with 4-11pH range
Secure landfill
(Class I)

LOCATION OF HAZARDOUS WASTE DISPOSAL SITES (cont'd)

*Calabasa Landfill

Wastes Handled:
Wastes Excluded:

Disposal:

Caustics, drummed wastes
Magnesium, conc.
acids, alkali
Secure landfill (Class
I)

*Cmar Rendering Company
P.O. Box 1236
Chula Vista, California
(714) 422-5311

Services:

Wastes Handled

Processing:

Disposal:

Collection, hauling,
processing/treatment, disposal,
storage
Acids, caustics, solvents,
etchants-liquids only
Evaporation
Open pit, lagoons

*Richmond Sanitary Service
1224 Nevin Avenue
Richmond, California
(415) 234-3314

Services:

Wastes Handled:

Wastes Excluded:

Disposal:

Collection/hauling, disposal
Acids, refinery wastes, lead
sludge, pesticide containers
Pending analysis
Lagoons, landfill

*San Diego County Site
5555 Overland Road
San Diego, California
(714) 565-5703

Services:

Wastes Handled:

Wastes Excluded:

Disposal:

Disposal, storage
Pesticides, chemical
Cyanides
Secure landfill

*Zero Waste System, Inc.
2928 Poplar St.
Oakland, California 94608
(415) 893-8257

Services:

Wastes Handled:

Disposal:

Wastes utilization and
waste exchange program, disposal
Most waste considered, lab
chemicals
Off-site landfills

LOCATION OF HAZARDOUS WASTE DISPOSAL SITES (cont'd)

*Rollins Environmental Services
(Main Offices) One Rollins Plaza
Wilmington, Delaware 19803
(302) 658-8541

Services:

Collection/haulage,
storage, processing/ treatment,
lab analysis, disposal

Wastes Handled:

All wastes considered

Processing/treatment:

Chemical Degradation
(neutralization, oxidation,
reduction), incineration,
biological

Disposal:

Landfill, incineration
(rotary kiln), ocean
disposal

*Lanham Waste Control
Rome, Georgia 30161
(404) 235-8503

Services:

Collection/haulage,
processing, storage, disposal

Wastes Handled:

Most wastes considered

Processing:

Chemical solidifications,
latex treatment.

*Wes Con, Inc.
245 Third Avenue, East
Twin Falls, Idaho 83301
(208) 733-0897

Services:

Disposal

Wastes Handled:

Pesticides, most wastes
considered

Disposal:

Secure burial

*Hyon Waste Management Services, Inc.
11700 Stony Island Avenue
Chicago, Illinois 60617
(312) 646-0016

Services:

Processing/treatment, storage,
lab analysis, disposal, reclamation
/recycling

Wastes Handled:

Most materials considered

Processing:

Chemical neutralization,
electrochemical oxidation,
biological activated sludge

Disposal:

Incinerator (rotary kiln)

LOCATION OF HAZARDOUS WASTE DISPOSAL SITES (cont'd)

*Nuclear Engineering Co., Inc.
Box 7246 Louisville, KY 40207
(Site) Sheffield, Illinois
(815) 454-2626

Wastes Handled:

Radioactive, pesticides, heavy
metals, organics

Wastes Excluded:

Reactive sodium and potassium

Disposal:

Secure landfill

*Waste Management, Inc.
900 Jorie Boulevard
Oak Brook, Illinois 60521

Also: Chem Waste Management,
Inc.
(312) 891-1500

Services:

Collection/hauling, storage,
processing/treatment, lab
analysis, disposal reclamation
/recovery

Wastes Handled:

Acids, caustics, solvents,
heavy metals

Wastes Excluded:

Cyanides, pesticides, herbicides

Processing:

Chemical neutralization,
precipitation

Disposal:

Landfill, sludge farming

*U.S. Scrap Company
11507 South Michigan Avenue
Chicago, Illinois

Services:

Collection/haulage,
reclamation/recycling, disposal
Solvents, oily wastes, sludges
Cyanide, arsenic
Landfill

Wastes Handled:

Wastes Excluded:

Disposal:

*BFI - Chemical Services Div. Inc.
Lemont, Illinois 60439
(312) 257-7707

Services:

Collection/hauling,
storage, processing/treatment,
lab analysis, reclamation/
recovery, disposal
Most wastes considered
Chemical fixing, neutralization,
oxidation/reduction
Landfill

Wastes Handled:

Processing:

Disposal:

LOCATION OF HAZARDOUS WASTE DISPOSAL SITES (cont'd)

*Rollins Environmental Services
(Main Office) Wilmington, Delaware 19803
Baton Rouge, Louisiana
(504) 778-1234

Services:	Collection/hauling, processing/treatment, storage, lab analysis, disposal, reclamation/ recycling
Wastes Handled:	All materials considered
Processing:	Chemical degradation, neutralization, precipitation
Disposal:	Incineration, landfill

*BFI - Chemical Services Div.
Baton Rouge, La.
(504) 293-4571

Also: Lake Charles
(318) 434-8329

Services:	Collection/hauling, processing/treatment, reclamation, disposal
Wastes Handled:	Most wastes considered
Processing:	Neutralization, chemical solidification
Disposal:	Landfill

*Robb Tyler, Inc.
Baltimore, Maryland
(301) 686-6161

(Subsidiary of BFI)

Services:	Collection/haulage, processing/ treatment, storage, lab analysis, reclamation, disposal
Waste Handled:	Most wastes considered
Processing:	Chemical fixing, neutralization, oxidation - reduction
Disposal:	Landfill

*Montvale Laboratories, Inc.
270 Talbot Avenue
Dorchester, Massachusetts 02124
(617) 288-0600

Services:	Collection/hauling, processing, reclamation/recycling, disposal
Wastes Handled:	Most wastes considered
Wastes Excluded:	Arsenic, pesticides,
Disposal:	Landfill

LOCATION OF HAZARDOUS WASTE DISPOSAL SITES (cont'd)

*Chem Met Services
18550 Allen Road
Wyandotte, Michigan
(313) 282-9250

Services:	Collection/hauling, processing/ treatment, disposal, storage
Wastes Handled:	Most wastes considered
Wastes Excluded:	Arsenic
Processing:	Chemical neutralization, chemical fixation
Disposal:	Landfill

*Precco Manufacturing Co.
Stephenson Highway
Madison Heights, Michigan 48701
(313) 399-6262

Services:	Lab analysis, processing/treatment, disposal
Wastes Handled:	Most wastes considered, some explosives
Disposal:	Incineration of liquids and solids

*Systech Waste Treatment Center
3030 Wood Street
Mushegon Heights, Michigan 49444
(616) 733-1444
Business Office: 513-298-6614

Services:	Collection/haulage, treatment processing, storage, disposal
Wastes Handled:	Most wastes considered
Processing:	Chemical and biological

*Conservation Chemical Company
215 West Pershing Road
Suite 703
Kansas City, Missouri 64108
(Plants):
St. Louis, Missouri
Gary, Indiana

Services:	Collection/haulage, processing/treatment, lab analysis, disposal, storage, recycling/ recovery
Wastes Handled:	Acids, caustics, arsenicals, cyanide, phenols, heavy metal solutions
Wastes Excluded:	Pending on analysis
Processing:	Distillation, neutralization recombination, Fe, flouride recovery, sedimentation

LOCATION OF HAZARDOUS WASTE DISPOSAL SITES (cont'd)

*Wheeling Disposal Service Co., Inc.
1805 South 8th Street
St. Joseph, Missouri 64503
(816) 279-0815
Site: Andrew County, Missouri

Services:
Wastes Handled:

Disposal:

Disposal, storage
Most waste considered,
including pesticides
Soil incorporation, landfill

*Big 3 Enterprises
10,000 E. Girmingham Rd.
Kansas City, Missouri 64161
(816) 452-0479

Services:
Wastes Handled:

Disposal:

Collection/haulage, disposal
Organic chemicals, liquid and
some solids
Incineration

*Astro Pak
1056 Route 1
P.O. Box 416
Edison, New Jersey 08817
(201) 549-1788

Services:

Wastes Handled:
Processing:
Disposal:

Collection/hauling, processing/
treatment, disposal, lab analysis,
storage
Petro-based, chemical
Chemical neutralization
Landfill

*Scientific Chemical Processing, Inc.
216 Paterson Plank Road
Carlstadt, New Jersey 07072
(201) 939-0467

Services:

Wastes Handled:
Processing:
Disposal:

Collection/haulage, lab analysis,
reclamation/recycling, processing/
treatment, disposal
Most wastes considered
Distillation, blending, neutralization
Landfills, incineration

*Browning - Ferris Industries, Inc.
Pedricktown, New Jersey
(609) 299-0835

Services:

Wastes Handled:
Processing:
Disposal:

Collection/hauling, processing/
treatment, reclamation, lab
analysis, disposal
Most wastes considered
Chemical fixation, neutralization
Landfill

LOCATION OF HAZARDOUS WASTE DISPOSAL SITES (cont'd)

*Rollins Environmental Services
Bridgeport, New Jersey (Logan Township) (609) 467-3100
(Main Office) Wilmington, Delaware 19803
(Main Office) (302) 658-8541

Services:	Collection/hauling, processing/ treatment, reclamation/recycling lab analysis, storage, disposal
Wastes Handled:	All wastes considered
Processing:	Chemical degradation, floccu- lation, trickling filter, neutralization, precipitation
Disposal:	Landfill, incineration (rotary kiln)

*Chemical Control Corp.
25 South Front Street
Elizabeth, New Jersey 07201
(201) 351-5460

Services:	Haulage/collection, lab analysis, storage, reclamation/recycling, treatment/processing, disposal
Waste Handled:	All materials considered
Processing:	Neutralization, chemical treatment
Disposal:	Incineration, landfill

*Solvent Recovery Service of New Jersey
1200 Sylvan Street
Linden, N.J., 07036
(201) 925-8600

Services:	Collection/haulage, processing/ treatment, storage, lab analysis disposal, recovery
Wastes Handled:	Liquid organic wastes; other waste considered
Processing:	Distillation, neutralization
Disposal:	Incineration, landfill

*Frontier Chemical Wastes Process, Inc.
4626 Royal Avenue
Niagara Falls, New York 14303
(716) 285-8208

Services:	Collection/hauling, processing/treatment, consulting, recycling/ reclamation, storage, brokerage, lab analysis, disposal
Wastes Handled:	All materials considered
Processing:	Chemical degradation, catalysis, pyrolysis
Disposal:	Landfill

LOCATION OF HAZARDOUS WASTE DISPOSAL SITES (cont'd)

*Chem-trol Pollution Services, Inc.
P.O. Box 200, 1550 Balner Road
Model City, New York 14107
(716) 754-8231

Services:	Collection/hauling, recycling/reclamation, processing/treatment, lab analysis, storage, disposal consulting
Wastes Handled:	Most wastes considered
Processing:	Chemical degradation (patented neutralization process), chemical fixation, distillation, centrifuging, (resource recovery)
Disposal:	Secure landfill, incineration

*Radiac Research Corporation
261 Kent Avenue
Brooklyn, New York 11211
(212) 963-2233

Services:	Collection/hauling, treatment, transfer to ultimate disposal operations
Wastes Handled:	Most wastes considered

*Pollution Abatement Services
West Seneca Street
P.O. Box 4065
Oswego, New York 13126
(315) 343-3356

Services:	Storage, lab analysis, disposal
Wastes Handled:	Most materials considered
Wastes Excluded:	Inorganic and organic solids
Disposal:	Liquid waste incinerator

*Recycling Laboratories
112 Hanison Place
Syracuse, New York 13202
(315) 422-4311

Services:	Collection/hauling, processing/ treatment, disposal, lab analysis recycling/reclamation
Materials Handled:	All materials considered
Processing:	Distillation
Disposal:	Incineration

LOCATION OF HAZARDOUS WASTE DISPOSAL SITES (cont'd)

*Systems Technology Corporation
Systech Waste Treatment Center
Baxter Road at Route 73
Franklin, Ohio 45002
(513) 746-8100

Also: Hilliard, Ohio
(614) 876-1186

Services:

Storage, process/treatment,
disposal, lab analysis

Wastes Handled:

Acids, caustics, plating wastes,
organic wastes (combustibles)

Wastes Excluded:

Pending lab analysis

Processing:

Chemical neutralization,
reduction, flocculation, precipitation

Disposal:

Incineration (fluid bed),
landfill

*Browning-Ferris of Ohio
1901 South Pine Street
Warren, Ohio 44881
(216) 399-8361

Services:

Collection/haulage, lab
analysis, treatment/ processing,
storage, disposal, recovery

Wastes Handled:

Most wastes considered

Processing:

Neutralization,
chemical fixing

Disposal:

Incineration, landfill

*Ecological Services, Inc.
East Palestine, Ohio
(216) 426-4171

Services:

Collection/hauling, processing/
treatment, lab analysis, disposal

Wastes Handled:

Most waste considered

Processing:

Chemical fixing, neutralization

Disposal:

Landfill

*Chem-Dyne Corporation
230 Northland Boulevard
Cincinnati, Ohio 45246
(513) 771-6885

Services:

Collection/haulage, processing,
storage, laboratory analysis,
reclamation/recycling, disposal

Wastes Handled:

Most wastes considered

Processing:

Chemical treatment, oxidation/
reduction

Disposal:

Incineration

LOCATION OF HAZARDOUS WASTE DISPOSAL SITES (cont'd)

*Robert Ross and Sons, Inc.
394 Giles Road
Grafton, Ohio

Services:	Disposal
Wastes Handled:	Most burnable wastes considered
Disposal:	Incineration

*Pottstown Disposal Service
Route 20 Sell Road
Pottstown, Pennsylvania 19464

Services:	Disposal, lab analysis
Wastes Handled:	All material considered
Disposal:	Sanitary landfill

*Wasteplex, Inc.
P.O. Box 396
Jonesboro, Tennessee 37659
(615) 753-2101

Services:	Processing/treatment, storage, disposal
Wastes Handled:	All materials considered
Processing:	Chemical degradation, precipitation
Disposal:	Incineration, landfill

*Bioecology Systems, Inc.
4100 East Jefferson
Grand Prairie, Texas 75050
(214) 264-4281

Services:	Collection/hauling, Processing/ treatment, lab analysis, disposal, reclamation/recycling
Wastes Handled:	Most wastes considered
Wastes Excluded:	Halogenated hydrocarbons
Processing:	Biological activated sludge, chemical neutralization, reductive oxidation
Disposal:	Secure landfill, incineration

*Browning-Ferris, Inc.
(Main Office)
300 Fannin Bank Building
Houston, Texas 77025
(713) 666-0758

Subsidiaries: Port Arthur, TX

Services:	Collection/hauling, processing/ treatment, reclamation/recovery lab analysis, storage, disposal
Wastes Handled:	Most materials considered
Processing:	Chemical degradation, bio- chemical
Disposal:	Landfill, incineration, encapsulation

LOCATION OF HAZARDOUS WASTE DISPOSAL SITES (cont'd)

*Rollins Environmental Services
Houston, Texas
(713) 479-6001

Services:

Collection/hauling, storage,
lab analysis, processing/
treatment, disposal

Wastes Handled:

Most wastes considered

Processing:

Neutralization, oxidation/
reduction

Disposal:

Incineration, landfill

*Texas Ecologists, Inc.
Robstown, Texas
(512) 387-3518

Subsidiary of: Nuclear
Engineering Co

Services:

Collection/hauling, processing,
treatment, disposal

Wastes Handled:

Most wastes considered

Wastes Excluded:

Cyanide

Processing:

Chemical neutralization,
evaporation

Disposal:

Secure landfill, incineration

*M/V Vulcanus
Ocean Combustion Service B.V.
P.O. Box 608
Rotterdam, Netherlands

U.S. Agent
Universal Shipping Co., Inc.
1911 N. Ft. Myer Drive, Suite 702
Arlington, Va. 22209
(202) 298-6100

Disposal:

Ocean-going incineration vessel

*Chemical Processors, Inc.
5501 Airport Way South
Seattle, Washington 98108
(206) 767-0350

Services:

Collection/hauling, processing/treatm
storage, reclamation, lab analysis

Wastes Handled:

All wastes considered; solvents, oil

Processing:

Distillation, evaporation

LOCATION OF HAZARDOUS WASTE DISPOSAL SITES (cont'd)

•Western Processing Company
7215 South 196th
Kent, Washington 98031
(206) 852-4350

Services:

Processing/treatment, lab analysis,
recycling/reclamation

Wastes Handled:

Most wastes considered

Wastes excluded:

Beryllium

Processing:

Chemical detoxification for reclamation

STATE SOLID WASTE MANAGEMENT AGENCIES

Alabama

Director
Division of Solid Waste
and Vector Control
State Department of Public Health
State Office Building
Montgomery, Alabama 36104
(205) 832-6728

Alaska

Solid Waste Program Coordinator
Dept. of Environmental Conservation
State of Alaska
Pouch O
Juneau, Alaska 99801
(907) 586-6721

American Samoa

Department of Public Works
Government of American Samoa
Pago Pago, American Samoa
Overseas Operator (Commercial Call)

Arizona

Division of Sanitation
Environmental Health Services
Arizona State Dept. of Health
1740 W. Adams Street
Phoenix, Arizona 85017
(602) 271-4641

Arkansas

Chief
Division of Solid Waste
Arkansas Dept. of Pollution Control
and Ecology
P. O. Box 9583
8001 National Drive
Little Rock, Arkansas 72209
(501) 371-1701

California

Chief, Hazardous Waste Mgmt. Program
Vector Control Bureau
State Department of Public Health
744 P Street
Sacramento, California 95814
(916) 322-2337

Colorado

State Department of Health
4210 East Eleventh Avenue
Denver, Colorado 80220
(303) 388-6111 Ext. 323

Connecticut

Solid Waste Management Programs
Department of Environmental Protection
State of Connecticut
State Office Building, Room 248
Hartford, Connecticut 06115
(203) 566-3672

Delaware

Chief, Solid Waste Section
Delaware Dept. of Natural Resources
& Environmental Control
Edward Tatnall Building
Dover, Delaware 19901
(302) 678-4781

District of Columbia

Director, Solid Waste Administration
Department of Environmental Sciences
415 12th Street, N.W., Room 307
Washington, D. C. 20004
(202) 629-4581

Florida

Executive Director
Department of Pollution Control
2562 Executive Center Circle, East
Montgomery Building
Tallahassee, Florida 32301
(904) 488-1345

Georgia

Director, Solid Waste Section
Environmental Protection Division
Department of Natural Resources
270 Washington Street, S.W.
Atlanta, Georgia 30334
(404) 656-2833

Guam

Administrator, Guam, EPA
P. O. Box 2999
Agana, Guam 96910
Overseas Operator (Commercial Call)
749-2486

Hawaii

Director, State Department of Health
P. O. Box 3378
Honolulu, Hawaii 96801
(808) 548-2811 Ext. 521

Idaho

Chief, Solid Waste Mgmt. Section
Environmental Services Division
Idaho Dept. of Env. & Comm. Services
State House
Boise, Idaho 83720
(208) 384-2390

Illinois

Division of Land Pollution Control
Illinois Env. Protection Agency
2200 Churchill Drive
Springfield, Illinois 62706
(217) 782-6760

Indiana

Chief, Solid Waste Section
Division of Sanitary Engineering
Indiana State Board of Health
1330 West Michigan Street
Indianapolis, Indiana 46207
(317) 633-4393

Iowa

Director, Land Quality Division
Department of Environmental Quality
3920 Delaware Avenue
P. O. Box 3326
Des Moines, Iowa 50319
(515) 265-8134

Kansas

Chief, Solid Waste Section
Kansas Department of Health and
Environment
Topeka, Kansas 66620
(913) 296-3821

Kentucky

Director, Division of Solid Waste
State Dept. for Natural Resources
and Environmental Protection
275 East Main Street
Frankfort, Kentucky 40601
(502) 564-6716

Louisiana

Louisiana Health and Social
Rehabilitation Services Admin.
State Office Building
P. O. Box 60630
New Orleans, Louisiana 70160
(504) 527-5123

Maine

Chief, Div. of Solid Waste Mgmt.
Dept. of Environmental Protection
State House
Augusta, Maine 04330
(207) 289-2963

Maryland

Acting Chief
Division of Solid Waste
Maryland State Dept. of Health
and Mental Hygiene
201 West Preston Street
Baltimore, Maryland 21201
(301) 383-2770/1/2

Massachusetts

Director, Bureau of Solid Waste
Disposal
Massachusetts Dept. of Public Works
100 Nashua Street
Boston, Massachusetts 02114
(617) 727-4293

Michigan

Chief, Solid Waste Mgmt. Division
Environmental Protection Branch
Department of Natural Resources
3500 Logan Street
Lansing, Michigan 48914
(517) 373-6620

Minnesota

Director
Minnesota Pollution Control Agency
Division of Solid Waste
1935 West County Road, B-2
Roseville, Minnesota 55113
(612) 296-7315

Mississippi

Director
Division of Solid Waste Management
and Vector Control
Mississippi State Board of Health
P. O. Box 1700
Jackson, Mississippi 39215
(601) 354-6616

Missouri

Director, Solid Waste Mgmt. Bureau
Department of Natural Resources
2511 Industrial Drive
P. O. Box 570
Jefferson City, Missouri 65101
(314) 751-2815

NOTE: Address all mail to:
P. O. Box 1368
State Office Building
Jefferson City, Missouri 65101

Montana

Chief, Solid Waste Management Bureau
Montana State Department of Health
and Environmental Sciences
1424 9th Avenue
Helena, Montana 59601
(406) 449-2821

Nebraska

Chief, Division of Solid Waste
Department of Environmental Control
State House Station, Box 94653
Lincoln, Nebraska 68509
(402) 471-2186

Nevada

State Department of Health & Welfare
1209 Johnson Street
Carson City, Nevada 89701
(702) 885-4670

New Hampshire

Solid Waste Management
Food & Chemistry Services
Division of Public Health Services
Department of Health & Welfare
Hazen Drive
Concord, New Hampshire 03301
(603) 271-2747

New Jersey

Acting Chief
Bureau of Solid Waste Management
Division of Environmental Protection
P. O. Box 1390
Trenton, New Jersey 08625
(609) 292-7645

New Mexico

Chief, Environmental Improvement
Agency
General Sanitation Div., Room 517
P. O. Box 2348, P.E.R.A. Building
Santa Fe, New Mexico 87501
(505) 827-2693

New York

Director, Div. of Solid Waste Mgmt.
New York State Department of
Environmental Conservation
50 Wolf Road
Albany, New York 12201
(518) 457-6603

North Carolina

Branch Head
Solid Waste and Vector Control Branch
Department of Human Resources
Division of Health Services
P. O. Box 2091
Raleigh, North Carolina 27602
(919) 829-2178

North Dakota

Assistant Director
Division of Water Supply & Pollution
Control - State Capital
State Department of Health
Bismark, North Dakota 58501
(701) 224-2386

Ohio

Division of Waste Management and
Engineering
Ohio Environmental Protection Agency
P. O. Box 1049
Columbus, Ohio 43216
(614) 466-7220

Oklahoma

Chief, Sanitation Service
State Department of Health
10th and Stonewall
Oklahoma City, Oklahoma 73105
(405) 271-5216

Oregon

Director, Solid Waste Mgmt. Div.
Oregon State Department of
Environmental Quality
1234 S.W. Morrison Street
Portland, Oregon 97201
(503) 229-5696

Pennsylvania

Director
Division of Solid Waste Management
Dept. of Environmental Resources
8th Floor Fulton Building
P. O. Box 2063
Harrisburg, Pennsylvania 17120
(717) 787-7381

Puerto Rico

Environmental Quality Board
Office of the Governor
Box 11488
Santurce, Puerto Rico 00910
(809) 725-5140 Ext. 226

Rhode Island

Chief, Div. of Solid Waste Mgmt.
State Health Department
204 Health Building
Davis Street
Providence, Rhode Island 02908
(401) 277-2808

South Carolina

Director, Solid Waste Mgmt. Div.
Dept. of Health & Environmental
Control
J. Marion Sims Building
2600 Bull Street
Columbia, South Carolina 29201
(803) 758-5681

South Dakota

Division of Solid Waste and Land
Management
South Dakota Dept. of Environmental
Protection
Office Building No. 2
Pierre, South Dakota 57501
(605) 224-3351

Tennessee

Director
Division of Sanitation & Solid
Waste Management
Bureau of Environmental Health
Services
State Dept. of Public Health
Capitol Hill Bldg., Suite 320
Nashville, Tennessee 37219
(615) 741-3424

Texas

Industrial Waste & Agricultural
Disposal
Division of General Operations
Texas Water Quality Board
P. O. Box 13246
Austin, Texas 78711
(512) 475-2651

Trust Territories

Chief, Dept. of Health Services
Office of High Commission
Trust Territory of the Pacific Islands
Saipan, Marianas 96950
Overseas Operator (Commercial Call)

Utah

Chief, General Sanitation Section
Utah State Division of Health
44 Medical Drive
Salt Lake City, Utah 84113
(801) 328-6163

Vermont

Air and Solid Waste Programs
Protection Division
Agency of Environmental Con-
servation
P. O. Box 489
Montpelier, Vermont 05602
(802) 828-3395

Wisconsin

Chief, Solid Waste Mgmt. Section
Division of Environmental Protection
Department of Natural Resources
Box 450
Madison, Wisconsin 53701
(608) 266-0158

Virgin Islands

Assistant Director
Division of Utilities & Sanitation
Department of Public Works
Government of the Virgin Islands
Charlotte Amalie
St. Thomas, Virgin Islands 00801
(809) 774-7970

Wyoming

SW Program Supervisor
Wyoming Dept. of Environmental
Quality
State Office Building West
Cheyenne, Wyoming 82002
(307) 777-7391

Virginia

Director
Bureau of Solid Waste & Vector Cont.
Virginia State Department of Health
Room 209, 401-A Colley Avenue
Norfolk, Virginia 23507
(804) 627-4511

Washington

Division Chief
Solid Waste & Resource Recovery
Division
Department of Ecology
Olympia, Washington 98501
(206) 753-6883

West Virginia

Director, Solid Waste Program
State Department of Health
1800 Washington Street, E.
Charleston, West Virginia 25305
(304) 348-2987

Environmental Protection Agency
Regional Offices

Information on the disposal of hazardous wastes can be obtained from the appropriate Regional Offices of the EPA or the Hazardous Waste Management Division (HWMD) of the Office of Solid Waste Management Programs, U.S. Environmental Protection Agency, Washington, D.C. 20460.

Information from the Regional Office of the EPA can be obtained either from the Regional Administrator, the Director of the Air and Waste Management Division or the Solid Waste Management Representative in each region. General information on the Federal Hazardous Waste Management Program can be obtained from the Director, Hazardous Waste Management Division (AW-465), Environmental Protection Agency, Washington, D.C. 20460. Telephone number: 202/755-9185.

<u>Regional Offices</u>	<u>Address</u>	<u>Telephone Contact</u>
<u>Region I</u> Maine, New Hampshire, Vermont, Conn., Mass., Rhode Island	Administrator John F. Kennedy Bldg. Boston, MA. 02203	Chief, Solid Waste Prgm. Air & Haz. Mtls. Division 617-223-5186
<u>Region II</u> New York, New Jersey, Delaware	Administrator 26 Federal Plaza New York, N.Y. 10007	Chief, Solid Waste Mgmt. Branch, Environmental Programs Division 212-264-2301
<u>Region III</u> Pa., Md., Va., W.Va., D.C.	Administrator 6th & Walnut Streets Philadelphia, PA. 19106	Solid Waste Mgmt. Representative Air & Hazardous Mtls. Div. 215-597-8131
<u>Region IV</u> Ala., Miss., Ga., N.C., S.C., Tenn., Ky., Fla.	Administrator 1421 Peachtree St., NE. Atlanta, Georgia 30309	Head, Solid Waste Mgmt Section, Air & Hazardous Mtls. Division 404-526-3454
<u>Region V</u> Minn., Wis., Ill., Ind., Ohio, Michigan	Administrator 230 South Dearborn St. Chicago, Illinois 60604	Chief, Solid Waste Branch Air & Hazardous Mtls. Div. 312-353-5248
<u>Region VI</u> Tex., Arkansas, N.M., La. Oklahoma	Administrator 1200 6th St., Suite 1100 Dallas, TX. 75201	Solid Waste Mgmt. Representative Air & Hazardous Mtls. Div. 214-749-1121
<u>Region VII</u> Kansas, Nebraska, Missouri, Iowa	Administrator 1735 Baltimore Avenue Kansas City, MO. 64108	Chief, Waste Mgmt. Section Air & Hazardous Mtls. Div. 816-374-3307
<u>Region VIII</u> Col., Utah, ND., SD., Montana, Wyoming	Administrator 1860 Lincoln Street Denver Colorado 80203	Chief, Waste Mgmt. Branch Air & Hazardous Mtls. Div. 303-837-2407

Regional OfficesAddressTelephone ContactRegion IX

California, Arizona,
Nevada, Hawaii

Administrator
100 California Street
San Francisco, CA. 94111

Chief, Solid Waste Mgmt.
Program, Air & Haz.
Mtls. Div.
415-556-0217

Region X

Oregon, Washington,
Idaho, Alaska

Administrator
1200 6th Avenue
Seattle, Washington 98108

Chief, Solid Waste Prgm.
Air & Hazardous Mtls.
Division, 206-442-1236

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APPENDIX C

Code of Federal Regulations, Title 49, Applicable to Containers for the Twelve Selected Chemicals and Propellants*

<u>Chemical/Propellant</u>	<u>C.F.R. Title 49 (Applicable Citations)</u>
Anhydrous Ammonia	173.304, 173.314, 173.315
Butadiene	173.304, 173.314, 173.315
Chlorine	173.304, 173.314, 173.315
Ethylene Oxide	173.124
Hydrazine	173.276
Liquid Hydrogen	173.316, 179.400
Liquid Oxygen	173.304
Monomethylhydrazine	173.145
Nitrogen Tetroxide	173.336
Propane	173.304, 173.314, 173.315
Unsymmetrical Dimethylhydrazine	173.145
Vinyl Chloride	173.304, 173.314, 173.315

* Container Specifications given in Section 3.2.5. (49 CFR §173, 178, 179)

AMA

AMMONIA, ANHYDROUS

Common Synonyms Liquid Ammonia		Liquidified compressed gas	Colorless	Ammoniac odor																																				
Flows and boils on water. Poisonous, visible vapor cloud is produced.																																								
Avoid contact with liquid and vapor. Keep people away. Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves). Stop discharge if possible. Stay upwind and use water spray to "knock down" vapor. Call fire department. Isolate and remove discharged material. Monitor local health and pollution control agencies.																																								
Fire		Combustible: Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves). Stop flow of gas or liquid if possible. Cool exposed container and protect men effecting shutoff with water. Let fire burn.																																						
Exposure		CALL FOR MEDICAL AID. VAPOR POISONOUS IF INHALED. Irritating to eyes, nose and throat. Move to fresh air. If in eyes, hold eyelids open and flush with plenty of water. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen. LIQUID Will burn skin and eyes. Harmful if swallowed. Will cause frostbite. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. DO NOT RUB AFFECTED AREAS. IF IN EYES, hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.																																						
Water Pollution		HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS. May be dangerous if it enters water intakes. Nuisy local health and wildlife officials. Nuisy operators of nearby water intakes.																																						
1. RESPONSE TO DISCHARGE (See Response Methods Handbook, CG 440-4) Issue warning - poison. Restrict access. Evacuate area. Disperse and flush.		2. LABELS   PRESENT NEW																																						
3. CHEMICAL DESIGNATIONS 3.1 Synonyms: Liquid ammonia 3.2 Coast Guard Compatibility Classification: Ammonia 3.3 Chemical Formula: NH ₃ 3.4 IMO/United Nations Hazardous Designation: 2.0 (100)		4. OBSERVABLE CHARACTERISTICS 4.1 Physical State (as shipped): Compressed liquefied gas 4.2 Color: Colorless 4.3 Odor: Pungent, extremely pungent																																						
5. HEALTH HAZARDS 5.1 Personal Protective Equipment: Gas-tight chemical goggles, self-contained breathing apparatus, rubber boots, rubber gloves, emergency shower and eye bath. 5.2 Symptoms Following Exposure: 700 ppm causes eye irritation, and permanent injury may result if prompt remedial measures are not taken. 5000 ppm can cause immediate death from asphyxiation, or edema of the larynx. Contact of the liquid with skin freezes the tissue and then produces a caustic burn. 5.3 Treatment for Exposure: INHALATION: move victim to fresh air and give artificial respiration if necessary. Oxygen may be useful. Observe for laryngeal spasm and perform tracheotomy if indicated. SKIN OR EYES: flush immediately with running water for 15 min. Treat subsequently as thermal burn. 5.4 Toxicity by Inhalation (Threshold Limit Value): 25 ppm 5.5 Short-Term Inhalation Limit: 100 ppm for 30 minutes. 5.6 Toxicity by Ingestion: Not pertinent. 5.7 Lethal Toxicity: Not pertinent. 5.8 Vapor (Gas) Irritant Characteristics: Vapors cause severe eye or throat irritation and may cause eye or lung injury. Vapors cannot be tolerated even at low concentrations. 5.9 Liquid or Solid Irritant Characteristics: Causes smearing of the skin and first-degree burns on short exposure. May cause secondary burns on long exposure. 5.10 Odor Threshold: 4.6 ppm																																								
6. FIRE HAZARDS 6.1 Flash Point: Not flammable under conditions likely to be encountered. 6.2 Flammable Limits in Air: 15.5% - 27.0% 6.3 Fire Extinguishing Agents: Stop flow of gas or liquid. Let fire burn. 6.4 Fire Extinguishing Agents Not to be Used: None. 6.5 Special Hazards of Combustion Products: Not pertinent. 6.6 Behavior in Fire: Not pertinent. 6.7 Ignition Temperature: 1304°F 6.8 Electrical Hazards: Class I, Group D 6.9 Burning Rate: 1 mm/min																																								
7. CHEMICAL REACTIVITY 7.1 Reactivity with Water: Dissolves with mild heat effect. 7.2 Reactivity with Common Materials: Lavoisier to copper and patinated surfaces. 7.3 Stability During Transport: Stable. 7.4 Neutralizing Agents for Acids and Caustics: Dilute with water. 7.5 Polymerizations: Not pertinent. 7.6 Inhibitor of Polymerization: Not pertinent.																																								
11. HAZARD ASSESSMENT CODE (See Hazard Assessment Handbook, CG 440-3) A-B-C-K-L-M-N-O																																								
12. HAZARD CLASSIFICATIONS 12.1 Code of Federal Regulations: Nonflammable compressed gas 12.2 NAS Hazard Rating for Bulk Water Transportation: <table><tr><th>Category</th><th>Rating</th></tr><tr><td>Fire</td><td>1</td></tr><tr><td>Health</td><td>1</td></tr><tr><td>Vapor Irritant</td><td>4</td></tr><tr><td>Liquid or Solid Irritant</td><td>2</td></tr><tr><td>Poison</td><td>2</td></tr><tr><td>Water Pollution</td><td>2</td></tr><tr><td>Human Toxicity</td><td>2</td></tr><tr><td>Aquatic Toxicity</td><td>2</td></tr><tr><td>Amphibic Effect</td><td>2</td></tr><tr><td>Reactivity</td><td>3</td></tr><tr><td>Other Chemicals</td><td>2</td></tr><tr><td>Water</td><td>2</td></tr><tr><td>Self-Reaction</td><td>0</td></tr></table> 12.3 NFPA Hazard Classifications: <table><tr><th>Category</th><th>Classification</th></tr><tr><td>Health Hazard (Blue)</td><td>2</td></tr><tr><td>Flammability (Red)</td><td>1</td></tr><tr><td>Reactivity (Yellow)</td><td>0</td></tr></table>					Category	Rating	Fire	1	Health	1	Vapor Irritant	4	Liquid or Solid Irritant	2	Poison	2	Water Pollution	2	Human Toxicity	2	Aquatic Toxicity	2	Amphibic Effect	2	Reactivity	3	Other Chemicals	2	Water	2	Self-Reaction	0	Category	Classification	Health Hazard (Blue)	2	Flammability (Red)	1	Reactivity (Yellow)	0
Category	Rating																																							
Fire	1																																							
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Liquid or Solid Irritant	2																																							
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Water Pollution	2																																							
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Amphibic Effect	2																																							
Reactivity	3																																							
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Water	2																																							
Self-Reaction	0																																							
Category	Classification																																							
Health Hazard (Blue)	2																																							
Flammability (Red)	1																																							
Reactivity (Yellow)	0																																							
8. WATER POLLUTION 8.1 Aquatic Toxicity: 0.3-0.4 ppm/24 hr (trout fry, eggs, or other fresh water) 0.7 ppm/6 hr (rainbow trout, stock or hatch/fresh water) *Time period not specified. 8.2 Waterbody Toxicity: 120 ppm 8.3 Biological Oxygen Demand (BOD): Not pertinent. 8.4 Food Chain Concentration Potential: None.																																								
9. SELECTED MANUFACTURERS 1. American Oil Co. 910 North Michigan Ave. Chicago, Illinois 60605 2. CF Industries Inc. 100 S. Wacker Drive Chicago, Illinois 60606 3. The Williams Companies Agrico Chemical Co., Inc. 5050 Poplar Ave. Memphis, Tenn. 38101																																								
10. SHIPPING INFORMATION 10.1 Grades or Purities: Commercial industrial, refrigeration electronic, and metallurgical grades all have purity greater than 99.5% 10.2 Storage Temperature: Ambient for pressurized ammonia, low temperature for ammonia at atmospheric pressure. 10.3 Inert Atmosphere: No requirement. 10.4 Venting: Safety relief 250 psi for ammonia under pressure. Pressure-vacuum for ammonia at atmospheric pressure.																																								
13. PHYSICAL AND CHEMICAL PROPERTIES 13.1 Physical State at 18°C and 1 atm: Gas 13.2 Molecular Weight: 17.03 13.3 Boiling Point at 1 atm: -28.1°F = -33.4°C = 239.8°K 13.4 Freezing Point: -106°F = -77.7°C = 265.5°K 13.5 Critical Temperature: 271°F = 133°C = 406°K 13.6 Critical Pressure: 1636 psi = 111.3 atm = 11.27 MN/m² 13.7 Specific Gravity: 0.882 at -33.4°C (liquid) 13.8 Liquid Surface Tension: Not pertinent. 13.9 Liquid-Water Interfacial Tension: Not pertinent. 13.10 Vapor (Gas) Specific Gravity: 0.8 13.11 Ratio of Specific Heats of Vapor (Gas): 1.3 at 30°C 13.12 Latent Heat of Vaporization: 589 Btu/lb = 327 cal/g = 13.7 x 10³ J/kg 13.13 Heat of Combustion: -7902 Btu/lb = -6640 cal/g = -185.9 x 10³ J/kg 13.14 Heat of Decomposition: Not pertinent. 13.15 Heat of Solution: -232 Btu/lb = -129 cal/g = -5.40 x 10³ J/kg 13.16 Heat of Polymerization: Not pertinent.																																								

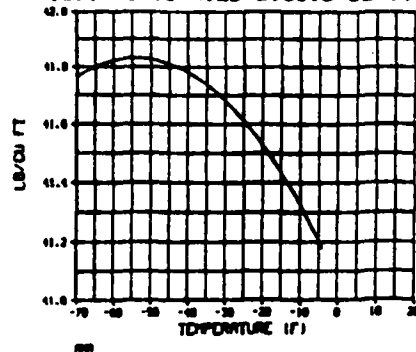
NOTES

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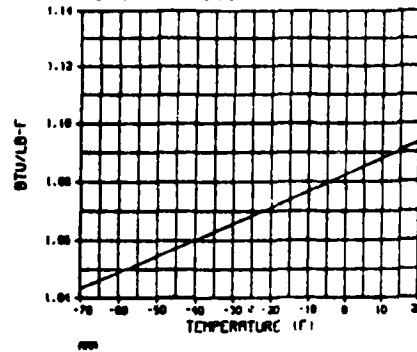
AMMONIA, ANHYDROUS

AMA

13.17 SATURATED LIQUID DENSITY



13.18 LIQUID HEAT CAPACITY



13.19 LIQUID THERMAL CONDUCTIVITY

NOT PERTINENT

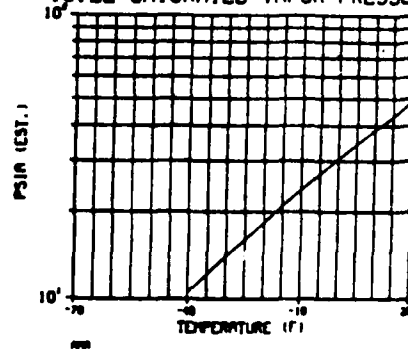
13.20 LIQUID VISCOSITY

NOT PERTINENT

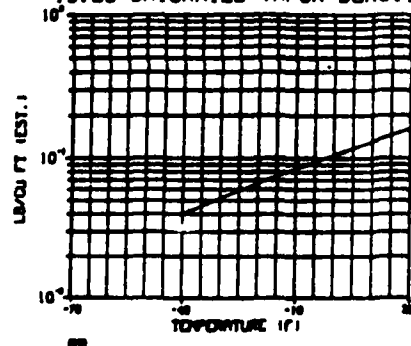
13.21 SOLUBILITY IN-WATER

MISCIBLE

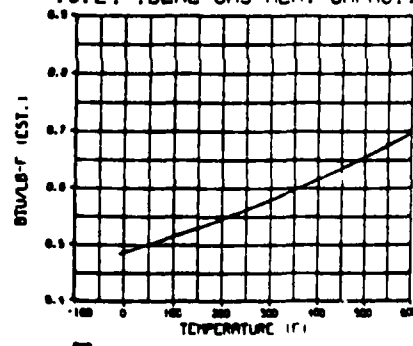
13.22 SATURATED VAPOR PRESSURE



13.23 SATURATED VAPOR DENSITY



13.24 IDEAL GAS HEAT CAPACITY



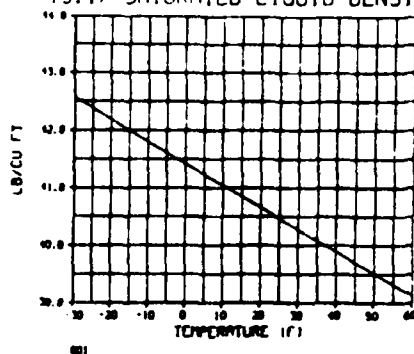
Common Synonyms: Diene May be used 1,3-Butadiene	Liquefied compressed gas Colorless Gasoline-like odor Flammable and boils on water. Flammable visible vapor cloud is produced.
Avoid contact with liquid and gas. Keep people away. Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves). Stop discharge if possible. Shut off upstream source and call fire department. Evacuate area at rear of large discharge. Toss upward and use water spray to "knock down" vapor. Isolate and remove discharged material. Notify local health and pollution control agencies.	
Fire	FLAMMABLE. Containers may explode in fire. Flashback along vapor trail may occur. Vapor may explode if ignited in an enclosed area. Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves). Stop flow of gas if possible. Cool exposed containers and protect man effecting shut-off with water. Let fire burn.
Exposure	CALL FOR MEDICAL AID VAPOR Irritating to eyes, nose and throat. Move to fresh air. LIQUID Irritating to skin and eyes. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water.
Water Pollution	Not harmful to aquatic life. May be dangerous if it causes oxygen depletion. Notify operators of nearby water intakes.
1. RESPONSE TO DISCHARGE (See Response Manual Handbook: CG 440-4) Issue warning: high flammability. Evaluate area.	2. LABELS 
3. CHEMICAL DESIGNATIONS 3.1 Synonyms: Butadiene 1,3-Butadiene Butene Diene Vinylbutadiene 3.2 Coast Guard Compatibility Classification: Monomer 3.3 Chemical Formula: C_4H_6 (C_4H_4 , H_2) 3.4 HMCO United Nations Hazardous Designation: 2.1 1010	4. OBSERVABLE CHARACTERISTICS 4.1 Physical State (at shipping): Gas 4.2 Color: Colorless 4.3 Odor: Mildly aromatic
5. HEALTH HAZARDS 5.1 Personal Protective Equipment: Chemical-type safety goggles, rescue harness and life line for those working in areas of enclosed storage space; hose mask with hose inlet in a vapor-free atmosphere; self-contained breathing apparatus; rubber suit. 5.2 Symptoms Following Exposure: Slight anesthetic effect at high concentrations; causes "frostbite" from skin; mild, slight irritation to eyes and nose at high concentrations. 5.3 Treatment for Exposure: Remove from exposure immediately. Call a physician. INHALATION: if breathing is irregular or stopped, start resuscitation; administer oxygen. SKIN CONTACT: remove contaminated clothing and wash affected skin area. EYE CONTACT: irrigate with water for 15 min. 5.4 Toxicity by Inhalation (Threshold Limit Value): 1,000 ppm 5.5 Short-Term Inhalation Limit: Data not available 5.6 Toxicity by Ingestion: Data not available 5.7 Lethal Toxicity: None 5.8 Vapor (Gas) Irritant Characteristics: Vapors cause a slight stinging of the eyes or respiratory system if inhaled in high concentrations. The effect is temporary. 5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause staining and reddening of the skin because of frostbite. 5.10 Odor Threshold: Data not available.	

6. FIRE HAZARDS 6.1 Flash Point: -105°F (est.) 6.2 Flammable Limits in Air: 2.0% - 11.5% 6.3 Fire Extinguishing Agents: Stop flow of gas. 6.4 Fire Extinguishing Agents Not to be Used: Not pertinent. 6.5 Special Hazards of Combustion Products: Not pertinent. 6.6 Behavior in Fire: Vapors heavier than air and may travel a considerable distance to a source of ignition and flash back. Containers may explode in a fire due to polymerization. 6.7 Ignition Temperature: 788°F 6.8 Electrical Hazard: Class I, Group B 6.9 Burning Rate: 8.0 mm/min	8. WATER POLLUTION 8.1 Aquatic Toxicity: Not pertinent. 8.2 Waterway Toxicity: Not pertinent. 8.3 Biological Oxygen Demand (BOD): Not pertinent. 8.4 Food Chain Concentration Potential: Not pertinent.																																				
7. CHEMICAL REACTIVITY 7.1 Reactivity with Water: No reaction. 7.2 Reactivity with Common Materials: No reaction. 7.3 Stability During Transport: Explosive decomposition when contaminated with peroxides formed by reaction with air. 7.4 Neutralizing Agents for Acids and Corrosives: Not pertinent. 7.5 Polymerization: Stable when inhibitors present. 7.6 Inhibitor of Polymerization: tert-Butylcatechol (0.01 - 0.02%)	9. SELECTED MANUFACTURERS 1. Baches Butene Products Co. Port Neches, Texas 77651 2. Petro-Tech Chemical Corp. Houston, Texas 77017 3. Phillips Petroleum Co. Bartlesville, Oklahoma 74004																																				
11. HAZARD ASSESSMENT CODE (See Hazard Assessment Handbook: CG 440-2) A-B-C-D-E-F-G-Z	10. SHIPPING INFORMATION 10.1 Grades or Purities: Research grade 99.9% mole % Special purity 99.5% mole % Rubber grade 99.0% mole % Commercial 98% 10.2 Storage Temperature: Ambient 10.3 Inert Atmosphere: No requirement 10.4 Venting: Safety relief																																				
12. HAZARD CLASSIFICATIONS 12.1 Code of Federal Regulations: Flammable compressed gas 12.2 NAB Hazard Rating for Bulk Water Transportation: <table> <thead> <tr> <th>Category</th><th>Rating</th></tr> </thead> <tbody> <tr> <td>Fire</td><td>4</td></tr> <tr> <td>Health</td><td></td></tr> <tr> <td> Vapor Irritant</td><td>1</td></tr> <tr> <td> Liquid or Solid Irritant</td><td>1</td></tr> <tr> <td> Poison</td><td>1</td></tr> <tr> <td>Water Pollution</td><td></td></tr> <tr> <td> Human Toxicity</td><td>0</td></tr> <tr> <td> Aquatic Toxicity</td><td>1</td></tr> <tr> <td> Anesthetic Effect</td><td>1</td></tr> <tr> <td>Reactivity</td><td></td></tr> <tr> <td> Other Chemicals</td><td>2</td></tr> <tr> <td> Water</td><td>0</td></tr> <tr> <td> Self-Reaction</td><td>3</td></tr> </tbody> </table> 12.3 NFPA Hazard Classifications: <table> <thead> <tr> <th>Category</th><th>Classification</th></tr> </thead> <tbody> <tr> <td>Health Hazard (Blue)</td><td>2</td></tr> <tr> <td>Flammability (Red)</td><td>4</td></tr> <tr> <td>Reactivity (Yellow)</td><td>2</td></tr> </tbody> </table>	Category	Rating	Fire	4	Health		Vapor Irritant	1	Liquid or Solid Irritant	1	Poison	1	Water Pollution		Human Toxicity	0	Aquatic Toxicity	1	Anesthetic Effect	1	Reactivity		Other Chemicals	2	Water	0	Self-Reaction	3	Category	Classification	Health Hazard (Blue)	2	Flammability (Red)	4	Reactivity (Yellow)	2	13. PHYSICAL AND CHEMICAL PROPERTIES 13.1 Physical State at 15°C and 1 atm: Gas 13.2 Molecular Weight: 54.09 13.3 Boiling Point at 1 atm: $24.1^{\circ}\text{F} = -4.4^{\circ}\text{C} = 268.8^{\circ}\text{K}$ 13.4 Freezing Point: $-164^{\circ}\text{F} = -108.9^{\circ}\text{C} = 164.3^{\circ}\text{K}$ 13.5 Critical Temperature: $306^{\circ}\text{F} = 152^{\circ}\text{C} = 425^{\circ}\text{K}$ 13.6 Critical Pressure: 628 psia = 42.7 atm = 4.32 MPa (m) 13.7 Specific Gravity: 0.621 at 20°C (liquid) 13.8 Liquid Surface Tension: 13.4 dyne/cm = 0.0134 N/m at 20°C 13.9 Liquid-Water Interfacial Tension: (est.) 16.7 dyne/cm = 0.0167 N/m at 22°C 13.10 Vapor (Gas) Specific Gravity: 1.9 at 20°C 13.11 Ratio of Specific Heats of Vapor (Gas): 1.1 13.12 Latent Heat of Vaporization: 180 Btu/lb = 100 cal/g = 4.19 $\times 10^3$ J/kg 13.13 Heat of Combustion: -19,006 Btu/lb = -10,540 cal/g = -442.13 $\times 10^3$ J/kg 13.14 Heat of Decomposition: Not pertinent. 13.15 Heat of Solution: Not pertinent. 13.16 Heat of Polymerization: -549 Btu/lb = -305 cal/g = -12.8 $\times 10^3$ J/kg
Category	Rating																																				
Fire	4																																				
Health																																					
Vapor Irritant	1																																				
Liquid or Solid Irritant	1																																				
Poison	1																																				
Water Pollution																																					
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NOTES (Continued on page 1 and 6)																																					

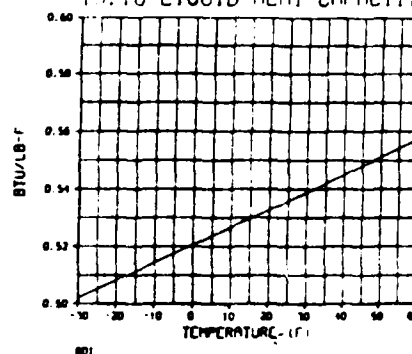
BUTADIENE, INHIBITED

BDI

13.17 SATURATED LIQUID DENSITY



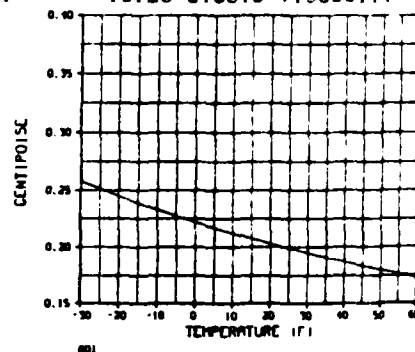
13.18 LIQUID HEAT CAPACITY



13.19 LIQUID THERMAL CONDUCTIVITY

NOT PERTINENT

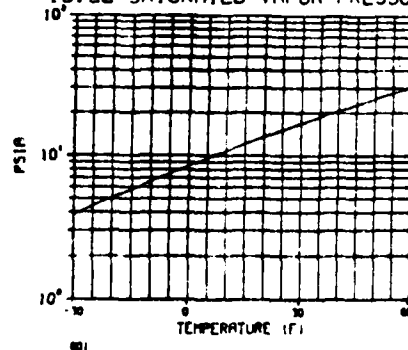
13.20 LIQUID VISCOSITY



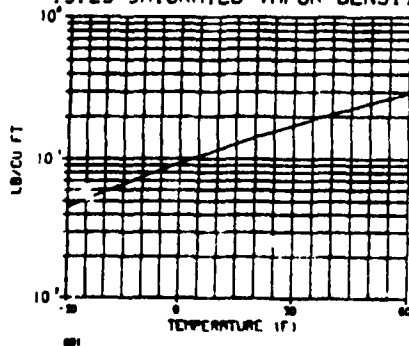
13.21 SOLUBILITY IN WATER

INSOLUBLE

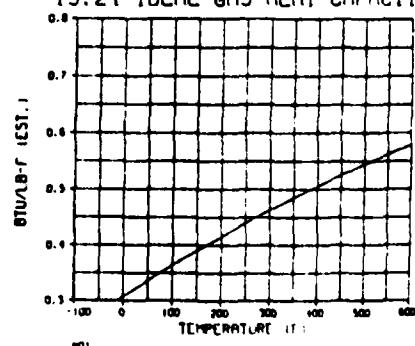
13.22 SATURATED VAPOR PRESSURE



13.23 SATURATED VAPOR DENSITY



13.24 IDEAL GAS HEAT CAPACITY



Common Synonyms:	Liquefied compressed gas. Greenish yellow. Irritating, bleach-like choking odor. Sinks and boils in water. Poisonous, visible vapor cloud is produced.
Fire	Not flammable. May cause fire on contact with combustibles. POISONOUS GASES ARE PRODUCED IN FIRES. Stop flow of gas if possible. Confined containers and protect men affecting stuff with water. Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves).
Exposure	CALL FOR MEDICAL AID. VAPOR POISONOUS IF INHALED. Will burn eyes. Move to fresh air. If breathing has stopped, give artificial respiration (but NOT mouth-to-mouth). If breathing is difficult, give oxygen. IF IN EYES, hold eyelids open and flush with plenty of water. LIQUID Will burn skin and eyes. Will cause frostbite. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water. DO NOT RUB AFFECTED AREAS.
Water Pollution	HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS. May be dangerous if it enters water bodies. Notify local health and wildlife officials. Notify operators of nearby water bodies.
1. RESPONSE TO DISCHARGE See Response to Materials Handbook, CG 440-11. First warning: poison. Material action: evacuate area.	2. LABELS   PRESENT NEW
3. CHEMICAL DESIGNATIONS 3.1 Synonyms: No common synonyms. 3.2 Coast Guard Competibility Classification: Halogen. 3.3 Chemical Formula: Cl₂. 3.4 IMCO/United Nations Hazardous Designation: 2.0/1017.	4. OBSERVABLE CHARACTERISTICS 4.1 Physical State (as shipped): Liquefied compressed gas. 4.2 Color: Greenish yellow. 4.3 Odor: Characteristic choking.
5. HEALTH HAZARDS 5.1 Personal Protective Equipment: Quick opening safety shower and eye fountain, respiratory equipment approved for chlorine service. Wear safety goggles at all times when in vicinity of liquid chlorine. 5.2 Symptoms Following Exposure: Eye irritation, sneezing, copious salivation, general excitement and restlessness. Irritation may persist for several days. High concentrations cause respiratory distress and violent coughing, often with bleeding. Death may result from suffocation. 5.3 Treatment for Exposure: INHALATION: remove victim from source of exposure, call a doctor, support respiration, administer oxygen. EYES: flush with copious amounts of water for at least 15 min. 5.4 Toxicity by Inhalation (Threshold Limit Value): 1 ppm. 5.5 Short Term Inhalation Limit: 1 ppm for 5 min. 5.6 Toxicity by Ingestion: Data not available. 5.7 Oral Toxicity: None. 5.8 Vapor (Gas) Irritant Characteristics: Vapors cause severe irritation of eyes and throat and can cause lung injury. They cannot be tolerated even at low concentrations. 5.9 Liquid or Solid Irritant Characteristics: Causes burning of the skin and first-degree burns on hot exposure. May cause secondary burns on long exposure. 5.10 Odor Threshold: 1.5 ppm.	

6. FIRE HAZARDS 6.1 Flash Point: Not flammable. 6.2 Flammable Limits in Air: Not flammable. 6.3 Fire Extinguishing Agents: Not pertinent. 6.4 Fire Extinguishing Agents Not to be Used: Not pertinent. 6.5 Special Hazards of Combustion Products: Toxic products are generated when combustibles burn in chlorine. 6.6 Behavior in Fire: Most combustibles will burn in chlorine, although gas is not flammable. 6.7 Ignition Temperature: Not flammable. 6.8 Electrical Hazard: Data not available. 6.9 Burning Rate: Not flammable.	8. WATER POLLUTION 8.1 Aquatic Toxicity: 0.16 ppm (48 hr LC50 for rainbow trout); 10 ppm (1 hr LC50 for rainbow trout); 10 ppm (1 hr LC50 for rainbow trout). 8.2 Waterborne Toxicity: Data not available. 8.3 Biological Oxygen Demand (BOD): None. 8.4 Food Chain Concentration Potential: None.																																				
7. CHEMICAL REACTIVITY 7.1 Reactivity with Water: Forms a corrosive solution. 7.2 Reactivity with Common Materials: Reacts vigorously with most metals at high temperature. Copper may burn spontaneously. 7.3 Stability During Transport: Stable. 7.4 Neutralizing Agents for Acids and Bases: Not pertinent. 7.5 Polymerization: Not pertinent. 7.6 Inhibitor of Polymerization: Not pertinent.	9. SELECTED MANUFACTURERS 1. Diamond Shamrock Corp. Electrochemical Division Deer Park, Texas 77536. 2. Dow Chemical Co. Midland, Mich. 48660. 3. PPG Industries Inc. Industrial Chemicals Division Warren, Ohio 44091.																																				
11. HAZARD ASSESSMENT CODE (See Hazard Assessment Handbook, CG 440-11) A-C(1)-J	10. SHIPPING INFORMATION 10.1 Grades or Purities: Research purity, ultra high purity, high purity. 10.2 Storage Temperature: Ambient. 10.3 Inert Atmosphere: No requirement. 10.4 Venting: Safety relief (100 psi).																																				
12. HAZARD CLASSIFICATIONS 12.1 Code of Federal Regulations: Nonflammable compressed gas. 12.2 HAS Hazard Rating for Bulk Water Transportation: <table border="1"> <thead> <tr> <th>Category</th> <th>Rating</th> </tr> </thead> <tbody> <tr> <td>Fire</td> <td>0</td> </tr> <tr> <td>Health</td> <td></td> </tr> <tr> <td>Vapor Irritant</td> <td>4</td> </tr> <tr> <td>Liquid or Solid Irritant</td> <td>2</td> </tr> <tr> <td>Poison</td> <td>4</td> </tr> <tr> <td>Water Pollution</td> <td></td> </tr> <tr> <td>Human Toxicity</td> <td>2</td> </tr> <tr> <td>Aquatic Toxicity</td> <td>3</td> </tr> <tr> <td>Asphyxiant Effect</td> <td>2</td> </tr> <tr> <td>Reactivity</td> <td></td> </tr> <tr> <td>Other Chemical</td> <td>4</td> </tr> <tr> <td>Water</td> <td>1</td> </tr> <tr> <td>Self-Reaction</td> <td>0</td> </tr> </tbody> </table> 12.3 HPPA Hazard Classifications: <table border="1"> <thead> <tr> <th>Category</th> <th>Classification</th> </tr> </thead> <tbody> <tr> <td>Health Hazard (Blue)</td> <td>3</td> </tr> <tr> <td>Flammability (Red)</td> <td>0</td> </tr> <tr> <td>Reactivity (Yellow)</td> <td>0</td> </tr> </tbody> </table> UN	Category	Rating	Fire	0	Health		Vapor Irritant	4	Liquid or Solid Irritant	2	Poison	4	Water Pollution		Human Toxicity	2	Aquatic Toxicity	3	Asphyxiant Effect	2	Reactivity		Other Chemical	4	Water	1	Self-Reaction	0	Category	Classification	Health Hazard (Blue)	3	Flammability (Red)	0	Reactivity (Yellow)	0	13. PHYSICAL AND CHEMICAL PROPERTIES 13.1 Physical State at 15°C and 1 atm: Gas. 13.2 Molecular Weight: 70.91. 13.3 Boiling Point at 1 atm: -79.6°F = -14.1°C = 259.1°K. 13.4 Freezing Point: -150°F = -101°C = 172°K. 13.5 Critical Temperature: 291°F = 144°C = 417°K. 13.6 Critical Pressure: 1118 psia = 76.05 atm = 7.706 MPa (abs). 13.7 Specific Gravity: 3.42 at 15°C (liq. vs. liq.). 13.8 Liquid Surface Tension: 26.55 dynes/cm at 15°C. 13.9 Liquid-Water Interfacial Tension: Not pertinent. 13.10 Vapor (Gas) Specific Gravity: 2.4. 13.11 Ratio of Specific Heats of Vapor (Gas): 1.325. 13.12 Latent Heat of Vaporization: 124 Btu/lb = 44.7 cal/g = 7.87 x 10³ J/kg. 13.13 Heat of Combustion: Not pertinent. 13.14 Heat of Decomposition: Not pertinent. 13.15 Heat of Solution: Not pertinent. 13.16 Heat of Polymerization: Not pertinent.
Category	Rating																																				
Fire	0																																				
Health																																					
Vapor Irritant	4																																				
Liquid or Solid Irritant	2																																				
Poison	4																																				
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Health Hazard (Blue)	3																																				
Flammability (Red)	0																																				
Reactivity (Yellow)	0																																				

NOTES

CHLORINE

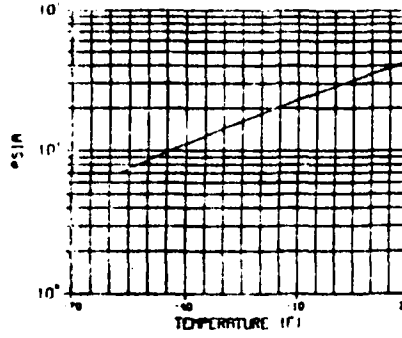
CLX

13.21 SOLUBILITY IN WATER

0.65 LB/100 LB WATER AT 77°F

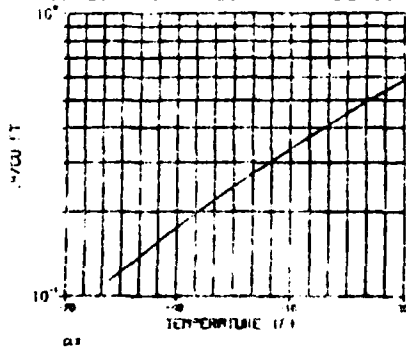
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13.22 SATURATED VAPOR PRESSURE



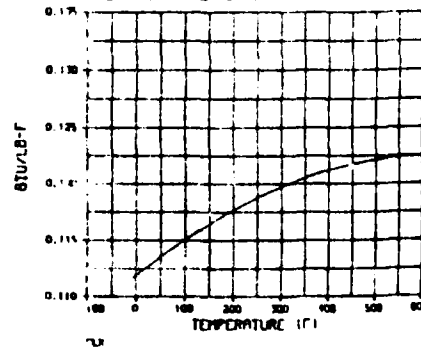
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13.23 SATURATED VAPOR DENSITY



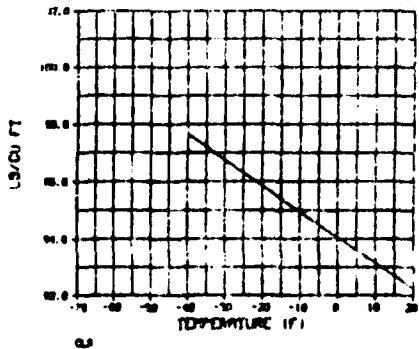
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13.24 IDEAL GAS HEAT CAPACITY



1.1

13.17 SATURATED LIQUID DENSITY



0.1

13.18 LIQUID HEAT CAPACITY

DATA NOT AVAILABLE

1.1

13.19 LIQUID THERMAL CONDUCTIVITY

NOT PERTINENT

0.1

13.20 LIQUID VISCOSITY

NOT PERTINENT

1.1

Common Synonyms Oxirane 1,3-epoxyethane		Liquefied gas	Colorless	Sweet odor
Flashes and mixes with water. Flammable, irritating vapor is produced. Boiling point is 51°F.				
Avoid contact with liquid. Keep people away. Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves). Shut off ignition sources and call fire department. Stop discharge if possible. Stay upwind and use water spray to "soak down" vapor. Isolate and remove discharged material. Notify local health and pollution control agencies.				
Fire	FLAMMABLE. Contents may explode when heated. Flashback along vapor trail may occur. Vapor may explode if ignited in an enclosed area. Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves). Stop flow of gas if possible. Combat fires from behind barrier, with unmanned hose holder or monitor nozzle. Flood discharge area with water. Cool exposed containers and protect men effecting shutoff with water. Extinguish with alcohol foam, dry chemical, or carbon dioxide.			
Exposure	CALL FOR MEDICAL AID. VAPOR Irritating to eyes, nose and throat. If inhaled, will cause nausea, vomiting and difficult breathing. Move to fresh air. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen. LIQUID Will burn skin and eyes. Harmful if swallowed. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open, and flush with plenty of water. IF SWALLOWED, and victim is CONSCIOUS, have victim drink water or milk.			
Water Pollution	Effect of low concentrations on aquatic life is unknown. May be dangerous if it causes oxygen depletion. Notify local health and wildlife officials. Notify operation of nearby water bodies.			
1. RESPONSE TO DISCHARGE See Response Methods Handbook, CB 440-4 Leak warning: high flammability Isolate area		2. LABELS  PRESENT NEW		
3. CHEMICAL DESIGNATIONS Synonyms: 1,2-Epoxyethane Oxirane Coast Guard Compatibility Classification: A1 (none inside) Chemical Formula: C ₂ H ₄ O IMCO/United Nations Numerical Designation: 201040		4. OBSERVABLE CHARACTERISTICS 4.1 Physical State (as shipped): Liquid 4.2 Color: Colorless 4.3 Odor: Sweet, characteristic ether-like		
5. HEALTH HAZARDS 5.1 Personal Protective Equipment: Air-supplied mask, goggles or face shield, rubber shoes and overalls. 5.2 Symptoms Following Exposure: Exposure to low vapor concentrations often results in delayed nausea and vomiting. Higher concentrations produce irritation of eyes, nose, and throat, high concentrations may cause edema of lungs. Contact with skin causes blistering and burns. 5.3 Treatment for Exposure: INHALATION: leave contaminated area immediately; if nausea and vomiting start, call a physician. SKIN OR EYES: flush immediately with plenty of water for at least 15 min. and seek medical attention. 5.4 Toxicity by Inhalation (Threshold Limit Values): 50 ppm 5.5 Short-Term Inhalation Limits: 200 ppm for 30 min 5.6 Toxicity by Ingestion: Data not available 5.7 Low Toxicity: Data not available 5.8 Vapor (Gas) Irritant Characteristics: Vapor is moderately irritating such that personnel will tolerate tolerable moderate or high vapor concentrations. 5.9 Liquid or Solid Irritant Characteristics: Fairly severe skin irritation; may cause pain and second-degree burns after a few minutes' contact. 5.10 Skin Threshold: 50 ppm				

6. FIRE HAZARDS

6.1 Flash Point: -10°F O.C.

6.2 Flammable Limits in Air: 3% - 100%

6.3 Fire Extinguishing Agents: Stop flow of gas. Use water, carbon dioxide, dry chemical or alcohol foam.

6.4 Fire Extinguishing Agents Not to be Used: Not pertinent.

6.5 Special Hazards of Combustion Products: Irritating vapors generated when heated.

6.6 Behavior in Fire: Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back. Containers may explode when heated.

6.7 Ignition Temperature: 904°F

6.8 Electrical Hazard: Class I, group B

6.9 Burning Rate: 3.5 mm/min

7. CHEMICAL REACTIVITY

7.1 Reactivity with Water: Slow reaction; not hazardous.

7.2 Reactivity with Common Materials: No reaction.

7.3 Stability During Transport: Stable.

7.4 Neutralizing Agents for Acids and Caustics: Not pertinent.

7.5 Polymerization: May polymerize violently if contaminated with alkali or acidic materials and metal oxides or chlorides.

7.6 Inhibitor of Polymerization: None used.

8. WATER POLLUTION

8.1 Aquatic Toxicity: Data not available.

8.2 Waterbody Toxicity: Data not available.

8.3 Biological Oxygen Demand (BOD): Data not available.

8.4 Food Chain Concentration Potential: None.

9. SELECTED MANUFACTURERS

1. Dow Chemical Co.
Midland, Mich. 48660
2. Jefferson Chemical Co., Inc.
151A Richmond Ave.
Houston, Texas 77052
3. Union Carbide Corp.
Chemicals and Plastics Div.
200 Park Ave.
New York, N.Y. 10017

10. SHIPPING INFORMATION

10.1 Grades or Purity: Commercial (98%); Must contain no acetylene.

10.2 Storage Temperature: Ambient.

10.3 Inert Atmosphere: Inerted.

10.4 Venting: Safety relief.

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook, CB 440-2)

A-B-C-K-L-M-N

12. HAZARD CLASSIFICATIONS

12.1 Code of Federal Regulations: Flammable liquid

12.2 NAB Hazard Rating for Bulk Water Transportation:

Category	Rating
Fire	4
Health	
Vapor Irritant	3
Liquid or Solid Irritant	3
Poison	2
Water Pollution	
Human Toxicity	3
Aquatic Toxicity	2
Aesthetic Effect	1
Reactivity	
Other Chemicals	3
Water	1
Self-Reaction	4

12.3 NPPA Hazard Classifications

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	4
Reactivity (Yellow)	3

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 Physical State at 15°C and 1 atm: (L)

13.2 Molecular Weight: 44.05

13.3 Boiling Point at 1 atm:
 $41.3^{\circ}\text{F} = 10.6^{\circ}\text{C} = 283.8^{\circ}\text{K}$

13.4 Freezing Point:
 $-110.7^{\circ}\text{F} = -81.0^{\circ}\text{C} = 192.1^{\circ}\text{K}$

13.5 Critical Temperature:
 $181^{\circ}\text{F} = 84^{\circ}\text{C} = 357^{\circ}\text{K}$

13.6 Critical Pressure:
1040 psia = 71.0 atm = 7.12 MPa (g)

13.7 Specific Gravity: 0.896 at 20°C (liquid)

13.8 Liquid Surface Tension:
24.3 dyn/cm = 0.0243 N/m at 20°C

13.9 Liquid-Water Interfacial Tension: Not pertinent.

13.10 Vapor (Gas) Specific Gravity: 1.5

13.11 Ratio of Specific Heats of Vapor (Gas): 1.212

13.12 Latent Heat of Vaporization: 149.1 Btu/lb = 136.5 cal/g = 5.796×10^3 J/kg

13.13 Heat of Combustion: -11,440 Btu/lb = -6380 cal/g = -2671×10^3 J/kg

13.14 Heat of Decomposition: Not pertinent.

13.15 Heat of Solution: At 100 lb/lb = 14 cal/g = -4×10^3 J/kg

13.16 Heat of Polymerization: Not pertinent.

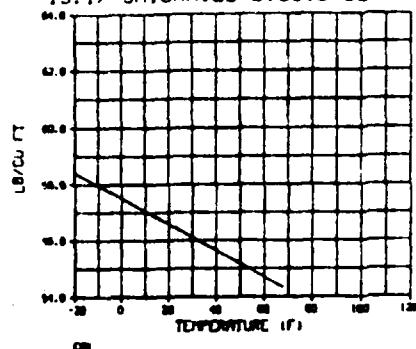
(Continued on page 7 and 8)

NOTES

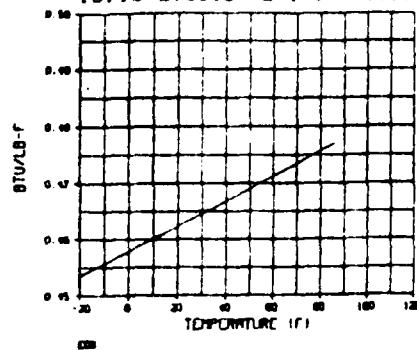
ETHYLENE OXIDE

EOX

13.17 SATURATED LIQUID DENSITY



13.18 LIQUID HEAT CAPACITY



13.19 LIQUID THERMAL CONDUCTIVITY

NOT PERTINENT

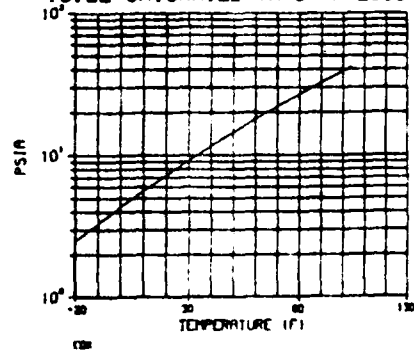
13.20 LIQUID VISCOSITY

NOT PERTINENT

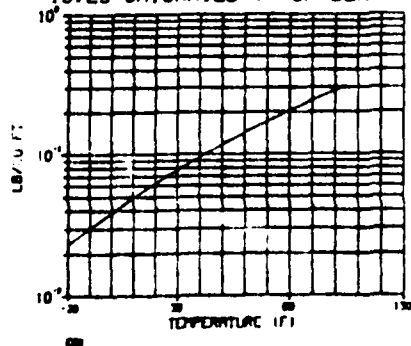
13.21 SOLUBILITY IN WATER

MISCIBLE

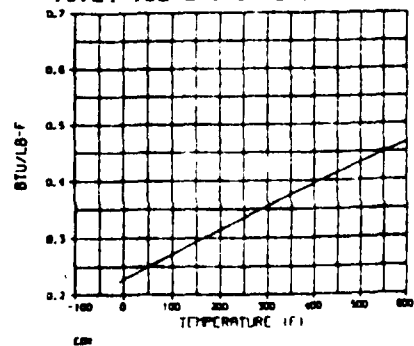
13.22 SATURATED VAPOR PRESSURE



13.23 SATURATED VAPOR DENSITY



13.24 IDEAL GAS HEAT CAPACITY

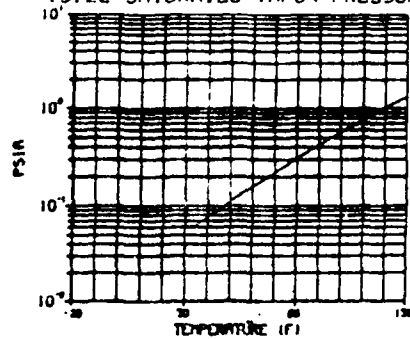


Emergency Response Watery liquid Colorless Ammonia odor Mixes with water. Poisonous. (Intense vapor is produced. Freezing point is 35° F.)																															
Fire Combustible May ignite by itself when in contact with earth, wood or cloth Vapor may explode if ignited in an enclosed area Wear chemical protective suit with self-contained breathing apparatus Combat fires from safe distance or protected location Flood discharge area with water Extinguish with dry chemical, alcohol foam, or carbon dioxide Cool exposed containers with water Continue cooling after fire has been extinguished	8. WATER POLLUTION 8.1 Aquatic Toxicity: 140 ppm/0.5 hr. rainbow trout died (fresh water) 8.2 Waterway Toxicity: Data not available 8.3 Biological Oxygen Demand (BOD): 100% 8.4 Food Chain Concentration Potential: None																														
Exposure CALL FOR MEDICAL AID VAPOR POISONOUS IF INHALED OR IF SKIN IS EXPOSED Irritating to eyes Move to fresh air If breathing has stopped, give artificial respiration If breathing is difficult, give oxygen LIQUID POISONOUS IF SWALLOWED OR IF SKIN IS EXPOSED Will burn eyes Remove contaminated clothing and shoes Flush affected areas with plenty of water IF IN EYES, hold eyelids open and flush with plenty of water IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk DO NOT INDUCE VOMITING	9. SELECTED MANUFACTURERS 1. Fairmount Chemical Co., Inc. 117 Blanchard St. Newark, N. J. 07105 2. Olin Corp. Chemical Division 120 Long Ridge Rd. Stamford, Conn. 06904 3. Uniroyal Inc. Uniroyal Chemical Division Spencer St. Naugatuck, Conn. 06770																														
Water Pollution HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS. May be dangerous if it enters water body. Notify local health and wildlife officials. Notify operators of nearby water bodies.	10. SHIPPING INFORMATION 10.1 Grade or Purity: Anhydrous 35-64% water solution 10.2 Storage Temperature: Ambient 10.3 Inert Atmosphere: Padded 10.4 Ventilator: Pressure-vacuum																														
1. RESPONSE TO DISCHARGE (See Response Material Handbook, CG 440-2) Toxic warning: high flammability Corrosive Material reacts: Chemical and physical treatment	2. LABELS   PRESENT NEW																														
3. CHEMICAL DESIGNATIONS 3.1 Synonyms: No common synonyms 3.2 Case Chemical Compatibility Classification: Not applicable 3.3 Chemical Formula: N_2H_4 3.4 IMCO/United Nations Hazardous Designation: H 02/20/01	4. OBSERVABLE CHARACTERISTICS 4.1 Physical State (as shipped): Liquid 4.2 Color: Colorless 4.3 Odor: Ammonia-like																														
5. HEALTH HAZARDS 5.1 Personal Protective Equipment: Ammonia type gas mask, self-contained breathing apparatus, and/or full body protective suit and apron; safety shower must be available. 5.2 Symptoms Following Exposure: Vapors cause itching, swelling, and blistering in eyes; skin; nose and throat. Symptoms may be delayed for several hours. Temporary blindness may occur. Liquid causes severe skin burn if not washed off at once. Ingestion or absorption through skin causes nausea, dizziness, headache. Severe exposure may cause death. 5.3 Treatment for Exposure: Call a doctor at once. INHALATION: remove to fresh air; observe for development of delayed symptoms. Keep open. INGESTION: do NOT induce vomiting; give egg white or other emollient. SKIN OR EYES: wash with large amounts of water for at least 15 min. 5.4 Toxicity by Inhalation (Threshold Limit Value): 1 ppm 5.5 Short-Term Inhalation Limit: 1 ppm for 30 min. 5.6 Toxicity by Ingestion: Grade 1; LD ₅₀ 50 to 100 mg/kg (rats) 5.7 Lethal Toxicity: Data not available 5.8 Vapor (Gas) Irritation Characteristics: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations. 5.9 Liquid or Solid Irritant Characteristics: Severe skin irritant. Causes second- and third-degree burns on short contact; severe, permanent to the eyes. 5.10 Odor Threshold: Data not available																															
6. FIRE HAZARDS 6.1 Flash Point: 20°F (0°C) 6.2 Flammable Limits in Air: 4-16% 6.3 Fire Extinguishing Agents: Water (Do not use foam or carbon dioxide or dry chemical) 6.4 Fire Extinguishing Agents Not to be Used: None known 6.5 Special Hazards of Combustion Products: Toxic gases are generated when heated 6.6 Behavior in Fire: No smoke is evolved 6.7 Ignition Temperature: 572°F (300°C) 6.8 Electrical Hazard: Non-pyrophoric 6.9 Burning Rate: 1.0 mm/min (steel)	7. CHEMICAL REACTIVITY Reacts with Water: No reaction Reactivity with Common Materials: No reaction with acids, alkalis, or oxidizing agents No reaction with organic solvents No reaction with carbon and steel 7.1 Stability During Transport: Stable No reaction with water. When heated, it decomposes into nitrogen and hydrogen gases, but decomposition is not hazardous unless material is confined. 7.2 Neutralizing Agents for Acids and Bases: Flush with water. Neutralize the resulting solution with sodium hydroxide (NaOH) (17 lbs. of NaOH per 100 lbs. of hydrazine). 7.3 Polymerization: Not polymerizable 7.4 Initiation of Polymerization: None known																														
11. HAZARD ASSESSMENT CODE See Response Material Handbook, CG 440-2 A-P-Q	13. PHYSICAL AND CHEMICAL PROPERTIES 13.1 Physical State at 15°C and 1 atm: Liquid 13.2 Molecular Weight: 32.05 13.3 Boiling Point at 1 atm: 236.3°F = 113.5°C = 386.7°K 13.4 Freezing Point: 34.7°F = 1°C = 273.1°K 13.5 Critical Temperature: 716°F = 380°C = 653°K 13.6 Critical Pressure: 2130 psia = 147 atm = 14.7 MPa 13.7 Specific Gravity: (Liquid at 15°C, liquid at 15°C) Not pertinent 13.8 Liquid Surface Tension: Not pertinent 13.9 Liquid-Water Interfacial Tension: Not pertinent 13.10 Vapor (Gas) Specific Gravity: Not pertinent 13.11 Ratio of Specific Heats of Vapor (Gas): 1.191 13.12 Latent Heat of Vaporization: 555 Btu/lb = 290 cal/g = 1215 J/kg 13.13 Heat of Combustion: 14,100 Btu/lb = 7816 cal/g = 32700 J/kg 13.14 Heat of Decomposition: Not pertinent 13.15 Heat of Solution: -120 Btu/lb = -67 cal/g = -2800 J/kg 13.16 Heat of Polymerization: Not pertinent																														
12. HAZARD CLASSIFICATIONS 12.1 Code of Federal Regulations: 29 CFR 1910.106 12.2 NAB Hazard Rating for Bulk Water Transportation: <table border="1"> <thead> <tr> <th>Category</th> <th>Rating</th> </tr> </thead> <tbody> <tr> <td>Fire</td> <td>4</td> </tr> <tr> <td>Health</td> <td>4</td> </tr> <tr> <td>Reactivity</td> <td>3</td> </tr> <tr> <td>Corrosion</td> <td>4</td> </tr> <tr> <td>Water Pollution</td> <td>4</td> </tr> <tr> <td>Human Toxicity</td> <td>3</td> </tr> <tr> <td>Acute Toxicity</td> <td>2</td> </tr> <tr> <td>Chronic Toxicity</td> <td>4</td> </tr> <tr> <td>Other</td> <td>0</td> </tr> <tr> <td>Reaction</td> <td>4</td> </tr> </tbody> </table> 12.3 HPPA Hazard Classifications: <table border="1"> <thead> <tr> <th>Category</th> <th>Classification</th> </tr> </thead> <tbody> <tr> <td>Health Hazard (Blue)</td> <td>3</td> </tr> <tr> <td>Flammability (Red)</td> <td>3</td> </tr> <tr> <td>Reactivity (Yellow)</td> <td>2</td> </tr> </tbody> </table>	Category	Rating	Fire	4	Health	4	Reactivity	3	Corrosion	4	Water Pollution	4	Human Toxicity	3	Acute Toxicity	2	Chronic Toxicity	4	Other	0	Reaction	4	Category	Classification	Health Hazard (Blue)	3	Flammability (Red)	3	Reactivity (Yellow)	2	NOTES
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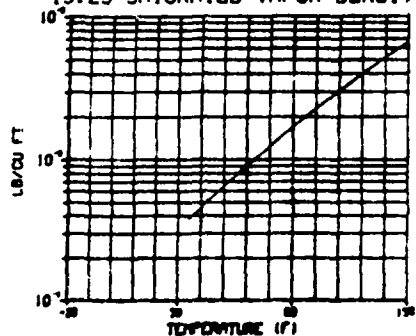
13.21 SOLUBILITY IN WATER

MISCIBLE

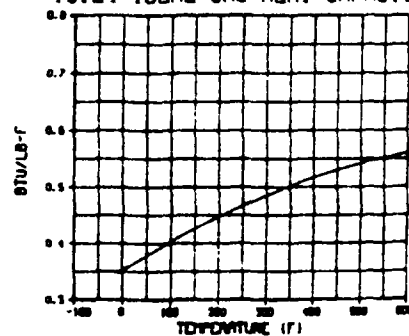
13.22 SATURATED VAPOR PRESSURE



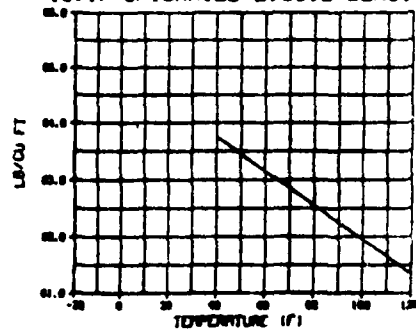
13.23 SATURATED VAPOR DENSITY



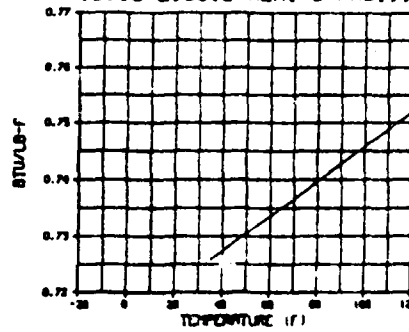
13.24 IDEAL GAS HEAT CAPACITY



13.17 SATURATED LIQUID DENSITY



13.18 LIQUID HEAT CAPACITY



13.19 LIQUID THERMAL CONDUCTIVITY

NOT PERTINENT

13.20 LIQUID VISCOSITY

NOT PERTINENT

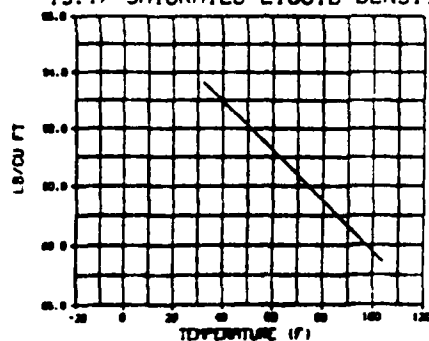
Common Synonyms Nitrogen peroxide Nitrogen dioxide Red oxide of nitrogen Oxides of nitrogen Dioxides nitroside	Liquidized compressed gas Red-brown Sharp, unpleasant, dominant odor Sinks and reacts with water. Potentest brown vapor is produced.
AVOID CONTACT WITH LIQUID AND VAPOR. Keep people away. Wear goggles, and contained breathing apparatus, and rubber overclothing (including gloves). Stop discharge if possible. Evacuate area in case of large discharge. Notify local health and pollution control agencies.	
Fire	Not flammable. May cause fire and explode on contact with combustibles. POISONOUS GASES ARE PRODUCED IN FIRE AND WHEN HEATED. Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves). Flood discharge area with water. Stop flow of gas or liquid. Avoid exposed containers with water.
 Exposure	CALL FOR MEDICAL AID. VAPOR POISONOUS IF INHALED. Irritating to eyes. Move to fresh air. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen. LIQUID Will burn skin and eyes. POISONOUS IF SWALLOWED. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victim drink water. DO NOT INDUCE VOMITING.
Water Pollution	HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS. May be dangerous if it enters water bodies. Notify local health and wildlife officials. Notify operators of nearby water bodies.
1. RESPONSE TO DISCHARGE (See Procedures Appendix Handbook, CB 446-4) Issue warning - poison, air contamination, water contamination, corrosion. Restrict access. Evacuate area.	2. LABELS  PRESENT NEW
3. CHEMICAL DESIGNATIONS 3.1 Synonyms: Dinitrogen tetroxide. Nitrogen peroxide, Nitrogen dioxide. Oxides of nitrogen, Red oxide of nitrogen. 3.2 Coast Guard Compatibility Classification: Not applicable. 3.3 Chemical Formula: N_2O_4 3.4 I.M.C.O./United Nations Hazardous Designation: 2/1067	4. OBSERVABLE CHARACTERISTICS 4.1 Physical State (as shipped): Liquid. 4.2 Color: Red-brown at ambient temperature, colorless below about 14°F. 4.3 Odor: Pungent, acid, mildly irritating.
5. HEALTH HAZARDS 5.1 Personal Protective Equipment: Rubber gloves, safety goggles and face shield, protective clothing, and gas analyzer respirator or self-contained breathing apparatus. 5.2 Symptoms Following Exposure: Very concentrated fumes produce coughing, headache, nausea, pain in chest and abdomen, asthma, low symptoms appear at time of exposure. After minimum time period of 5-12 hours, pulmonary edema gradually develops, causing fatigue, restlessness, coughing, difficulty in breathing, frothy expectoration, mental confusion, lethargy, numb skin, and weak, rapid pulse. Since NO_2 interferes with gas exchange in lungs, unconsciousness and death by asphyxiation can result, usually within a few hours after onset of pulmonary edema. 5.3 Treatment for Exposure: INHALATION: remove patient to fresh air and have him breathe as deeply as possible; call a doctor, enforce complete rest for 34-48 hours, keep warm, give oxygen if coughing starts; physician may administer morphine (10 mg); EYES AND SKIN: flush with water for at least 15 min. 5.4 Toxicity by Inhalation (Threshold Limit Value): 5 ppm 5.5 Short-Term Inhalation Limits: 25 ppm for 5 min. 5.6 Toxicity by Ingestion: Data not available. 5.7 Low Toxicity: Data not available. 5.8 Vapor (Gas) Irritant Characteristics: Vapors cause severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations. 5.9 Liquid or Solid Irritant Characteristics: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes. 5.10 Oral Threshold: 5 ppm.	

6. FIRE HAZARDS 6.1 Flash Point: Not flammable. 6.2 Flammable Limits in Air: Not flammable. 6.3 Fire Extinguishing Agents: Stop flow of gas. 6.4 Fire Extinguishing Agents Not to be Used: Not pertinent. 6.5 Special Hazards of Combustion Products: Produces toxic gas when heated. 6.6 Behavior in Fire: Does not burn, but supports combustion of combustible materials such as wood. May cause fire or explode on contact with other materials. 6.7 Ignition Temperature: Not flammable. 6.8 Chemical Hazards: Data not available. 6.9 Burning Rate: Not flammable.	8. WATER POLLUTION 8.1 Aquatic Toxicity: 12 ppm/96 hr bioassay fish/TLM: fresh water. 350-1000 ppm/48 hr bioassay/LC50: all water. 8.2 Waterway Toxicity: Data not available. 8.3 Biological Oxygen Demand (BOD): None. 8.4 Food Chain Concentration Potential: None.																																				
7. CHEMICAL REACTIVITY 7.1 Reactivity with Water: Dissolves to form nitric acid and nitric oxide. Nitric oxide reacts with air to form more nitrogen tetroxide. 7.2 Reactivity with Common Materials: Very corrosive to metals when wet. Reacts vigorously with combustible materials such as wood. 7.3 Stability During Transport: Stable. 7.4 Neutralizing Agents for Acids and Bases: Flush with water, then use soda ash or lime. 7.5 Polymerization: Not pertinent. 7.6 Inhibitor of Polymerization: Not pertinent.	9. SELECTED MANUFACTURERS Hercules, Inc. Explosives and Chemical Propulsion Dept. Hercules, Calif. 94547. 10. SHIPPING INFORMATION 10.1 Grades or Purity: 90-100%, usually 98.5+%. 0-10% nitric oxide. 10.2 Storage Temperature: Data not available. 10.3 Inert Atmosphere: Data not available. 10.4 Venting: Data not available.																																				
11. HAZARD ASSESSMENT CODE (See Hazard Assessment Handbook, CB 446-3) A-I-J-O	13. PHYSICAL AND CHEMICAL PROPERTIES 13.1 Physical State at 15°C and 1 atm: Liquid or gas. 13.2 Molecular Weight: 92.02. 13.3 Boiling Point at 1 atm: 70.1°F = 21.2°C = 294°K. 13.4 Freezing Point: 11.8°F = -11.2°C = 262°K. 13.5 Critical Temperature: 317.0°F = 158.2°C = 431.4°K. 13.6 Critical Pressure: (470 psia = 100 atm = 10.1 MN/m²). 13.7 Specific Gravity: 1.45 at 20°C (liquid). 13.8 Liquid Surface Tension: Not pertinent. 13.9 Liquid-Water Interfacial Tension: Not pertinent. 13.10 Vapor (Gas) Specific Gravity: 3.2. 13.11 Ratio of Specific Heats of Vapor (Gas): (see 13.10). 13.12 Latent Heat of Vaporization: (see 13.10) 120 Btu/lb = 63 cal/g = 2.7 x 10³ J/kg. 13.13 Heat of Combustion: Not pertinent. 13.14 Heat of Decomposition: Not pertinent. 13.15 Heat of Solution: (see 13.10) 30 Btu/lb = 20 cal/g = 0.7 x 10³ J/kg. 13.16 Heat of Polymerization: Not pertinent.																																				
12. HAZARD CLASSIFICATIONS 12.1 Code of Federal Regulations: Poisonous gas or liquid, Class A. 12.2 HAZ Hazard Rating for Bulk Water Transportation: <table> <thead> <tr> <th>Category</th> <th>Rating</th> </tr> </thead> <tbody> <tr> <td>Fire</td> <td>0</td> </tr> <tr> <td>Health</td> <td></td> </tr> <tr> <td>Vapor Irritant</td> <td>4</td> </tr> <tr> <td>Liquid or Solid Irritant</td> <td>4</td> </tr> <tr> <td>Poison</td> <td>4</td> </tr> <tr> <td>Water Pollution</td> <td></td> </tr> <tr> <td>Human Toxicity</td> <td>3</td> </tr> <tr> <td>Aquatic Toxicity</td> <td></td> </tr> <tr> <td>Aesthetic Effect</td> <td>3</td> </tr> <tr> <td>Reactivity</td> <td></td> </tr> <tr> <td>Other Chemicals</td> <td>4</td> </tr> <tr> <td>Water</td> <td>2</td> </tr> <tr> <td>Self-Reaction</td> <td>0</td> </tr> </tbody> </table> 12.3 NFPA Hazard Classifications: <table> <thead> <tr> <th>Category</th> <th>Classification</th> </tr> </thead> <tbody> <tr> <td>Health Hazard (Blue)</td> <td>3</td> </tr> <tr> <td>Flammability (Red)</td> <td>0</td> </tr> <tr> <td>Reactivity (Yellow)</td> <td>0</td> </tr> </tbody> </table>	Category	Rating	Fire	0	Health		Vapor Irritant	4	Liquid or Solid Irritant	4	Poison	4	Water Pollution		Human Toxicity	3	Aquatic Toxicity		Aesthetic Effect	3	Reactivity		Other Chemicals	4	Water	2	Self-Reaction	0	Category	Classification	Health Hazard (Blue)	3	Flammability (Red)	0	Reactivity (Yellow)	0	NOTES (continued on pages 5 and 6)
Category	Rating																																				
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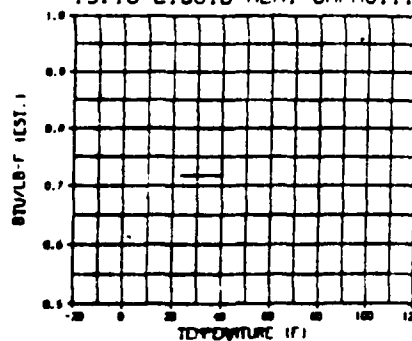
NITROGEN TETROXIDE

NOX

13.17 SATURATED LIQUID DENSITY



13.18 LIQUID HEAT CAPACITY



13.19 LIQUID THERMAL CONDUCTIVITY

NOT PERTINENT

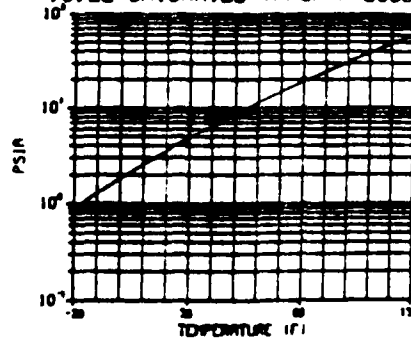
13.20 LIQUID VISCOSITY

DATA NOT AVAILABLE

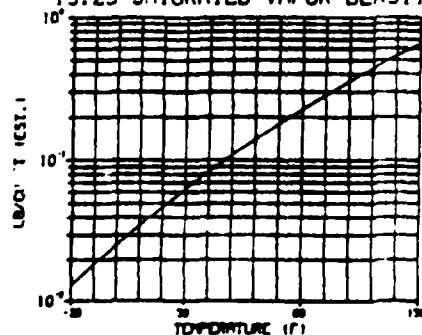
13.21 SOLUBILITY IN WATER

REACTS

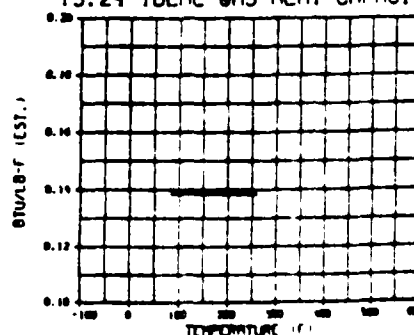
13.22 SATURATED VAPOR PRESSURE



13.23 SATURATED VAPOR DENSITY



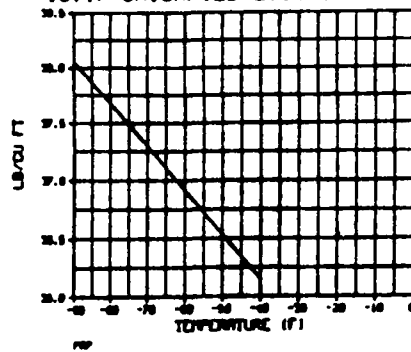
13.24 IDEAL GAS HEAT CAPACITY



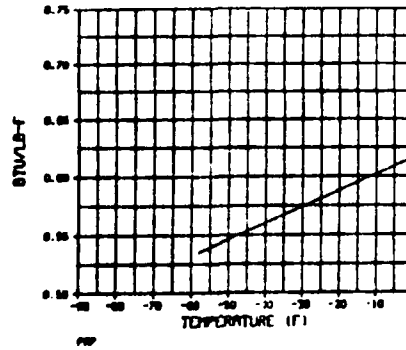
PROPANE

PRP

13.17 SATURATED LIQUID DENSITY



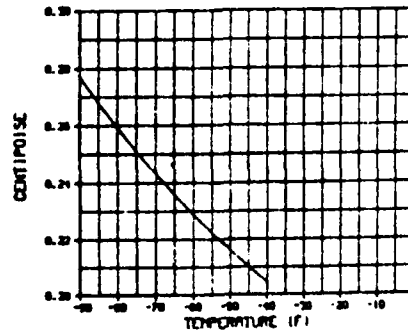
13.18 LIQUID HEAT CAPACITY



13.19 LIQUID THERMAL CONDUCTIVITY

NOT PERTINENT

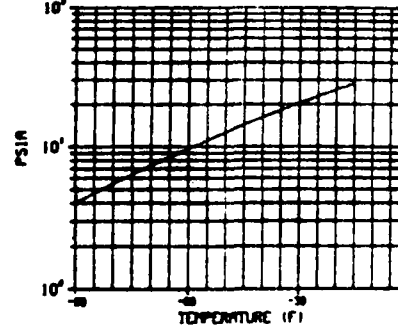
13.20 LIQUID VISCOSITY



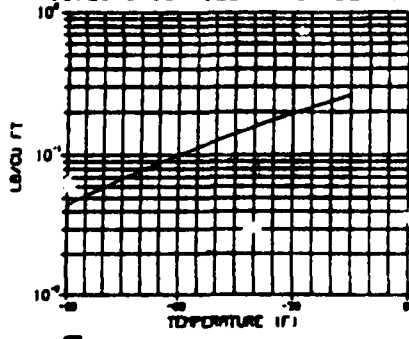
13.21 SOLUBILITY IN WATER

INSOLUBLE

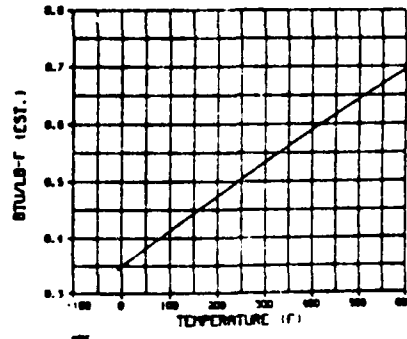
13.22 SATURATED VAPOR PRESSURE



13.23 SATURATED VAPOR DENSITY



13.24 IDEAL GAS HEAT CAPACITY

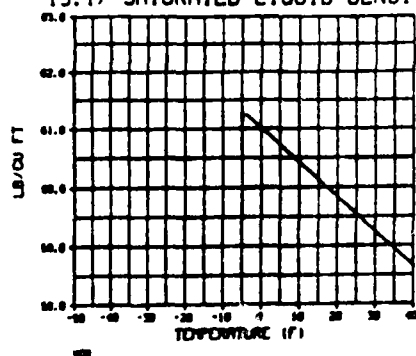


Common Synonyms Chloroethene VCL Vinyl Chloride	Liquefied compressed gas Corrosive Sweet odor Liquid floats and boils on water. Flammable, irritating visible vapor cloud is produced.																																				
Stop discharge if possible. Keep people away. Shut off ignition sources and call fire department. Say upwind and use water spray to "knock down" vapor. Evacuate area in case of large discharge. Avoid contact with liquid and vapor. Notify local health and pollution control agencies.																																					
Fire	FLAMMABLE. POISONOUS GAS IS PRODUCED BY FIRE. Flashback along vapor and may cause. May explode if ignited in an enclosed area. Wear self-contained breathing apparatus. Cool exposed containers and prevent any overflowing overflow with water. Stop flow of gas if possible. Let fire burn. Extinguish small fires with dry chemical.																																				
Exposure	CALL FOR MEDICAL AID. VAPOR Irritating to eyes, nose, and throat. If inhaled, will cause difficulty in breathing. Move to fresh air. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen. LIQUID WBI cause frostbite. Flush affected areas with plenty of water. DO NOT RUB AFFECTED AREAS.																																				
Water Pollution	Not harmful to aquatic life.																																				
1. RESPONSE TO DISCHARGE (See Response to Discharge Handbook, CG 440-1) Issue warning—high flammability Evacuate area	2. LABELS  																																				
3. CHEMICAL DESIGNATIONS 3.1 Synonyms: Chloroethene Chloroethylene Vinyl Chloride VCL VCM 3.2 Coast Guard Competibility Classification: Monomer 3.3 Chemical Formula: $CH_2=CHCl$ 3.4 IBCO/United Nations Hazardous Designation: 1.0/1000	4. OBSERVABLE CHARACTERISTICS 4.1 Physical State (as shipped): Liquefied gas 4.2 Color: Colorless 4.3 Odor: Pleasant, sweet																																				
5. HEALTH HAZARDS 5.1 Personal Protective Equipment: Rubber gloves and shoes, gas-tight goggles, organic vapor canister or self-contained breathing apparatus 5.2 Symptoms Following Exposure: INHALATION: high concentrations cause dizziness, anesthesia, lung irritation. SKIN: may cause frostbite, phenol inhibitor may be absorbed through skin if large amounts of liquid evaporate 5.3 Treatment for Exposure: INHALATION: remove patient to fresh air and keep him quiet and warm; call a doctor; give artificial respiration if breathing stops. EYES AND SKIN: flush with plenty of water for at least 15 min.; for eyes, get medical attention, remove contaminated clothing 5.4 Toxicity by Inhalation (Threshold Limit Values): 200 ppm 5.5 Short-Term Inhalation Limit: 500 ppm for 5 min 5.6 Toxicity by Ingestion: Not pertinent 5.7 Late Toxicity: Chronic exposure may cause 5.8 Vapor (Gas) Irritant Characteristics: Vapor moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary. 5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin. May cause frostbite 5.10 Odor Threshold: 200 ppm																																					
6. FIRE HAZARDS 6.1 Flash Point: $-110^{\circ}\text{F}/\text{C}$ 6.2 Flammable Limits in Air: 4% - 21% 6.3 Fire Extinguishing Agents: For small fires use dry chemical or carbon dioxide. For large fires stop flow of gas. Cool exposed containers with water. 6.4 Fire Extinguishing Agents Not to be Used: Not pertinent 6.5 Special Hazards of Combustion Products: Forms highly toxic combustion products such as hydrogen chloride, phosgene, and carbon monoxide. 6.6 Behavior in Fire: Container may explode in fire. Gas is heavier than air and may travel considerable distance to a source of ignition and flash back. 6.7 Ignition Temperature: 882°F 6.8 Electrical Hazard: Class I, Group D 6.9 Burning Rate: 4.3 mm/min	8. WATER POLLUTION 8.1 Aquatic Toxicity: None 8.2 Waterfowl Toxicity: None 8.3 Biological Oxygen Demand (BOD): None 8.4 Food Chain Concentration Potential: None																																				
7. CHEMICAL REACTIVITY 7.1 Reactivity with Water: No reaction 7.2 Reactivity with Common Materials: No reaction 7.3 Stability During Transport: Stable 7.4 Neutralizing Agents for Acids and Caustics: Not pertinent 7.5 Polymerization: Polymerizes in presence of air, sunlight, or heat unless stabilized by inhibitors 7.6 Inhibitor of Polymerization: Not normally used except when high temperatures are expected. Then 40-100 ppm of phenol used	9. SELECTED MANUFACTURERS - Dow Chemical Co Midland, Mich 48640 - The B. F. Goodrich Co 6100 Oak Tree Blvd Cleveland, Ohio 44111 - PPG Industries, Inc. Chemical Division Guaynilla, Puerto Rico 00816																																				
11. HAZARD ASSESSMENT CODE (See Hazard Assessment Handbook, CG 440-1) A-B-C-D-E-F-G-Z	10. SHIPPING INFORMATION 10.1 Grades or Purities: Commercial or technical 99+% 10.2 Storage Temperature: Under pressure, ambient At atm pressure, low 10.3 Inert Atmosphere: No requirement 10.4 Venting: Under pressure, safety relief At atm pressure, pressure-vacuum																																				
12. HAZARD CLASSIFICATIONS 12.1 Code of Federal Regulations: Flammable compressed gas 12.2 NAB Hazard Rating for Bulk Water Transportation: <table border="1"> <thead> <tr> <th>Category</th> <th>Rating</th> </tr> </thead> <tbody> <tr> <td>Fire</td> <td>4</td> </tr> <tr> <td>Health</td> <td></td> </tr> <tr> <td> Vapor Irritant</td> <td>2</td> </tr> <tr> <td> Liquid or Solid Irritant</td> <td>1</td> </tr> <tr> <td> Poison</td> <td>2</td> </tr> <tr> <td>Water Pollution</td> <td></td> </tr> <tr> <td> Human Toxicity</td> <td>0</td> </tr> <tr> <td> Aquatic Toxicity</td> <td>0</td> </tr> <tr> <td> Aesthetic Effect</td> <td>0</td> </tr> <tr> <td>Reactivity</td> <td></td> </tr> <tr> <td> Other Chemicals</td> <td>2</td> </tr> <tr> <td> Water</td> <td>0</td> </tr> <tr> <td> Self-Reaction</td> <td>2</td> </tr> </tbody> </table> 12.3 NFPA Hazard Classifications: <table border="1"> <thead> <tr> <th>Category</th> <th>Classification</th> </tr> </thead> <tbody> <tr> <td>Health Hazard (Blue)</td> <td>2</td> </tr> <tr> <td>Flammability (Red)</td> <td>4</td> </tr> <tr> <td>Reactivity (Yellow)</td> <td>1</td> </tr> </tbody> </table>	Category	Rating	Fire	4	Health		Vapor Irritant	2	Liquid or Solid Irritant	1	Poison	2	Water Pollution		Human Toxicity	0	Aquatic Toxicity	0	Aesthetic Effect	0	Reactivity		Other Chemicals	2	Water	0	Self-Reaction	2	Category	Classification	Health Hazard (Blue)	2	Flammability (Red)	4	Reactivity (Yellow)	1	13. PHYSICAL AND CHEMICAL PROPERTIES 13.1 Physical State at 15°C and 1 atm: Gas 13.2 Molecular Weight: 62.50 13.3 Boiling Point at 1 atm: $72^{\circ}\text{F} = 13.9^{\circ}\text{C} = 259.4^{\circ}\text{K}$ 13.4 Freezing Point: $-244.8^{\circ}\text{F} = -153.8^{\circ}\text{C} = -119.4^{\circ}\text{K}$ 13.5 Critical Temperature: $317.1^{\circ}\text{F} = 158.4^{\circ}\text{C} = 431.6^{\circ}\text{K}$ 13.6 Critical Pressure: 773 psi = 52.7 atm = 5.34 MN/m² 13.7 Specific Gravity: 0.940 at -13°C (liquid) 13.8 Liquid Surface Tension: 16.0 dynes/cm = 0.0160 N/m at 25°C 13.9 Liquid-Water Interfacial Tension: (est.) 30 dynes/cm = 0.03 N/m at 20°C 13.10 Vapor (Gas) Specific Gravity: 2.2 13.11 Ratio of Specific Heats of Vapor (Boyle): 1.106 13.12 Latent Heat of Vaporization: 160 Btu/lb = 68 cal/g = $3.7 \times 10^4 \text{ J/kg}$ 13.13 Heat of Combustion: -61.6 Btu/lb $-4520 \text{ cal/g} = -189 \times 10^3 \text{ J/kg}$ 13.14 Heat of Decomposition: Not pertinent 13.15 Heat of Solution: Not pertinent 13.16 Heat of Polymerization: -729 Btu/lb $-405 \text{ cal/g} = -16.9 \times 10^4 \text{ J/kg}$
Category	Rating																																				
Fire	4																																				
Health																																					
Vapor Irritant	2																																				
Liquid or Solid Irritant	1																																				
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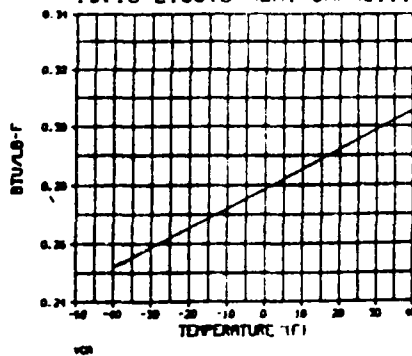
VINYL CHLORIDE

VCM

13.17 SATURATED LIQUID DENSITY



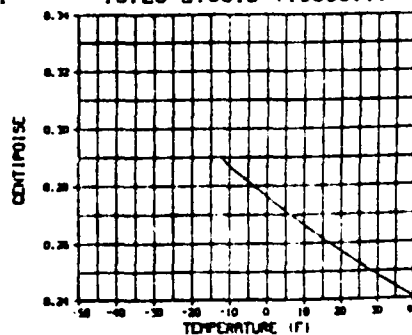
13.18 LIQUID HEAT CAPACITY



13.19 LIQUID THERMAL CONDUCTIVITY

NOT PERTINENT

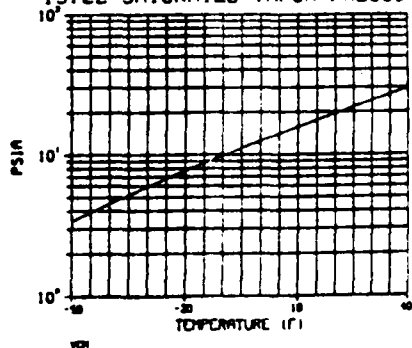
13.20 LIQUID VISCOSITY



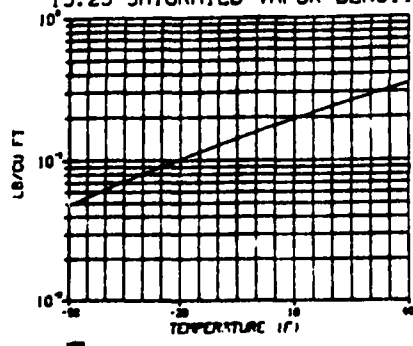
13.21 SOLUBILITY IN WATER

0.8 LB/100 LB WATER AT 68°F

13.22 SATURATED VAPOR PRESSURE



13.23 SATURATED VAPOR DENSITY



13.24 IDEAL GAS HEAT CAPACITY

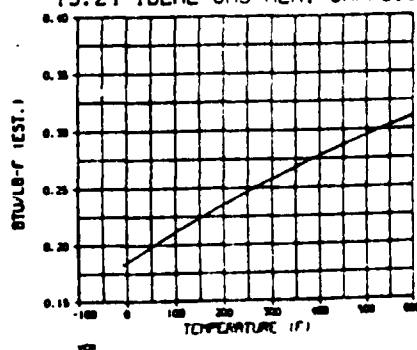


TABLE D-1 U.S. COAST GUARD - CAUTIONARY AND CORRECTIVE RESPONSE INDEX

	Cautionary Response							Corrective Response										Reference Key To Special Precautions/Information *	
	Restrict Access	Restrict Ignition	Evacuate	Restrict Human Use	Restrict Farm Use	Restrict Industrial Use	Dilute and Disperse	Stop discharge chemicals	Contain	Skim	Pump	Dredge	Burn	Neutralize	Absorption	Other Treatments	Clean Shore Line		Salvage Waterfowl
Ammonia, anhydrous	X	X	X	X			X	This response applies to all chemicals		X			X						1, 2, 5, 11, 20
Butadiene, inhibited	X	X	X		X	X												X	1, 2, 4, 6, 20
Chlorine	X	X	X	X	X	X	X												1, 2, 5, 8, 11, 20
1,1-Dimethylhydrazine	X	X	X	X	X	X	X												1, 2, 5, 12
Ethylene oxide	X	X	X				X												1, 2, 6, 20
Hydrazine	X	X	X	X	X	X	X							X					1, 2, 5, 6
Methylhydrazine	X	X	X	X	X	X	X												1, 2, 3, 5, 6, 8, 21
Nitrogen tetroxide	X	X	X	X	X	X	X												1, 2, 5, 8, 20
Oxygen, liquefied	X	X	X																1, 2, 6, 7, 20, 21
Propane	X	X	X															X	1, 2, 4, 6, 14, 20
Vinyl chloride	X	X	X	X			X											1, 2, 12, 20	

* Dilute and disperse only when other corrective methods cannot be used.
 ** Response index key in Table D-1

TABLE D-2 RESPONSE DEFINITIONS

A. CAUTIONARY RESPONSES

1. RESTRICT ACCESS - This response is invoked when appreciable danger arises from a flammable or toxic spill, and the general public (spectators) should be kept from the spill area. Access is restricted if ignition is considered possible (restrict ignition), or if evacuation is recommended.
2. RESTRICT IGNITION - This response is invoked when chemicals are involved which develop flammable vapors.
3. EVACUATE - This response is invoked when there is a very real danger that a highly flammable or toxic spill may spread, or develop a detrimental reaction with water. This category includes flammable chemicals and extremely toxic chemicals, e.g. poisonous gases.
4. RESTRICT HUMAN USE - This response is invoked when mostly soluble substances or those which are exceptionally toxic are involved in a spill. The primary danger is that of ingesting the chemicals in drinking water.
5. RESTRICT FARM USE - This response is invoked when a toxic chemical contaminant is spilled in water used for irrigation or animals.
6. RESTRICT INDUSTRIAL USE - This response is invoked when the spill contains chemicals which could corrode machinery, or if the possibility of ignition from highly flammable organics is developed. Those chemicals which upon heating could release poisonous gases could also cause this response to be invoked; as could those which might form an insulating film on internal boiler surfaces.

B. CORRECTIVE RESPONSES

It is possible that several responses may be appropriate for a particular chemical spill. On-site conditions will dictate which responses are required. Also, a chemical could exist in more than

TABLE D-2 RESPONSE DEFINITIONS (continued)

one physical form and thus require several ameliorative responses. In cases where multiple responses are checked, "dilute and disperse" should be the last response implemented.

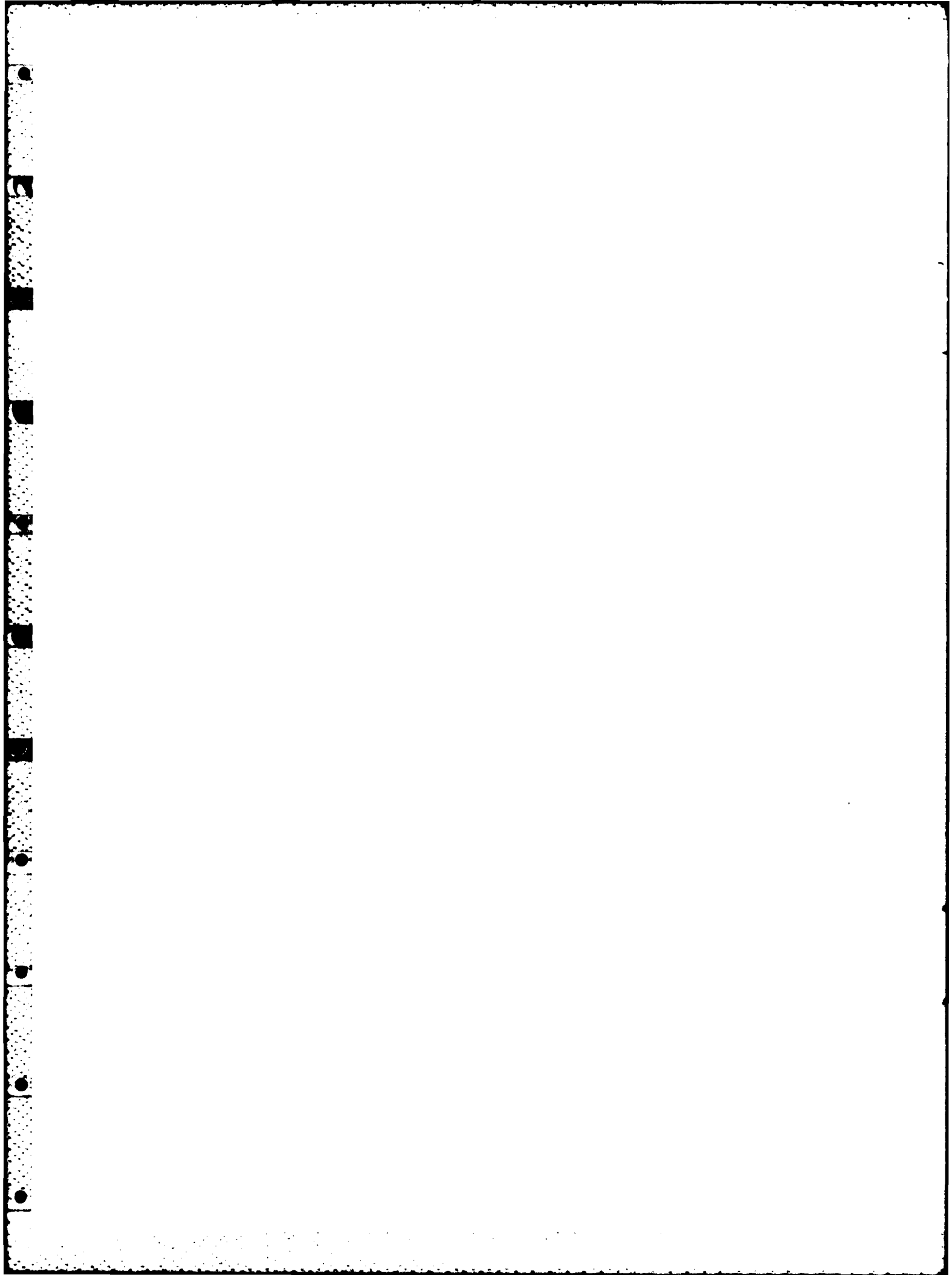
1. DILUTE AND DISPERSE - This response is invoked to handle spills primarily involving dissolved species which are dangerous in a concentrated state. The situation can be ameliorated by water jets, propellers, or similar means of agitation spreading and mixing.
2. CONTAIN - This response is invoked to contain spills involving insoluble species which form surface slicks. Slicks having vapors of very low flammability may be contained near ships, piers, etc., but highly flammable materials should only be confined in areas which are remote from ignition sources. Explosion-proof equipment should be employed. Corrosivity with respect to materials should also be considered.
3. SKIM - This response is invoked to handle insoluble species which float and foam surface slicks. Corrosivity with respect to hoses and pump should be considered.
4. PUMP - This response is invoked to handle insoluble species which sink (particularly liquids or finely divided solids), but which may be pumped directly from the spill. Again, corrosivity should be considered.
5. DREDGE - This response is invoked to handle insoluble species which sink (solids and some liquids).
6. BURN - This response is invoked to handle highly flammable floating chemicals. Even though there is an ignition danger, the "contain" category is checked. Containment may have to be accomplished by air barriers, herders, or expendable booms since few booms are fire-resistant.

TABLE D-2 RESPONSE DEFINITIONS (continued)

7. NEUTRALIZE - This response is invoked to handle acids, bases, oxidants, or reductants. Calcium hypochlorite or caustic soda is often used in neutralization. This response action is largely confined to still or confined non-flowing waters.
8. ABSORPTION - This response is invoked to handle chemical species which can be absorbed or adsorbed. These species which form surface slicks (float) and include: oil-like chemicals, solvents, toxic compounds (e.g. pesticides and halogenated hydrocarbons). Treatment by iron exchange is also possible for miscible chemicals. Materials for sorption include hay, paper, styrofoam, plastic, glass beads, charcoal and iron exchange resins.
9. OTHER TREATMENTS - This response is invoked to handle oils and other floating materials by specialized methods. These treatments include the use of emulsifiers, dispersants, sinking agents, coagulants and flocculants. Biological degradation is also included in this category.
10. CLEAN SHORE LINE - This response is invoked to handle insolubles (especially oils) with high surface tensions.
11. SALVAGE WATERFOWL - This response is invoked when it is deemed feasible to salvage waterfowl that have been exposed to an oil discharge.

TABLE D-3 REFERENCE KEY TO RESPONSE INDEX

1. Avoid inhalation. Vapors or dust are irritating or toxic.
2. Avoid direct contact. Contact with skin or eyes can cause irritation or burns.
3. No ignition hazard once material is dissolved, reacted, or covered with water.
4. Burning may be prohibited by anti-air pollution laws and regulations.
5. Poisonous gas or vapor danger. Substance is highly volatile.
6. Flammable or explosive gas or vapor danger. Substance is highly volatile.
7. Powerful oxidant - explosion and/or fire hazard in the presence of organic matter.
8. Highly corrosive, particularly to eyes and skin.
9. Sorbs strongly on bottom sediments. Substance is not at all soluble or reactive.
10. Reacts with water to form explosive or flammable gas or vapor.
11. Water reactive compound which reacts vigorously or violently. Disperse or neutralize contaminated waters after reaction subsides.
12. Burning not recommended; fire difficult to control and/or poisonous gas is formed.
13. Cover with organic sulfur-containing compounds or free sulfur.
14. Clean burning.
15. Sooty burning.
16. DO NOT ADD water to chemical; AFTER the chemical has reacted with water, the resulting alkaline solution can be diluted.
17. Floating solid.
18. Strong acids formed in water.
19. First try to contain and skim; THEN dilute and disperse what has dissolved in water.
20. Chemical shipped as gas or liquefied compressed gas; depending on atmospheric conditions, a large portion of the hazard will be dissipated with no action necessary.
21. Has unusual fire or toxicity hazards. See the hazardous chemical data sheets for chemical.
22. May float or sink as insoluble substance or dissolve like miscible substance. See the hazardous chemical data sheets for chemicals.



EPA - MANUAL FOR THE CONTROL OF HAZARDOUS MATERIALS
SPILLS: VOLUME 1

TABLE E-1 SPILLS ON LAND

TYPE	APPLICATION OR CONSTRUCTION METHOD	USE	ADVANTAGES	DISADVANTAGES
Dikes Earthen	Create with bulldozer or earth- moving equipment to compact earth (height depends on earth type)	Flat or sloped surface	1. Material on site 2. Construct with common equipment 3. Construct quickly	1. Natural permeability of soil 2. Seepage through ground 3. Surface composition of soil not suitable in all cases
Foamed Polyurethane	Use trained personnel to construct	Hard, dry surfaces	1. Hold up to several feet of water (1)	1. Leaks on wet ground 2. Hard to obtain disper- sion device
Foamed Concrete	Use trained personnel to construct	Flat ground Slow moving spill	1. Better adhesion to substrates (clay/ shale/grass)	1. Hard to obtain foam and dispersion device 2. Must set for a time period Will not hold high hydraulic heads (15)
Evacuation	Bulldozer or earthmoving equipment - line if possible	Soft ground Natural cavitation	1. Material on site 2. Construct with common equipment	1. Move large amounts of material 2. Natural permeability of soil 3. Surface of soil not suitable in all cases
Evacuation & Dikes	Bulldozer or earthmoving equipment - line if possible	Soft ground	1. Need less space than separate 2. Material on site 3. Construct with common equipment	1. Move large amounts of material 2. Natural permeability of soil 3. Surface of soil not suitable in all cases

TABLE E-2 SPILLS IN WATER - HEAVIER THAN WATER SPILLS

TECHNIQUE	APPLICATION OR CONSTRUCTION METHOD	USE	ADVANTAGES	DISADVANTAGES
Natural Excavations and Dikes	None	Where a natural barrier exists	No construction needed	Can't control the area which contains the spill
Construction of Excavation and Dikes	Dredges: hydraulic or vacuum pumps Divers with pumps then place concrete or sand bags around to form dike if bottom material is not sufficient	If bottom can be moved	Material is on site	1. Hard to construct 2. Stirred up bottom may cause dispersion and increased turbidity

TABLE E-3 SPILLS IN WATER - SOLUBLE OR MISCIBLE SPILLS

METHOD	APPLICATION OR CONSTRUCTION MATERIALS	USE	ADVANTAGES	DISADVANTAGES
Sealed booms	Boom Device to anchor	Contain depth limited volumes leaking containers	Contain entire depth of water	1. Deployment difficult 2. Not used for large bodies 3. Difficult to get good seal(16)
Diversion of Uncontaminated Flow	Earthmoving Equipment	Special area where topography is right	1. Can put cleaned water into diverted stream 2. Used for flowing water	1. Difficult to move large amounts of earth 2. Clear area needed 3. Impermeability of ground
Diversion of Contaminated Flow	Block entrance with sandbags, sealed booms or dikes	Special area where topography is right	1. Can put clean water back into stream 2. Used for flowing water	1. Difficult to move large amount of earth 2. Clear area needed 3. Impermeability of ground 4. Adverse environmental impact
Gelling Agent (40)	Gels, Dispersion Devices; use experienced personnel	If small volumes	1. Stop flowing contaminant 2. Stop permeation	1. Hard to obtain 2. Can't use in large area 3. Must haul to dispose
Containment of Entire Waterbody	Diking Materials Earthmoving Equipment Sandbags, etc. Lining	For entirely contaminated area	1. Can allow containment of a large waterbody 2. Materials on site 3. Easily constructed	1. Not all waterbodies have containable overflow 2. Permeability 3. May be an unstable condition

TABLE E-4 SPILLS IN WATER - FLOATING SPILLS

METHOD	APPLICATION OF CONSTRUCTION MATERIALS	USE	REFERENCE*	ADVANTAGES	DISADVANTAGES
Foams	Varies; need deployment device	Not too much current	CG-446-4 (41) p. 6-10 to 6-25	Used on large area; Many varieties	1. Only in waves < 2-4 feet 2. Current speed < 0.7 knots
Weirs	Weir & Boat	Calm	CG-446-4 (41) p. 6-25	Not easily clogged; Collects & contains	Not used in rough water
Pneumatic Barriers	Air compressor diffuser deployment method	Only shallow water	CG-446-4 (41) p. 6-25	Do not create a physical barrier to vessels	1. Not in rough water 2. Only shallow water 3. Only thin layers or materials
Spill Herding Methods	Chemicals on water spray or prop. wash	To protect shore or other facilities	CG-446-4 (41) p. 6-31 to 6-35	Useful in rough water	1. Not easily obtainable 2. Not 100% effective

TABLE E-5 SPILLS IN AIR

TECHNIQUE	METHOD	USE	ADVANTAGES	DISADVANTAGES
Mist Knock Down	Spray fine mist into air	Water soluble or low lying vapors	Removes hazard from air	Create water pollution problem and must be contained in solution
Fans or Blowers	Disperse air by directing blower toward it	Very calm and sheltered areas	Can direct air away from populated areas	1. Not at all effective if any wind 2. Need large capacity of blowers 3. Hard to control

TABLE E-6 EPA - SUGGESTED TREATMENT SCHEMES

CHEMICAL	APPROPRIATE BIOLOGICAL TREATMENT AT MUNICIPAL STP	TREATMENT SCHEME	TREATMENT SPECIFICATIONS	COMMENTS
Ammonia (in water aqueous ammonia or ammonium hydroxide)	When diluted (and neutralized if necessary)		1. Neutralize to pH 7 with HCl 2. Add H_2SO_4 to pH 6-7 /exchange/neutralize to pH 7	Ammonium will exert oxygen demand on receiving body unless removed or oxidized. Adjusting pH to 6 insures formation of NH_4^+ if needed for resin
Chlorine	When reduced and diluted		Add H_2SO_4 to pH 2-3; add Na bisulfite until small or no chlorine residual; neutralize to pH 7	Carbon can be used for low concentration of Cl_2
Nitrogen Dioxide (Tetroxide)	After neutralization and dilution		Add $Ca(OH)_2$ to pH 7-8 dilute with water	Beware of flashfire Self contained breaking apparatus mandatory/lime addition forms nitrates which require dilution

APPENDIX F

AAR - EMERGENCY HANDLING OF HAZARDOUS MATERIALS IN SURFACE TRANSPORTATION

ANHYDROUS AMMONIA NONFLAMMABLE GAS, CORROSIVE STCC 4904210

Anhydrous ammonia is a clear colorless gas with a characteristic odor. Although it is classed as a nonflammable gas, it will burn within certain vapor concentration limits, and it will increase fire hazard in the presence of oil or other combustible materials. Its "combustibility" is definitely not a common problem in the event of leakage. It is shipped as a liquid under pressure. Contact with the liquid can cause frostbite. It is soluble in water forming a corrosive liquid. Although ammonia is lighter than air, the vapors from a leak initially hug the ground.

If Material Involved in Fire

- Extinguish fire using agent suitable for type of surrounding fire (Material itself does not burn or burns with difficulty.)
- Cool all affected containers with flooding quantities of water
- Apply water from as far a distance as possible
- Use water spray to absorb vapors

If Material Not Involved in Fire

- Keep material out of water sources and sewers
- Attempt to stop leak if without hazard
- Use water spray to knock-down vapors

Personnel Protection

- Avoid breathing vapors
- Keep upwind
- Wear self-contained breathing apparatus
- Avoid bodily contact with the material
- Wear boots, protective gloves, and safety glasses
- Do not handle broken packages without protective equipment
- Wash away material which may have contacted the body with copious amounts of water or soap and water
- If contact with the material anticipated, wear full protective clothing

Evacuation

- If material leaking (not on fire), downwind evacuation must be considered

BUTADIENE, INHIBITED (Butadiene from Petroleum)
FLAMMABLE GAS
STCC 4905704

Butadiene, inhibited is a colorless gas with an aromatic odor. It is shipped as a liquefied gas under its vapor pressure. Contact with the liquid can cause frostbite. It must be shipped inhibited as butadiene is liable to polymerization. If polymerization were to take place in a cylinder or tank car, the cylinder or tank car may violently rupture. It is easily ignited. Its vapor is heavier than air and a flame can flash back to the source of leak very easily. It can asphyxiate by the displacement of air. Under fire conditions the cylinders or tank cars may violently rupture and rocket.

If Material on Fire or Involved in Fire

- Do not extinguish fire unless flow can be stopped
- Use water in flooding quantities as fog
- Cool all affected containers with flooding quantities of water
- Apply water from as far a distance as possible

If Material Not on Fire and Not Involved in Fire

- Keep sparks, flames, and other sources of ignition away
- Keep material out of water sources and sewers
- Attempt to stop leak if without hazard
- Use water spray to knock-down vapors

Personnel Protection

- Avoid breathing vapors
- Keep upwind
- Wear protective gloves and safety glasses
- Do not handle broken packages without protective equipment
- Approach fire with caution

Evacuation

- If fire becomes uncontrollable or container is exposed to direct flame - evacuate for a radius of 2500 feet
- If material leaking (not on fire), downwind evacuation must be considered

CHLORINE
NONFLAMMABLE GAS, POISONOUS
STCC 4904120

Chlorine is a greenish yellow gas with a pungent suffocating odor. It is toxic by inhalation. It is soluble in water. It reacts explosively or forms explosive compounds with many common chemicals. It is normally shipped as a liquid in cylinders or tank cars. Contact with liquid should be avoided as it can cause frostbite; the liquid does readily vaporize to gas. The vapors are much heavier than air and tend to settle in low areas.

If Material Involved in Fire

- Extinguish fire using agent suitable for type of surrounding fire (Material itself does not burn or burns with difficulty.)
- Cool all affected containers with flooding quantities of water
- Apply water from as far a distance as possible
- Use water spray to absorb vapors

If Material Not Involved in Fire

- Keep material out of water sources and sewers
- Attempt to stop leak if without hazard
- Use water spray to knock-down vapors

Personnel Protection

- Avoid breathing vapors
- Keep upwind
- Wear self-contained breathing apparatus
- Avoid bodily contact with the material
- Wear full protective clothing
- Do not handle broken packages without protective equipment
- Wash away material which may have contacted the body with copious amounts of water or soap and water

Evacuation

- If material leaking (not on fire), evacuate for a radius of 2500 feet

ETHYLENE OXIDE
FLAMMABLE LIQUID, CORROSIVE
THERMALLY UNSTABLE
STCC 4906610

Ethylene oxide is a clear, colorless, volatile liquid with an ethereal odor. It has a flash point of less than 0 deg. F, and is flammable over a wide vapor-air concentration range. The material has to be diluted on the order of 24 to 1 with water before the liquid loses its flammability. If contaminated it may polymerize violently with evolution of heat and rupture of its container. The vapors may burn inside a container. The vapors are irritating to the eyes, skin, and respiratory system. Prolonged contact with the skin may result in delayed burns. It is lighter than water and soluble in water. The vapors are heavier than air.

If Material on Fire or Involved in Fire

- Do not extinguish fire unless flow can be stopped
- Use water in flooding quantities as fog
- Solid streams of water may be ineffective
- Cool all affected containers with flooding quantities of water
- Apply water from as far a distance as possible
- Use "alcohol" foam, carbon dioxide or dry chemical

If Material Not On Fire and Not Involved In Fire

- Keep sparks, flames, and other sources of ignition away
- Keep material out of water sources and sewers
- Build dikes to contain flow as necessary
- Attempt to stop leak if without hazard
- Use water spray to disperse vapors and dilute standing pools of liquid

Personnel Protection

- Avoid breathing vapors
- Keep upwind
- Wear self-contained breathing apparatus
- Avoid bodily contact with the material
- Wear full protective clothing
- Do not handle broken packages without protective equipment
- Wash away material which may have contacted the body with copious amounts of water or soap and water

ETHYLENE OXIDE (continued)

Evacuation

- If fire is prolonged and material is confined in the container - evacuate for a radius of 5000 feet
- If fire becomes uncontrollable or container is exposed to direct flame - evacuate for a radius of 5000 feet

**HYDRAZINE, ANHYDROUS
FLAMMABLE LIQUID, POISONOUS, CORROSIVE
THERMALLY UNSTABLE
STCC 4906225**

Hydrazine, anhydrous is a colorless, fuming oily liquid with an ammonia like odor. It has a flash point of 99 deg. F. It can ignite spontaneously on contact with oxidizers, and may ignite spontaneously on contact with porous materials such as earth, wood and cloth. It is toxic by inhalation and by skin absorption. It is corrosive to tissue. Toxic oxides of nitrogen are produced during combustion of this material.

If Material on Fire or Involved in Fire

- Do not extinguish fire unless flow can be stopped
- Use water in flooding quantities as fog
- Solid streams of water may be ineffective
- Cool all affected containers with flooding quantities of water
- Apply water from as far a distance as possible
- Use "alcohol" foam, carbon dioxide or dry chemical

If Material Not On Fire and Not Involved in Fire

- Keep sparks, flames, and other sources of ignition away
- Keep material out of water sources and sewers
- Build dikes to contain flow as necessary
- Attempt to stop leak if without hazard
- Use water spray to disperse vapors and dilute standing pools of liquid

Personnel Protection

- Avoid breathing vapors
- Keep upwind
- Wear self-contained breathing apparatus
- Avoid bodily contact with the material
- Wear full protective clothing
- Do not handle broken packages without protective equipment
- Wash away material which may have contacted the body with copious amounts of water or soap and water

Evacuation

- If fire becomes uncontrollable or container is exposed to direct flame - evacuate for a radius of 2500 feet
- If material leaking (not on fire), downwind evacuation must be considered

**HYDROGEN
FLAMMABLE GAS
STCC 4905746**

Hydrogen is a colorless, odorless gas. It is easily ignited. It is lighter than air, but a flame can flash back to the source of the leak very easily. It is flammable over a wide range of vapor air concentrations. It may be shipped in cylinders and special tank cars. Under fire conditions the cylinders may violently rupture and rocket.

If Material on Fire or Involved in Fire

- Do not extinguish fire unless flow can be stopped
- Use water in flooding quantities of water
- Apply water from as far a distance as possible

If Material Not on Fire and Not Involved in Fire

- Keep sparks, flames, and other sources of ignition away
- Keep material out of water sources and sewers
- Attempt to stop leak if without hazard
- Use water spray to knock-down vapors

Personnel Protection

- Avoid breathing vapors
- Keep upwind
- Wear protective gloves and safety glasses
- Do not handle broken packages without protective equipment
- Approach fire with caution

Evacuation

- If fire becomes uncontrollable or container is exposed to direct flame - evacuate for a radius of 1500 feet
- If material leaking (not on fire), downwind evacuation must be considered

METHYL HYDRAZINE
FLAMMABLE LIQUID, POISONOUS, CORROSIVE
THERMALLY UNSTABLE
STCC 4906230

Methyl hydrazine is a colorless liquid with an ammonia like odor. It has a flash point of 17 deg. F. It is flammable over a wide range of vapor air concentrations. It may ignite spontaneously in contact with porous materials such as earth, wood, cloth, etc., and with oxidizing materials. It is toxic and the vapors attack the eyes and respiratory system. It is also corrosive to the skin. It is lighter than water and slightly soluble in water. The vapors are heavier than air. Prolonged exposure of the containers of the material to fire or heat may result in spontaneous decomposition of the material and violent rupture of the container. Toxic oxides of nitrogen are produced during combustion of this material.

If Material on Fire or Involved in Fire

- Do not extinguish fire unless flow can be stopped
- Use water in flooding quantities as fog
- Solid streams of water may be ineffective
- Cool all affected containers with flooding quantities of water
- Apply water from as far a distance as possible
- Use "alcohol" foam, carbon dioxide or dry chemical

If Material Not on Fire and Not Involved in Fire

- Keep sparks, flames, and other sources of ignition away
- Keep material out of water sources and sewers
- Build dikes to contain flow as necessary
- Attempt to stop leak if without hazard
- Use water spray to disperse vapors and dilute standing pools of liquid

Personnel Protection

- Avoid breathing vapors
- Keep upwind
- Wear self-contained breathing apparatus
- Avoid bodily contact with the material
- Wear full protective clothing
- Do not handle broken packages without protective equipment
- Wash away material which may have contacted the body with copious amounts of water or soap and water

METHYL HYDRAZINE (continued)

Evacuation

- If fire becomes uncontrollable or container is exposed to direct flame - evacuate for a radius of 5000 feet
- If material leaking (not on fire), downwind evacuation must be considered

NITROGEN TETROXIDE, LIQUID
POISON A, OXIDIZING
STCC 4920360

Nitrogen tetroxide liquid is a reddish brown colored gas which becomes a yellowish brown liquid on cooling or compressing. It is shipped as a liquefied gas under its vapor pressure. Its vapor is heavier than air. It dissolves in water forming nitric acid, a corrosive material. It is noncombustible, but will accelerate the burning of combustible materials. It is toxic by inhalation and by skin absorption. The cylinders and "ton container" tank cars may not be equipped with a safety relief device. Prolonged exposure to fire or heat can cause the violent rupturing and rocketing of the cylinders and "ton container" tank cars, and the possible violent rupturing and rocketing of the single unit tank car.

If Material Involved in Fire

- Do not use carbon dioxide
- Extinguish fire using agent suitable for type of surrounding fire (Material itself does not burn or burns with difficulty.)
- Use water in flooding quantities as fog
- Cool all affected containers with flooding quantities of water
- Apply water from as far a distance as possible
- Use "alcohol" foam, carbon dioxide or dry chemical

Personnel Protection

- Avoid breathing vapors
- Keep upwind
- Wear self-contained breathing apparatus
- Avoid bodily contact with the material
- Wear full protective clothing
- Do not handle broken packages without protective equipment
- Wash away material which may have contacted the body with copious amounts of water or soap and water

Evacuation

- If material leaking (not on fire) evacuate for a radius of 2500 feet

OXYGEN, PRESSURIZED LIQUID
NONFLAMMABLE GAS, OXIDIZING
STCC 4904360

Oxygen, pressurized liquid is an odorless, colorless to light blue liquid. It is non-combustible but it will actively support the burning of combustible material. Contact with liquid make many normally hard to burn materials readily combustible. When the liquid contacts combustible or oxidizable materials, an explosion may result. Contact with the liquid will cause frostbite. Leaked or spilled material will readily vaporize to the gaseous state. It may only be shipped in cylinders.

If Material Involved in Fire

- Dangerously explosive
- Cool all affected containers with flooding quantities of water
- Do not use water on material itself
- Apply water from as far a distance as possible

If Material Not Involved in Fire

- Keep sparks, flames, and other sources of ignition away
- Attempt to stop leak if without hazard
- Do not use water on material itself

Personnel Protection

- Wear boots, protective gloves, and safety glasses
- Do not handle broken packages without protective equipment
- Approach fire with caution

Evacuation

- If fire becomes uncontrollable or container is exposed to direct flame - evacuate for a radius of 1500 feet

PROPANE
FLAMMABLE GAS
STCC 490581

Propane is a colorless gas with a faint petroleum like odor. It is shipped as a liquefied gas under its vapor pressure. For transportation it may be stenciled. Contact with the liquid can cause frostbite. It is easily ignited. Its vapors are heavier than air and a flame can flash back to the source of leak very easily. This leak can be either a liquid or vapor leak. It can asphyxiate by the displacement of air. Under fire conditions the cylinders or tank cars may violently rupture and rocket.

If Material on Fire or Involved in Fire

- Do not extinguish fire unless flow can be stopped
- Use water in flooding quantities as fog
- Cool all affected containers with flooding quantities of water
- Apply water from as far a distance as possible

If Material Not On Fire and Not Involved in Fire

- Keep sparks, flames, and other sources of ignition away
- Keep material out of water sources and sewers
- Attempt to stop leak if without hazard
- Use water spray to knock-down vapors

Personnel Protection

- Avoid breathing vapors
- Keep upwind
- Wear protective gloves and safety glasses
- Do not handle broken packages without protective equipment
- Approach fire with caution

Evacuation

- If fire becomes uncontrollable or container is exposed to direct flame - evacuate for a radius of 2500 feet
- If material leaking (not on fire), downwind evacuation must be considered

VINYL CHLORIDE
FLAMMABLE GAS
STCC 4905792

Vinyl chloride is a colorless gas with a sweet odor. It is shipped as a liquefied gas under its vapor pressure. Contact with the liquid can cause frostbite. It is easily ignited. Its vapors are heavier than air and a flame can flash back to the source of leak very easily. This leak may be either a liquid or vapor leak. It can asphyxiate by the displacement of air. Under fire conditions the cylinders or tank cars may violently rupture and rocket. Prolonged exposures of the cylinders or tank cars to heat or fire may cause the material to polymerize with possible container rupture. This material is thought to be a cancer suspect agent on long term exposure to low concentrations. However, this effect has not been demonstrated for single exposures to high concentrations of the material.

If Material on Fire or Involved in Fire

- Do not extinguish fire unless flow can be stopped
- Use water in flooding quantities as fog
- Cool all affected containers with flooding quantities of water
- Apply water from as far a distance as possible

If Material Not On Fire and Not Involved in Fire

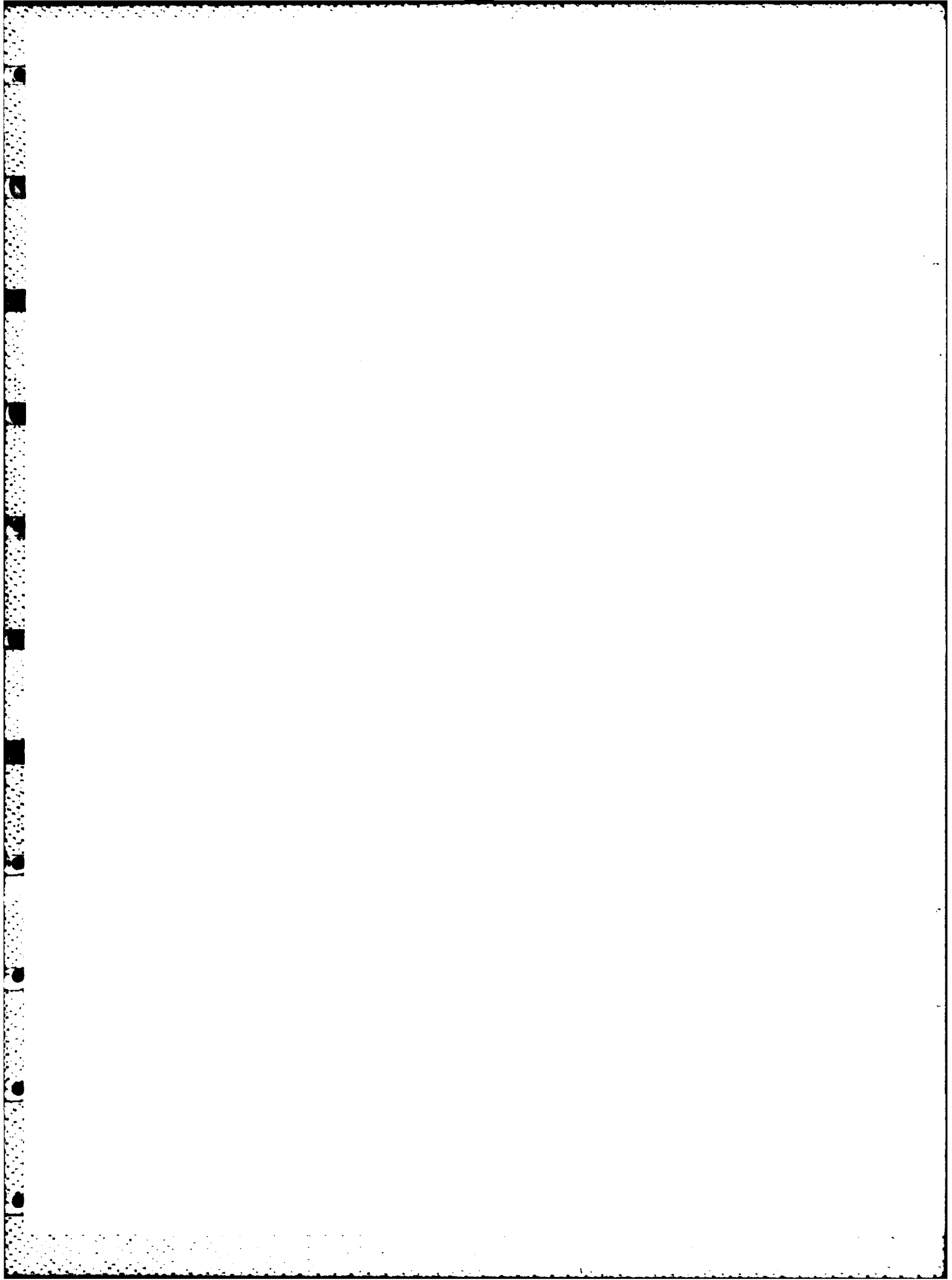
- Keep sparks, flames, and other sources of ignition away
- Keep material out of water sources and sewers
- Attempt to stop leak if without hazard
- Use water spray to knock-down vapors

Personnel Protection

- Avoid breathing vapors
- Keep upwind
- Wear self-contained breathing apparatus
- Wear protective gloves and safety glasses
- Do not handle broken packages without protective equipment
- Approach fire with caution

Evacuation

- If fire becomes uncontrollable or container is exposed to direct flame - evacuate for a radius of 2500 feet
- If material leaking (not on fire), downwind evacuation must be considered



APPENDIX G

DOT-HAZARDOUS MATERIALS EMERGENCY RESPONSE GUIDE

DOT RESPONSE GUIDE 5

ANHYDROUS AMMONIA - UN 1005

POTENTIAL HAZARDS

Health Hazards

- Poison (if inhaled may be fatal)
- Contact may cause burns to skin and eyes
- Contact with liquid may cause frostbite
- Runoff from fire control or dilution water may cause pollution

Fire or Explosion

- Some of these materials may burn, but do not ignite readily
- Container may explode in heat of fire

IN CASE OF ACCIDENT

- Keep unnecessary people away
- Stay upwind; keep out of low areas
- Isolate hazard area and deny entry
- Wear positive pressure breathing apparatus and full protective clothing
- Evacuate area endangered by poison gas (see distance table, Part 4)
- FOR EMERGENCY ASSISTANCE CALL CHEMTREC (800) 424-9300 (in case of water pollution call local authorities)

Fire

- Small Fires: Dry chemical or CO₂
- Large Fires: Water spray, fog or foam
- Move container from fire area if you can do it without risk
- Stay away from ends of tanks
- Cool containers that are exposed to flames with water from the side until well after fire is out
- Isolate area until gas has dispersed

Spill or Leak

- Stop leak if you can do it without risk
- Use water spray to reduce vapors

DOT RESPONSE GUIDE 5 (continued)

ANHYDROUS AMMONIA - UN 1005

First Aid

- Move victim to fresh air; call emergency medical care
- If not breathing, give artificial respiration
- If breathing, is difficult, give oxygen
- Remove and isolate contaminated clothing and shoes
- In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes
- Keep victim quiet and maintain normal body temperature
- Effects may be delayed, keep victim under observation

DOT RESPONSE GUIDE 10
CHLORINE - UN 1017
NITROGEN TETROXIDE - UN 1067

POTENTIAL HAZARDS

Fire or Explosion

- May ignite combustibles (wood, paper, oil, etc.)
- Mixture with fuels may explode
- Container may explode in heat of fire
- Vapor explode in heat of fire
- Vapor explosion and poison hazard indoors, outdoors or in sewers

Health Hazards

- Poison (if inhaled may be fatal)
- Contact may cause burns to skin or eyes
- Contact with liquid may cause frostbite
- Runoff from fire control or dilution water may cause pollution

IN CASE OF ACCIDENT

- Keep unnecessary people away
- Stay upwind; keep out of low areas
- Isolate hazard area and deny entry
- Wear positive pressure breathing apparatus and full protective clothing
- Evacuate area endangered by poison gas (see distance table, Part 4)
- FOR EMERGENCY ASSISTANCE CALL CHEMTREC (800) 424-9300 (in case of water pollution call local authorities)

Fire

- Small Fires: Dry chemical or CO₂
- Large Fires: Water spray, fog or foam
- Move container from fire area if you can do it without risk
- Stay away from ends of tanks
- Cool containers that are exposed to flames with water from the side until well after fire is out
- For massive fire in cargo area, use unmanned hose holder or monitor nozzles
- If this is impossible, withdraw from area and let fire burn

DOT RESPONSE GUIDE 10 (continued)

CHLORINE - UN 1017

NITROGEN TETROXIDE - UN 1067

Spill or Leak

- Keep combustibles (wood, paper, oil, etc.) away from spilled material
- Stop leak if you can do it without risk
- Use water spray to reduce vapors

First Aid

- Move victim to fresh air; call emergency medical care
- If not breathing, give artificial respiration
- If breathing is difficult, give oxygen
- Remove and isolate contaminated clothing and shoes
- In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes
- Keep victim quiet and maintain normal body temperature
- Effects may be delayed, keep victim under observation

DOT RESPONSE GUIDE 20
ETHYLENE OXIDE - UN 1040

POTENTIAL HAZARDS

Fire or Explosion

- Will burn. May be ignited by heat, sparks and flames
- Flammable vapor may be spread away from spill
- Container may explode in heat of fire
- Vapor explosion and poison hazard indoors, outdoors or in sewers
- Runoff to sewer may create fire or explosion hazard

Health Hazards

- Poison. May be fatal if inhaled, swallowed or absorbed through skin
- Contact may cause burns to skin or eyes
- Runoff from fire control or dilution water may cause pollution

IN CASE OF ACCIDENT

- Keep unnecessary people away; isolate hazard area and deny entry
- Stay upwind; keep out of low areas
- Wear positive pressure breathing apparatus and special protective clothing
- Isolate for 1/2 mile in all directions if tank or tankcar is involved in fire
- FOR EMERGENCY ASSISTANCE CALL CHEMTREC (800) 424-9300 (in case of water pollution call local authorities)

Fire

- Small Fires: Dry chemical or CO₂, water spray or foam
- Large Fires: Water spray, fog or foam
- Stay away from ends of tanks
- Do not get water inside container
- Cool containers that are exposed to flames with water from the side until well after fire is out
- For massive fire in cargo area, use unmanned hose holder or monitor nozzles
- If this is impossible, withdraw from area and let fire burn
- Withdraw immediately in case of rising sound from venting safety device or discoloration of tank

DOT RESPONSE GUIDE 20 (continued)

ETHYLENE OXIDE - UN 1040

Spill or Leak

- No flares, smoking or flames in hazard area
- Do not touch spilled material
- Stop leak if you can do it without risk
- Use water spray to reduce vapors
- Small Spills: Flush area with flooding amounts of water
- Do not get water inside containers
- Large Spills: Dike far ahead of spill for later disposal

First Aid

- Move victim to fresh air; call emergency medical care
- If not breathing, give artificial respiration
- If breathing is difficult, give oxygen
- Remove and isolate contaminated clothing and shoes
- In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes
- Keep victim quiet and maintain normal body temperature
- Effects may be delayed, keep victim under observation.

DOT RESPONSE GUIDE 12
LIQUID HYDROGEN - UN 1966
PROPANE - UN 1075

POTENTIAL HAZARDS

Fire or Explosion

- Extremely flammable
- May be ignited by heat, sparks and flames
- Container may explode in heat of fire
- Vapor explosion and poison hazard indoors, outdoors or in sewers

Health Hazards

- Vapors may cause dizziness or suffocation
- Contact will cause severe frostbite
- Fire may produce irritating or poisonous gases

IN CASE OF ACCIDENT

- Keep unnecessary people away
- Stay upwind; keep out of low areas
- Isolate hazard area and deny entry
- Wear self-contained breathing apparatus and full protective clothing
- Isolate for 1/2 mile in all directions if tank or tankcar is involved in a fire
- FOR EMERGENCY ASSISTANCE CALL CHEMTREC (800) 424-9300

Fire

- Let burn unless leak can be stopped immediately
- Small Fires: Dry chemical or CO₂
- Large Fires: Water spray, fog or foam
- Move container from fire area if you can do it without risk
- Stay away from ends of tanks
- Cool containers that are exposed to flames with water from the side until well after fire is out
- For massive fire in cargo area, use unmanned hose holder or monitor nozzles
- If this is impossible, withdraw from area and let fire burn
- Withdraw immediately in case of rising sound from venting safety device or discoloration of tank

DOT RESPONSE GUIDE 12 (continued)

LIQUID HYDROGEN - UN 1966

PROPANE - UN 1075

Spill or Leak

- No flares, smoking or flames in hazard area
- Do not touch spilled material
- Stop leak if you can do it without risk
- Use water spray to reduce vapors
- Isolate area until gas has dispersed

First Aid

- Move victim to fresh air; call emergency medical care
- If not breathing, give artificial respiration
- If breathing is difficult, give oxygen
- In case of frostbite, thaw frosted parts with water
- Keep victim quiet and maintain normal body temperature

DOT RESPONSE GUIDE 28
HYDRAZINE ANHYDROUS - UN 2029
METHYLHYDRAZINE - UN 1244
UNSYMMETRICAL DIMETHYLHYDRAZINE - UN 1163

POTENTIAL HAZARDS

Fire or Explosion

- Will burn. May be ignited by heat, sparks and flames
- Flammable vapor may spread away from spill
- Container may explode in heat of fire
- Vapor explosion and poison hazard indoors, outdoors or in sewers
- Runoff to sewer may create fire or explosion hazard

Health Hazards

- Poison. May be fatal if inhaled, swallowed or absorbed through skin
- Contact may cause burns to skin or eyes
- Runoff from fire control or dilution water may cause pollution

IN CASE OF ACCIDENT

- Keep unnecessary people away; isolate hazard area and deny entry
- Stay upwind; keep out of low areas
- Wear positive pressure breathing apparatus and full protective clothing
- Isolate for 1/2 mile in all directions if tank or tankcar is involved in a fire
- FOR EMERGENCY ASSISTANCE CALL CHEMTREC (800) 424-9300 (in case of water pollution call local authorities)

Fire

- Small Fires: Dry chemical or CO₂, water spray or foam
- Large Fires: Water spray, fog or foam
- Move container from fire area if you can do it without risk
- Stay away from ends of tanks
- Cool containers that are exposed to flames with water from the side until well after fire is out
- Withdraw immediately in case of rising sound from venting safety device or discoloration of tank

DOT RESPONSE GUIDE 28 (continued)
HYDRAZINE ANHYDROUS - UN 2029
METHYLHYDRAZINE - UN 1244
UNSYMMETRICAL DIMETHYLHYDRAZINE - UN 1163

Spill or Leak

- No flares, smoking or flames in hazard area
- Do not touch spilled material
- Stop leak if you can do it without risk
- Use water spray to reduce vapors
- Small Spills: Take up with sand, or other noncombustible absorbent material, then flush area with water
- Large Spills: Dike far ahead of spill for later dispersal

First Aid

- Move victim to fresh air; call emergency medical care
- If not breathing, give artificial respiration
- If breathing is difficult, give oxygen
- Remove and isolate contaminated clothing and shoes
- In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes
- Keep victim quiet and maintain normal body temperature
- Effects may be delayed, keep victim under observation

DOT RESPONSE GUIDE 23
OXYGEN, CRYOGENIC LIQUID - UN 1073

POTENTIAL HAZARDS

Fire or Explosion

- May ignite combustibles (wood, paper, oil, etc.)
- Mixture with fuels may explode
- Container may explode in heat of fire
- Vapor explosion and poison hazard indoors, outdoors or in sewers

Health Hazards

- Vapors may cause dizziness or suffocation
- Contact will cause severe frostbite
- Fire may produce irritating or poisonous gases

IN CASE OF ACCIDENT

- Keep unnecessary people away; isolate hazard area and deny entry
- Stay upwind; keep out of low areas
- Wear self-contained breathing apparatus and full protective clothing
- Isolate for 1/2 mile in all directions if tank or tankcar is involved in a fire
- FOR EMERGENCY ASSISTANCE CALL CHEMTREC (800) 424-9300

Fire

- Small Fires: Dry chemical or CO₂
- Large Fires: Water spray, fog or foam
- Move container from fire area if you can do it without risk
- Stay away from ends of tanks
- Cool containers that are exposed to flames with water from the side until well after fire is out
- For massive fire in cargo area, use unmanned hose holder or monitor nozzles
- If this is impossible, withdraw from area and let fire burn

Spill or Leak

- Keep combustibles (wood, paper, oil, etc.) away from spilled material
- Do not touch spilled material
- Stop leak if you can do it without risk
- Isolate area until gas has dispersed

DOT RESPONSE GUIDE 23 (continued)
OXYGEN, CRYOGENIC LIQUID - UN 1073

First Aid

- Move victim to fresh air; call emergency medical care
- Remove and isolate contaminated clothing and shoes
- In case of frostbite, thaw frosted parts with water
- Keep victim quiet and maintain normal body temperature

APPENDIX H

DETAILED ANALYSIS OF PROCEDURES USED AT ACCIDENTS INVESTIGATED BY NTSB

H.1 ASSESSMENT OF PROCEDURES RELATED TO THE SEPTEMBER 24, 1977 TRACTOR-CARGO-TANK-SEMITRAILER OVERTURN AT BEATTYVILLE, KENTUCKY.

The hazardous material involved in this accident was gasoline, which is not one of the twelve propellants and chemicals specified in the contract, but is transported in enormous quantities throughout the country. The accident involved a tractor-cargo-tank-semitrailer overturn which released gasoline, ignited the tank car and resulted in fire which engulfed a number of nearby vehicles and buildings. Procedural aspects on emergency response and hazards mitigation are summarized. No significant wreckage removal, cleanup and disposal or transfer procedure information was obtained.

H.1.1 Emergency Response Procedures

- The Beattyville Volunteer Fire Department (VFD) received a call about the reported accident three minutes after the accident occurred. This indicates the alerting procedure was good.
- One unit of the Beattyville VFD was dispatched to the accident scene. This would be a normal procedure.
- Beattyville VFD decided to fight the gasoline fire with foam. This was a normal procedure.
- Within 25 minutes after the accident occurred, the fire chief requested additional firefighting units from two adjacent counties, three adjacent cities and the shipper. These actions indicate procedures were in place to seek additional assistance.
- The major structural fires were contained and the trailer fire was extinguished nearly five hours after the accident occurred. Considering the magnitude of the fire, one can assume normal procedures were used.
- County officials set up Civil Defense Coordination Headquarters two blocks away from the accident site. At this site, State personnel provided information, directed recovery of bodies and interviewed key witnesses. These actions indicated that a plan with well-defined procedures was in place.

- While the State of Kentucky had previously adopted National Fire Protection Association (NFPA) Code 101, entitled "Code for Safety to Life from Fire in Buildings and Structures" whose purpose was to ensure alternative means of escape from buildings in case of fire, this was not enforced in Beattyville. The NTSB concluded that "The Life Safety Codes under NFPA 101 cover entrances being blocked inside during an emergency and do not adequately consider hazardous material transportation accidents in which entrances can be blocked from the outside." The NFPA code did not address blockage of exits from the outside of a building as occurred in this accident, so even with enforcement of the fire code the same hazardous situation would have arisen. Steps need to be taken to amend the code and further assure its enforcement by local officials.
- Under NFPA Code 101, the fire chief took responsibility as the on-scene coordinator, which is a normal procedure.

H.1.2 Hazards Mitigation Procedures

- The National Transportation Safety Board report stated that the gasoline spilled, ignited and formed a 100-foot yellow plume of smoke and fire within four seconds. Apparently procedures did not exist to handle such a rapid ignition. Indeed, prior to this specific accident, five other accidents had occurred at this location in the past eight years. Procedures to eliminate hazards need to be adopted promptly.
- To mitigate hazardous materials accidents in this location, truck traffic was prohibited subsequent to this accident, until the roadway was improved. This procedure was long overdue.
- The fire chief had the portion of tank which had not ignited, pulled away from buildings in order to protect the rescue personnel who were searching the premises for victims. There was no indication that a procedure existed or was used to assure that it was in fact safe to move the tank section. Tank assessment procedures are required for decisions such as this one.

H.2 ASSESSMENT OF PROCEDURES RELATED TO THE MAY 30, 1970 LIQUEFIED OXYGEN TANK TRUCK EXPLOSION IN BROOKLYN, NEW YORK

This accident involved the explosion of a tank truck partially filled with liquefied oxygen. The force of the explosion and subsequent fires resulted in two fatalities and 30 injuries. According to the NTSB, the accident case docket file has been

destroyed because of its age. Therefore, the only document available for examination was Report NTSB-HAR-71-6, the NTSB's Accident Summary Report. Because of the very limited procedural information contained in the report, review of all emergency response, hazard mitigation, wreckage removal, cleanup and disposal (including product transfer) procedures revealed only a few points:

- The fire department responded to the scene of the accident as a result of the noise of the explosion and the smoke from the ensuing fires without receiving a call for assistance.
- Additional firefighting units responded to the accident scene at the request of the initial responding unit.
- The fire department utilized proper procedures, according to the NTSB, to extinguish the fires quickly and search the wreckage debris for casualties.
- Four firemen and two policemen were treated for minor injuries during the course of the emergency response effort, although the nature of the injuries was not explained. This indicates a possible lack of procedures for safe handling of liquefied oxygen. The firefighters might not have been familiar with characteristics of liquefied oxygen particularly its ability to cause frostbite. Training of response personnel to recognize and respond to hazards presented by cryogenic materials as well as other hazardous materials is necessary.

H.3 ASSESSMENT OF PROCEDURES RELATED TO THE APRIL 8, 1979 TRAIN DERAILMENT NEAR CRESTVIEW, FLORIDA

This accident involved release of anhydrous ammonia, chlorine and other hazardous materials; necessitated the evacuation of about 4,500 persons; and resulted in 14 persons requiring treatment for toxic fume inhalation.

H.3.1 Emergency Response Procedures

- Crestview and Okaloosa County officials had developed a contingency plan for hazardous materials accidents. This plan was put into operation when word was received by the Crestview Fire Department from the L&N operator.
- The NTSB reports that "[i]n the confusion of the early hours of the emergency, the first chlorine specialist team was turned back by local officials when they learned the team was enroute." This is very difficult to

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POST ACCIDENT PROCEDURES FOR CHEMICALS AND PROPELLANTS

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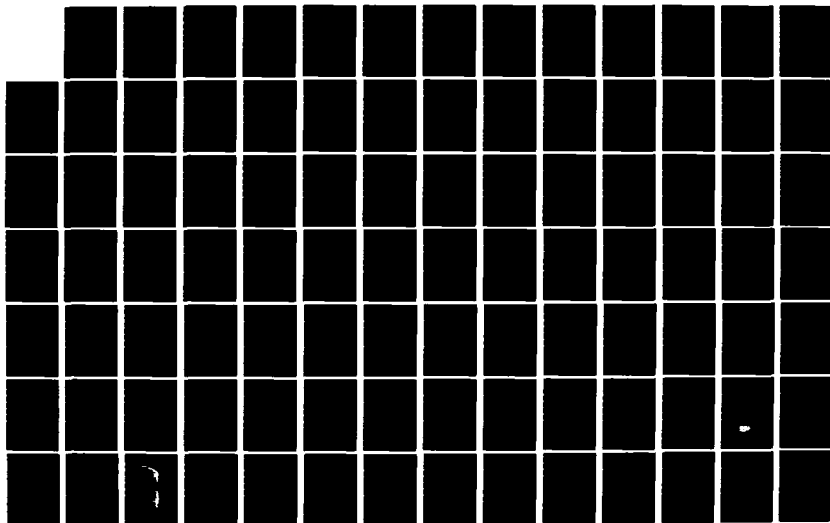
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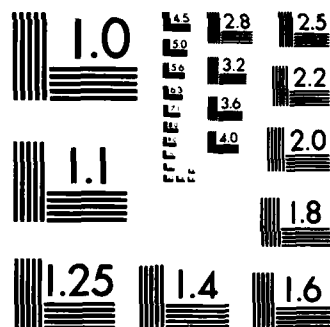
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understand in view of the fact that an emergency response plan existed and was being utilized. Response plan procedures must assure proper assistance is sought promptly and certainly not be turned back due to confusion.

- The fact that some response teams arrived on their own or were dispatched to the scene by someone other than the OSC demonstrates that coordination and communication procedures were inadequate.
- The local officials, during the arrival of the teams tried to find someone who could take charge of the response teams and advise them regarding evacuation, fire control and wreckage removal. The procedures in the response plan need to show how to seek and utilize specialized help, clearly delineate who has what legal authorities and responsibilities, and the official in charge must be designated by title.
- The train crew acted in accordance with the general operating instruction of the L&N. The engineer notified the L&N operator at Crestview who in turn notified the local emergency personnel. The train crew cooperated with the fire and sheriff departments and other authorities.
- In November 1977, L&N began to furnish crew members with consist data containing hazardous material emergency information. This was a procedural improvement. However, the list of hazardous materials was with the conductor in the caboose. There is a need for a procedure requiring waybills and consist information to be in both the caboose and locomotive.
- NTSB Recommendation R-78-47 states, "[p]romulgate regulations to require railroads to provide pertinent hazardous materials information on waybills and make this information available to public emergency personnel." The L&N conductor did this. However, this information should have been conveyed to the L&N operator at Crestview who in turn could have advised the fire department and other authorities. Approximately 45 minutes delay occurred before the firefighters had this information. The conductor witnessed a gas hiss and the first explosion. While walking from the scene, he met two arriving deputy sheriffs and said the cloud might contain chlorine. Later he gave the waybills and train consist, which listed the hazardous materials in the train, to the trainmaster who in turn gave the information to the firefighters. The firefighters apparently did not have the proper training to know the location or procedures to find this information or the person with it promptly. The conductor's meeting with the deputies appeared to be happenstance. Coincidence had the trainmaster on the scene

earlier than would normally have been expected. The head brakeman had met the firefighters and radioed the engineer for the hazardous materials list. The engineer did not have it. L&N procedures require all crew members to be knowledgeable of the train consist and have this information immediately available for firefighters. These procedures apparently were not followed entirely. There needs to be a procedure which will assure that appropriate members of the crew carry the information concerning what hazardous materials are aboard and that they seek out as quickly as possible the fire chief, law enforcement officials or other first-on-the-scene responders and provide them with the information.

- The locomotive had a radio for communicating with the caboose, other trains and the train dispatcher. The review of this information implies that the head brakeman had a portable transmitter because he radioed the engineer about the derailed cars, fire and gas cloud. There need to be written procedures to assure that local authorities, the train dispatcher and the National Response Center (NRC) are alerted immediately when there is an accident involving hazardous materials and are given the identification of hazardous materials aboard. The shippers should also be alerted immediately when there is an accident involving their hazardous commodities and of the possible involvement of other HM's in the accident. It is further recommended that a procedure be established requiring appropriate crew members to carry two-way radios tied into the locomotive's radio system, so that there is constant communication linkage among the crew and beyond the train. Requiring the trainmaster and other key officials to carry a "beeper" could further improve response communications.
- Fire service personnel spoke with chemical company (shipper) personnel regarding the dangers of the hazardous materials. This may have been via CHEMTREC or through toll free dialing via a number on the waybill. The latter could expedite making the contact. Each emergency action plan needs a clear set of procedures on how to establish this contact. Even though the National Response Center (NRC) becomes completely involved and establishes an alerting procedure, listing an emergency response number for a shipper on each waybill or shipping paper is currently done by some shippers and can further speed up availability of proper assistance.

H.3.2 Hazards Mitigation Procedures

The effectiveness of hazard mitigation is a function of how early the alerting is accomplished and taking the proper course of action.

- o The original location and subsequent shifting of the command post evidenced some assessment procedure was being used which took into account current and forecasted weather conditions. Successful hazard mitigation requires the existence of a procedure to acquire, on a continuing basis, real-time and predicted meteorological information and to use this in decision-making.
- o Search and rescue have been a regular part of the firefighters' duties. In this case, they wore self-contained breathing apparatus (SCBA) to go into the derailment site, but no procedures were evident that permitted them to know that it was safe to enter, particularly with respect to the integrity and condition of the remaining tank cars which had been exposed to fire as well as the dynamic stresses and strains of the accident. Similarly, the conductor uncoupled the 35th car from the derailed 36th car. This action was not backed by a procedure which would have assured that it was safe to approach the derailed car. Such procedures are critically needed, along with accurate, remote means for identifying the presence of specific hazardous materials in the accident.
- o The NRC had been advised of the accident because of a potential water pollution threat, and in turn notified the EPA in Atlanta, Georgia. EPA then dispatched an On-Scene Coordinator (OSC). A special Regional Response Team (RRT) was also sent in accordance with the procedures in the National Oil and Hazardous Substances Pollution Contingency Plan. A day and a half elapsed before the OSC and RRT convened and the local officials knew what outside government assistance could be expected. Either the local officials did not notify the National Response Center promptly or there was a delayed response. It is essential that procedures assure the earliest possible notifications and involvement of all parties who are concerned with responding to and mitigating the hazards from hazardous materials emergencies.
- o The passerby who witnessed the derailment could have driven away from the area but elected to remain in his car with the windows closed and suffered ammonia exposure. He was given oxygen treatment when he ran to the firefighters. Procedures are needed to have the train crew or emergency responders warn such persons to leave the area because of the danger. A

public education program should include a simple procedure for passersby to evacuate accident areas or avoid them without prior warning.

- The fire services did not have equipment or procedures to extinguish or control the fires in this remote location, thus limiting their capability to mitigate the hazards. Such support equipment and procedures are urgently needed.
- The flagman complied with established procedures when he went further north along the track to provide required flagging protection. Such procedures are necessary to reduce the chance of another wreck.
- Remote locations do not necessarily mean there is no significant population exposure potential. In this instance, 4,500 people were evacuated. Evacuation procedures are a necessary part of every emergency action plan regardless of location.
- From the scene, the Eglin AFB firefighting unit requested aerial surveillance. The availability of aerial reconnaissance enabled the law enforcement and civil defense personnel to track the toxic vapor cloud and evacuate the residents accordingly. The community response plan needs to contain a procedure whereby this surveillance would be initiated automatically when contact is first made by the community official. Additionally, the plan should contain a written agreement for such support from a nearby military base, with air patrol, police news media or other flight service. The National Response Center should assist in this effort.
- The sheriff department and civil defense personnel handled the control and evacuation of inhabitants, while the fire service and railroad personnel concentrated on assessing the accident situation, thus showing a clear definition of responsibilities. It is absolutely essential that a single coordination point, and one person in charge be designated immediately in an emergency and that this must be worked out ahead of time by each community. The Federal, State and local officials must work together with industry to establish such emergency plans.
- Further evidence of positive safety procedures was the request by the Crestview officials to the FAA to prohibit unauthorized aircraft from entering the area. Such a procedure is necessary to preclude interference with surveillance and to prevent possible additional exposure or accidents.

- The OSC and RRT were not involved early in the emergency and also left three days before it was over, having fulfilled what was apparently considered their mission -- namely, assuring that the water pollution threat was over. The operating procedures of the planned expanded NRC need to assure OSC and RRT have immediate involvement and provide assistance which continues to the end of the emergency.
- Among the hazardous materials, small amounts of phosgene, resulting from severe heating of carbon tetrachloride, were detected the first day. Chlorine and ammonia were detected for five days. This monitoring was apparently discontinued on the second day of wreckage clearing and transfer operations. Procedures are required to: (1) provide continuous monitoring in the work area and beyond; (2) translate monitoring data into action decisions (e.g., stop work); (3) avoid false sense of security about protective equipment being used; and (4) preclude persons from being exposed to toxic vapors or hazards.

H.3.3 Wreckage Removal and Cleanup/Disposal Procedures (Includes Transfer)

These two areas have been combined because of considerable overlap in the procedural aspects covered.

- The OSC and members of the RRT approved the L&N plans for hazardous materials removal and wreckage clearance. The exposure of several persons during product transfer and wreckage operations is evidenced that the handling procedures were not adequate. The capability for safe certain assessment does not currently exist.
- NTSB Recommendation R-79-5 states "Provide guidelines to railroad employees to aid them in assessment of tank car damage and procedures for proper handling of tank cars."
- NTSB Recommendation I-78-14 states "Complete development and documentation of safety procedures for identifying and assessing hazardous materials dangers, and for coordinating wreckage clearing operations with local public safety officials". This is somewhat akin to R-79-5. There was at least a general awareness of the hazards of the materials, but there was an apparent lack of coordination, adequate procedures and specific understanding of the danger as evidenced by the 14 persons who had to be treated for inhalation exposure. Procedures are needed to assure that an area is safe to enter following a hazardous material spill.

- The chlorine car was dragged to an open-air mixing pit and the chlorine neutralized with caustic soda. There was no indication that any attempt was made to plug the 18-inch puncture hole. The Chlorine Institute has emergency repair kits and teams located strategically around the country to plug or otherwise handle chlorine leaks. The officials turned one such team back. The emergency action plan must recognize such expertise and have a procedure for promptly obtaining this assistance.
- The information does not say that the firefighters wore protective clothing suitable for chlorine or ammonia atmospheres. Without such clothing, the firefighters do not have the capability to handle such materials. Procedures must exist and be followed to assure that any person working in the presence of hazardous materials is fully protected and qualified before attempting such work.
- The fact that the 58th car, containing ammonia, began to leak on April 16 during transfer operations indicates that the transfer procedures were inadequate or the car had suffered more damage than thought initially. There is an urgent need for a practical procedure for determining container integrity on-scene.
- Wreckage-removal and product transfer operations were held up until the tank cars had burned out—the morning of the third day. These operations required six days during which ten persons had to be treated for inhalation of ammonia or other toxic fumes. This situation shows a strong need for procedures to assure: (1) absence of toxic vapors or a concentration low enough for the person to work safely with the protective gear being worn; (2) continued monitoring of the work area; (3) respiratory equipment and protective clothing are suitable for the types of hazardous materials being encountered for the time duration involved (there is a question of the adequacy of currently available items); (4) responding personnel are thoroughly trained and proficient in the use of this protective gear and its limitations in the on-scene environment; (5) leaks are stopped or controlled before transfer and wreckage removal operations; (6) the number of persons working at the site to be held to the lowest practical minimum and their locations and activities be coordinated so that one person does not expose another to additional hazard; (7) no one be permitted to enter or work in an area without proper protective gear and then only when competent authority considers it safe to do so; (8) vapor monitoring equipment indicates which

specific hazardous materials are present; (9) medical authorities are made aware of the hazardous material so they can render proper medical assistance in the event of exposure; and (10) all hazards are recognized and properly dealt with.

- No details on the wreckage-removal or transfer procedures per se were obtained. The wreckage was removed and the products were transferred successfully, which indicates the procedures worked satisfactorily. However, as mentioned in the preceding paragraph, the procedures, protective clothing and equipment were inadequate to assure the safety of the personnel.

H.4 ASSESSMENT OF PROCEDURES RELATED TO THE SEPTEMBER 21, 1974 RAILROAD ACCIDENT AT ENGLEWOOD YARD, HOUSTON, TEXAS

This accident involved the release of butadiene vapors, necessitated the evacuation of approximately 1,700 people and resulted in one death and 234 injuries.

Although there must have been various emergency response, hazard mitigation, cleanup and disposal and wreckage-removal procedures instituted on-scene, the NTSB docket contains very little information in this regard. Therefore, these types of procedures are documented together. This investigation revealed the following information leading to a procedural assessment of the accident.

- The Houston Fire Department responded to the scene soon after the explosion, and put into effect a plan previously developed with railroad personnel. Community pre-planning is essential to timely response and effective mitigation of accidents involving hazardous materials.
- A command post was established by the Fire Department. This is a good procedure and should be established at every accident site.
- Approximately 1,700 people were evacuated from the area, reducing exposure of the general public to the fire and potential releases of other hazardous materials involved.
- The retarder operator gave the first warning of the impending catastrophe. When he saw the butadiene vapor dispersing from the punctured tank car, he warned employees in the area by using the yard's loud speaker system. This was a quick and effective warning procedure. However, the resulting vapor-air explosion occurred almost instantaneously (three minutes after detection) so that very little time was available for people to take emergency action. In this case, blast overpressure, flying debris and a radiant fireball were the

immediate primary hazards to be dealt with. In retrospect, the rail employees should have sought cover immediately to escape the potential hazards. The topic of self-help procedures for those in the immediate vicinity of hazardous material releases needs to be addressed. At the same time, there is a need to develop practical means to eliminate, control and reduce the quantity of hazardous materials that can escape bulk containers when punctured.

- The first impression of Southern Pacific personnel when they saw a white cloud was that it was a nitrogen car with an overflow valve operating. There needs to be a procedure to properly identify the hazardous material.
- Specific waybills on the train (e.g., those of cars carrying butadiene, denatured alcohol and ethyl chloride) had a toll-free emergency number to contact in the case of an accident. This is a very useful and important procedure.
- The fire was controlled in roughly nine hours, but some cars continued to burn for days. Other cars of hazardous material contributed to the fire, but no subsequent explosions or ruptures occurred. In such cases, it can be valuable to cool tank cars down with water streams. When it can be done safely, extinguishing fires is also very important because it can mitigate further problems.
- The yard operating restrictions on the humping of multiple cars containing sulfuric acid, hydrofluoric acid and acetone cyanohydrin were introduced after overspeed experiences with cars carrying these commodities.
- A need exists to prevent tank cars containing toxic or polymerizable liquids or gases or flammable compressed gases from rolling freely.
- Southern Pacific employees had no special training for handling hazardous materials. Employees who work around hazardous materials need at least basic knowledge of hazards involved and self-protective measures to handle given a release.

H.5 ASSESSMENT OF PROCEDURES RELATED TO THE MAY 11, 1976, TRACTOR SEMITRAILER (TANK) COLLISION AT HOUSTON, TEXAS

This accident involved the release of anhydrous ammonia and resulted in six deaths and 178 injuries with all, except the driver's death, attributable to inhalation of ammonia fumes.

H.5.1 Emergency Response Procedures

There existed a City of Houston Emergency Operations Plan (EOP). Some highlights of the plan follow:

1. The Mayor is authorized to declare a civil disaster when there is a major threat to life and property and to make decisions governing the direction of disaster operations.
2. The Civil Defense Director shall assist the Mayor in all programs and phases of civil disaster: coordinate...; maintain liaison...; assure all organizations and assignments are staffed...; and shall be authorized to declare and carry out disaster control actions until the Mayor is available.
3. The Chief of the Houston Police Department will be responsible for the normal police services necessary for the protection of life and property and for evacuation.
4. The Houston Fire Department is responsible for fires, chemical situations, explosions and rescue, and its Ambulance Division shall be responsible for the transportation and emergency care for those in need of medical attention at an emergency. Fire department standard procedures will be used except where the nature of the emergency requires expanded operations.
5. The Civil Defense, Police, Fire, Public Works and Health Departments have communication systems. During an emergency, normal radio to communication systems of these departments will be used as much as possible. However, Civil Defense will maintain coordination and a backup of communications for all departments plus radio communications with Federal and State agencies, as well as a Public Information Emergency System.
6. The Director of the City of Houston Health Department is responsible for emergency health services.

The assessment of the procedures is as follows:

- The Deputy Fire Chief was the on-scene coordinator (OSC). This procedure was good because it placed one person in charge at the scene.
- The Fire Liaison Officer heard of the accident on his radio ten minutes after it occurred, learned that it involved an ammonia tank truck and said he would be enroute to the scene. Because of traffic delays, it took him 15 minutes to reach the scene, where he assisted in moving some of the people who were overcome by fumes. Nothing was indicated as to whether or not he was wearing appropriate breathing apparatus, although standard operating procedures should have required this. He then reported to the on-scene

coordinator at whose request he contacted the Civil Defense unit and had them contact the news media to inform the public to stay away from the area. The Civil Defense people did this. Procedures should include an immediate public announcement by the OSC.

- The Fire Liaison Officer (FLO) requested that a police helicopter hover over the pockets of fumes approximately 20 to 25 above ground level to disperse them. This procedure raises questions such as: Did the FLO know it was safe to do this? How did he know? What procedure did he use to make this assessment? There is no doubt that the air wash from a helicopter creates atmospheric disturbance. However, it is conceivable that ammonia fumes could enter the helicopter and expose the pilot. Use of water spray to knock down the fumes would appear to be a safer procedure. Water spray was actually being used. Why the decision was made to use the helicopter was not explained.
- Where the release of the product is large and almost instantaneous as it was in this case, emergency services cannot possibly arrive on-scene in time to prevent some death or injury. This points out the need for the general public to know and use simple precautionary procedures to save their own lives if confronted with hazardous materials emergencies. This is not an easy task, but is one which the chemical manufacturers, transporters, emergency services, government officials and the news media need to work on jointly. In this case, the first ambulance was there within five minutes.
- The first ambulance reported to the dispatcher that ammonia was involved. The dispatcher then alerted the hospital emergency rooms. This procedure was very good because it told the hospital authorities promptly and precisely what they could expect people to have been exposed to and be prepared to treat them accordingly.
- It was not clear how promptly the fire equipment arrived. Within 32 minutes, 14 ambulances and four pieces of fire equipment had responded. Part of the delay might have been due to traffic delays. There is a need to come up with some realistic, practical procedures to overcome traffic delays experienced by emergency responders in heavy traffic. Perhaps airlifting is a possibility and the concept should be studied as a countermeasure.
- The emergency responders were equipped to handle massive hazardous materials spills. For example, emergency oxygen supplies were available to help the victims. Having such auxiliary equipment is a procedure which can

do much to enhance the effectiveness of the response operations.

- Helicopters were used to guide patrols in sealing off the area. This procedure is another one which augments the aerial surveillance and rescue procedures which helicopters can perform.

H.5.2 Hazard Mitigation, Wreckage Removal, Cleanup and Disposal Procedures (Including Product Transfer)

- Firefighters effectively used water fog spray to dissipate ammonia on the ground and wash down automobiles that contained ammonia fumes. No mention was made about any procedures to contain the resulting aqueous ammonia solution, test the concentration and treat it, if necessary, so that it did not contaminate any waterways.
- The City of Houston's plan requiring routing of hazardous materials around the city is an effective hazard mitigation procedure which helps prevent such accidents from occurring in highly congested urban locations. However, this incident points out the fact that in locations where transport vehicle speeds are high, the potential severity of an accidents might be increased. Procedures must assure hazardous materials vehicles do not travel faster than a safe speed.
- There is an urgent need for development of new container designs and chemical or physical means to restrict the amount of product released when bulk liquid or gas containers are punctured. This case clearly illustrates that even immediate response by emergency services would not have been fast enough to save everyone.
- All major debris was cleaned up within 19 hours, which indicates an efficient and effective cleanup operation.

H.6 ASSESSMENT OF PROCEDURES RELATED TO THE OCTOBER 19, 1971, RAILROAD ACCIDENT AT HOUSTON, TEXAS

This accident involved the derailment of a freight train containing six tank cars of vinyl chloride monomer and two cars of another hazardous material. Two of the tank cars were punctured in the derailment, releasing vinyl chloride monomer which then ignited. Approximately 45 minutes after the initial derailment one tank car ruptured violently and another tank car "rocketed" roughly 300 feet from its initial resting place. During the response activities to this accident one fireman was killed and 50 people injured.

The two tank cars containing liquefied vinyl chloride released approximately 35,000 gallons. As the escaping vinyl chloride entered the atmosphere, about eight percent of the liquid turned to gaseous vapors.

H.6.1 Emergency Response Procedures

- When the train derailed, the engineer radioed a request to dispatch fire trucks to the scene. This prompt contact with local authorities is a good operating procedure and should be used at any accident site.
- Of the injured, thirty-nine were Houston Fire Department employees, eight were reporters or photographers and three were spectators. The number of injuries could have been decreased if spectators were not permitted at any potential hazardous accident site, if senior fire personnel were more aware of the hazards inherent on-site, and if they had greater capabilities and knowledge in hazardous materials identification and behavior.
- Numerous residents reported the accident to the Houston Fire Department one minute after the accident occurred. Railroad personnel telephoned the fire department 13 minutes later. This act by local residents was beneficial. The delay in notifying the fire department by railroad personnel should be minimized as much as possible because knowing the specific nature of the commodities is imperative for "quick-response."
- Hose lines were being laid on the eastern side of the train accident to cool off the cars that were not on fire. The decision was made by the acting district fire chief. During this time, the firefighters laying these hose lines were unaware of the contents of the tank cars or what methods they could use to extinguish the tank cars which were already on fire. The decision to cool the tanks is proper if the approach can be made without endangering personnel and this procedure does not heat the contents of the car. It is not certain whether or not the acting district fire chief knew the specific contents of these tank cars. There is an urgent need for both senior fire personnel and those firefighters who lay hose lines to be able to identify the contents of a tank car quickly. This ability to identify the contents of a tank car quickly is needed so that proper firefighting procedures can be implemented.
- The acting district chief arrived at the accident site, discussed the hazardous situation with the deputy chief who had made the initial hazards assessment, and decided to call in a second alarm. This is a proper

procedure when the situation warrants. There was no discussion concerning the criteria used to determine if a second alarm was needed.

- The conductor, unaware of communications by the engineer, instructed the brakeman to advise railroad personnel of the derailment at a radio-equipped switch engine 1-1/2 to 2 miles south of the accident scene. While the brakeman was carrying out the conductor's instructions, he obtained the waybills, walked to a grade-crossing and talked to a policeman and fireman. Neither of these representatives asked about the identity of the commodities in the derailment nor did he tell them. He later went to a tavern to notify the train dispatcher. The latter action of the conductor was proper, but he should have notified both the policeman and fireman as to the nature of the hazardous materials being transported. The emergency responders should have asked about the identity of the hazardous materials. Procedures should assure prompt HM identification.
- The firefighters were unable to identify railroad crewmen who could have consist information or where such information on the train is located. The situation was due to inadequate training of the Houston Fire Department in handling hazardous materials transportation emergencies.
- The deputy chief persuaded the assistant chief to evacuate citizens from the area. Proper training would have prevented this situation. If the assistant chief had been aware of the potential hazards involved he would have immediately ordered an evacuation based on this knowledge.
- The first on-scene senior fire department officer approached the wreckage scene from the western side and observed markings on the damaged tank cars. The words "vinyl chloride" were stenciled on one of the overturned tank cars. The official, however, did not transmit or write down this information. There is a need for timely communication to emergency responders, train officials, etc. as to the identity of tank numbers and contents of those cars involved.
- The deputy chief who arrived on-scene noticed that the pressure relief value on the overturned tank car was under the liquid level. He was aware that the safety valve oriented in this position could not prevent the internal pressure of the material from rapidly increasing. This fact was recognized, but he should have ordered an immediate evacuation of all personnel to a "safe distance." This clearly shows the need for procedures for assessing the dangers and making prompt decisions based on correct evaluations.

H.6.2 Hazards Mitigation Procedures

- When the railroad contacted the fire department of the accident, the hazardous material involved was not identified even though it was requested by firefighting authorities. The expeditious relay of hazardous materials identification will help establish and thereby minimize the hazards of a hazardous material transportation accident.
- The assistant chief was aware that the safety relief valve was below the liquid level of the material. He felt that if the safety relief valve "popped off" the tank car that this would be an indication that pressure was increasing and that it would be necessary to evacuate firefighting personnel. He expected that this warning would come in time to permit safe withdrawal. Due to his lack of training in assessing tank car damage and in the operation of a safety relief valve in a disoriented position, an improper analysis was made. The safety relief valve popped off at the time of the explosion.
- A member of a maintenance crew fixing track in the area of the accident attempted to warn motorists to stay away from the area of the accident site. This procedure can minimize additional injuries or fatalities. This job was completed by police who rerouted traffic.
- Thirty minutes after the accident occurred the assistant chief of the Houston Fire Department arrived at the accident scene. He inquired as to the contents of the hazardous material being transported. Various firefighters told him that it could be up to six different hazardous materials - none of which were the correct material. Each firefighter should have the proper training to identify hazardous materials.

H.6.3 Cleanup and Disposal and Wreckage Removal Procedures

No procedures were mentioned in the accident review.

In conclusion, the NTSB believes that the severity of the accident was increased by "the lack of adequate training, information and documented procedures for on-scene identification and assessment of the threats to public safety and fireman's reliance on firefighting recommendations which did not take into account the full range of hazards."

H.7 ASSESSMENT OF PROCEDURES RELATED TO THE APRIL 19, 1975, TANK-SEMITRAILER OVERTURN NEAR EAGLE PASS, TEXAS

This highway accident involved the release of liquefied petroleum gas (LPG); produced an explosion and fireball; and resulted in 16 deaths and 35 persons with burn injuries.

H.7.1 Emergency Response Procedures

- There was a gross rupture of the tank and almost instantaneous production, ignition and explosion of a massive LPG-air mixture with resultant blast overpressure and fireball. There was no time for the people in the immediate vicinity to escape, nor could emergency responders have been able to reach the scene in time even if they had received notice the instant the accident occurred. In cases such as this, there are no procedural improvements that can be made for the emergency response community in dealing with the LPG itself because it was gone in a matter of seconds. Essentially, the same thing is true with respect to persons who happen to be in the vicinity, except that it might be possible by mass education to warn people of precautionary safeguarding procedures such as keeping plenty of distance between themselves and hazardous materials-carrying vehicles, not having curiosity if they hear an accident impact and instinctively seeking cover if they do hear anything. It is possible that had people remained in their cars until the fireball ceased, they might have been less severely burned. The direction for attacking this problem, although more hazard mitigation than emergency response, lies in procedures which will reduce the quantity of product that can be released and control the behavior of the hazardous materials that are spilled. Research is critically needed to: (1) assess the failure modes of bulk containers and to improve container integrity; (2) develop practical, effective compartmentation, porous filters, or other physical means to slow the release from a puncture, keeping in mind that ability to easily and thoroughly clean the inside of the container is absolutely mandatory; and (3) develop practical, compatible chemical means for controlling or preventing release from punctures (e.g., gels, suppressants). Cost-benefit and risk analyses are needed for each of the potential improvements.

- In this accident, pressure vessels were ruptured propelling the forward section of the tank a distance of 1,654 feet. Such fragments can create secondary problems, such as when the forward tank section hit a mobile home and it was burned because its own LPG tank failed. Community hazardous materials emergency action plans need to include educating the public to have a good understanding rather than a fear of rocketing (often with flame) parts of tanks and simple precautionary procedures on how to avoid the fragments and heat radiation.
- Emergency medical assistance was rendered at the scene by personnel from the local hospital and local rescue units. On-scene first aid by trained personnel can decrease fatalities and injuries and exposure damage.
- The Eagle Pass Police Department was aware almost immediately of the accident. Mention was not made of any formal Eagle Pass hazardous materials response plan in existence. The Police Department radioed a State Highway Patrol car and told them that there had been an explosion and gave them the location. The patrol car went to the scene and advised a city patrol unit to block all traffic at the nearby intersection because of two fires visible in that area. What, if any, procedure was used by the State Highway Patrol personnel to determine it was safe to proceed to the fire scene was not mentioned. It is important to have procedures that assure that complete information is provided in communications. In this case, it so happened that the major threat was over. The highway patrolman notified the D.D.S. Del Rio upon arriving at the scene.
- The Eagle Pass Fire Department Chief arrived at the fire scene about the same time as the highway patrol car. He called for trucks and asked for assistance from Peidras Negras Fire Department. Presumably, the Eagle Pass Police Department had notified the Fire Chief. These were standard fire procedures based upon the Chief's assessment of the magnitude of the fires.
- A Border Patrolman had been in the nearby body shop at the time of the explosion. He advised a highway patrolman that there were 10 or 15 badly burned people near the intersection.
- About this time, the first ambulance arrived and picked up two badly burned women in front of the body shop. About 20 minutes elapsed after the highway patrolman arrived before all victims were transported to the hospital. Presumably, the Eagle Pass Police Department contacted the

hospital ambulance service, however, it also could have been the Fire Department. In retrospect, it seems that ambulances could have been there faster had a formalized hazardous materials emergency response plan been in operation and had communications procedures been better. The existence of a systematic danger assessment procedure was not evident. Every available vehicle, both police and private, were used to transport victims to the hospital.

H.7.2 Hazard Mitigation, Wreckage Removal, Cleanup and Disposal Procedures
(Includes Product Transfer)

- The LPG was consumed immediately, so no product transfer was necessary, nor was there any residual toxic materials that had to be cleaned up and disposed. Cleanup operations were confined to picking up the debris and removing the wreckage which involved no hazardous materials handling.
- Fires had been put out within one hour, using standard firefighting techniques. The procedures prevented fires from extending to other areas.
- More extensive searches were conducted for bodies of injured persons after the fires were extinguished. Again, this is a standard search and rescue procedure.
- The NTSB report stated that it is unlikely any fatalities would have occurred if the LPG had been shipped in smaller containers, such as cylinders. Also, NTSB suggested that if LPG were shipped in a self-refrigerated form, the rate of tank breakup and material evaporation and dispersion would be reduced. Research on container design, possible porous fillers and self-mitigating hazardous materials treatment procedures should be conducted. There is a critical need for a feasible method or procedure to give potential victims more time for survival.

H.8 ASSESSMENT OF PROCEDURES RELATED TO THE NOVEMBER 9, 1977,
TRAIN DERAILMENT AT PENSACOLA, FLORIDA

This accident involved the inadvertent release of anhydrous ammonia; necessitated the evacuation of about 1,000 persons; and resulted in two deaths and 46 injuries.

H.8.1 Emergency Reponse Procedures

- The conductor radioed the engineer when the train stopped. He was told by the engineer that there was a derailment. This implies two-way radio communications between the front and rear of the train. Such a procedure is a necessity.
- Within one minute a resident notified the Pensacola Police Department dispatcher of the accident. This was an extremely fortunate voluntary action which did much to speed emergency response and ultimately mitigate the hazards. In considering hazardous materials emergency response plans and related training, it is recommended that serious attention be given to training the public so that they might similarly recognize potential problems, promptly report them, and have a simple procedure for so doing.
- As a result of three previous hazardous materials accidents, a Pensacola Pre-Fire Plan for Train Disaster had been developed. The police dispatcher contacted the Fire Chief, Civil Defense Coordinator, City Manager and County Administrator. Fire and police units were on the scene within four to six minutes. The plan was in full operation within 21-23 minutes. This plan apparently had responsibilities and actions well thought out. However, at one point in time, the Director of Civil Defense for Pensacola and a member of the Santa Rosa County Civil Defense each thought himself to be in charge of the on-scene operations. Procedures were not completely clear. Who is in charge must clearly be spelled out in the planned procedures.
- The Fire Department dispatcher received two calls from the L&N railroad people confirming the derailment and suggesting the Police Department should be notified because an evacuation might be necessary. The L&N procedure to notify the Fire Department was good, and it did state that ammonia was leaking. The communication procedure should identify the hazardous materials involved.
- The emergency response procedures in the plan indicated the conductor would have the information about any hazardous materials in terms of waybills and one or more emergency responders went looking for the conductor.
- The responders had been trained in the use of self-contained breathing apparatus and wore them when seeking the conductor. It was not stated whether their clothing was adequate for protecting the body from the

ammonia fumes. Both procedures are necessary. A serious point needs to be made here. The responders did not know what was in the other cars or their condition and might well have had to pass by the entire wreckage to reach the conductor. Mention was made that the Fire Chief circumvented the cloud while trying to locate the consist information. Procedures should preclude such unnecessary risk by having that information available at both ends of the train. There should also be continuous two-way radio contact between appropriate crew members regardless of where they happen to be. They were successful in locating the conductor and determining from the waybills which cars had anhydrous ammonia.

- Coincidentally, the air traffic controller at the Pensacola Airport observed a one-mile-wide echo blip (the ammonia cloud) on the radar screen. He detoured aircraft heading toward the blip. Use of radar to spot and track hazardous materials vapor clouds should also be included where possible in emergency plans. Detouring aircraft should also be a standard procedure in such cases. The radar procedure can augment aerial surveillance and in this instance be substituted for it. Both procedures are highly recommended.
- The Fire Chief requested Emergency Services for ambulances to remove exposed individuals.
- The conductor inspected 92 remaining cars which were not derailed. The head brakeman and reserve engineer inspected the derailed portion of the train. They smelled ammonia and noticed a vapor cloud forming at the tenth car. They radioed the engineer who in turn radioed the Goulding Yardmaster of the derailment. The lead engine was uncoupled and moved one-half mile to escape the enlarging vapor cloud. The communications and procedures for moving the engine were good. However, there was no indication that any of the crew members were wearing breathing apparatus or other protective gear or had any hazardous materials detection devices with them while inspecting the cars. They were fortunate in not having suffered injuries due to ammonia exposure. Procedures should require the use of appropriate protective gear, clothing and detection instruments for train crews.
- The Baycrest Nursing Home was put on standby alert to handle possible evacuees.
- Subsequent to the accident (about November 30, 1977), L&N implemented a computer program which shows hazardous materials information on train consists and waybills and instructs crew members to provide the information

to emergency services. This was an improvement in procedures. As mentioned previously, these items need to be on both ends of the train.

- Within 21-23 minutes, a Civil Defense Command Post was set up for coordinating pedestrian and vehicular traffic. The disaster plan designated the Director of Civil Defense to coordinate accident site operations.
- It appears that those persons remaining inside their dwellings by closing doors and windows, stuffing towels in openings around doors and windows and breathing through damp cloth fared better than those who attempted to flee or were evacuated. In retrospect, it seems that remaining indoors would have been the best course of action, particularly at the onset. Under other circumstances rapid evacuation might be the best course of action. This whole subject of if and when to evacuate needs to be studied and procedures worked out for the emergency response people as well as for the individual residents to know what to do on their own.
- Two firefighters had been unaccounted for at a time when their air supply would have been exhausted. They had been air-rescued with residents on the beach. All emergency response personnel when away from the command post should have continuous two-way radio communications with their superior or a central communications point, so their status can be determined at any time.
- The Fire Chief requested assistance of Air Products and Chemicals, Inc. (Pensacola), and the company responded with a seven-man emergency team equipped with protective gear and clothing. They were on-scene within 36-38 minutes of the accident. Response procedures need to be worked out beforehand with the chemical companies. Industry has worked out a mutual assistance arrangement through CHEMTREC.
- The Fire Chief, upon arriving at the scene, contacted his dispatcher and instructed him to notify all agencies which would normally respond to a serious emergency. He especially mentioned the Police, Red Cross, and Civil Defense. All together, about 36 different agencies were involved in this incident. This stresses the need for procedures to assure complete coordination, prearranged understandings and agreements, good communications and a single authority in charge.
- The rescue helicopter from a Pensacola hospital did not have direct communications with the command post or rescue personnel, so communications were via radio-telephone through the hospital dispatcher.

Procedures in the emergency plan need to assure complete, coordinated communications. It was not clear what aerial surveillance, other than locating and rescuing people, was carried out by the helicopter. Such surveillance is very useful.

- The hazardous material released was positively identified within seven minutes of the accident. Procedures to assure prompt identification are vital to successful emergency response and hazard mitigation.
- It seems worthwhile to include the basic outline of the emergency response plan that was utilized at Pensacola. It is as follows:

1. First captain to report his company location and specific nature of the incident.
2. Obtain nature and source of cargo, using (a) serial numbers from tank cars or box cars involved in derailment, (b) serial number from first car on track ahead and behind derailment, and (c) conductor's waybill located in caboose.
3. Relay involved cars' serial numbers to fire dispatcher.
4. Fire dispatcher shall contact railroad yardmaster for information concerning cargo and relay to fire ground (he shall contact CHEMTREC for additional information).
5. Once the nature of cargo is known, refer to the DOT Hazardous Materials Emergency Action Guide for evacuation distance and handling directions.
6. Make decision to attack or evacuate according to information in Hazardous Materials Action Guide.
7. If positive decision is made, request additional alarms as needed.
8. Decide whether to initiate disaster plan.
9. Second captain position back-up companies for attack or evacuation after consideration of (a) potential of explosion, (b) exposure, (c) location and density of population, (d) wind direction and velocity, (e) available water sources, and (f) topography.
10. Dispatcher to call off-duty personnel to active-duty as planned for recall (a) all reserve apparatus to be manned with four-man crews and (b) all other personnel to report to fireground command post.

11. Police Department handles (a) evacuation, (b) traffic control, and (c) security.
12. Command Post (City Civil Defense vehicle) handles (a) Mutual Aid (Naval Units Emergency Service), (b) Manpower (city employees), (c) Apparatus (city equipment), (d) Utilities (water, gas, sewer, street, power company) and (e) News Media).
13. Pollution Control handled by (a) Coast Guard, (b) Marine Patrol, (c) Health Department, (d) Department of Pollution Control and (e) Carriers.
14. Red Cross and Salvation Army offer (a) medical assistance, (b) shelter and (c) food and clothing.

H.8.2 Hazards Mitigation Procedures

- The utilization of a medical helicopter speeded up the removal of residents and thus reduced their exposure time and time in getting medical assistance.
- L&N alerted authorities to the possible need for evacuation. Evacuation was begun and the evacuation area was later expanded. Evacuation can be a positive hazard mitigation procedure when it gets people out of an area and prevents their exposure to toxic vapors, fire or other danger. At other times, and this case appears to be an example, it is safer for people to remain inside and take action to seal up openings to keep vapors out. Procedures are needed for addressing both situations along with guidelines on how to select the proper procedures.
- Firefighters shared their breathing oxygen with residents they were helping to evacuate, however, procedures should assure that sufficient oxygen equipment is available to use without the firefighters jeopardizing their own safety.
- No mention was made of any threat to the waterway nor any effort to contain ammonia-contaminated spray water. Such procedures are needed to reduce environmental damage or contaminating the water supply (e.g., via the broken water main).
- The condition of the remaining hazardous materials cars was not known. Nor was mention made of what precautionary procedures were exercised to protect persons involved with the leaking cars in the event any of these cars failed. Procedures for safely assessing container integrity are badly needed.
- Common sense and simple knowledge can do much to reduce injuries from hazardous materials. The authorities should actively carry out awareness

campaigns to instruct the general public in simple precautionary steps such as stuffing cracks and breathing through a damp cloth. The authorities should augment this by public announcements at times of emergencies. They should not drive through areas using loud speakers where they would endanger themselves or the car engine might ignite a flammable vapor cloud.

- The DOT Hazardous Materials Emergency Action Guide contains only rough estimates for evacuation distances and should not be relied upon entirely. Aerial surveillance and radar tracking procedures need to be utilized. Possibly the DOT Guide could be improved but conditions can be so varied that the guide can at best only be an approximation.
- Water spray was applied to the escaping gas and this reduced the cloud size. This is an effective mitigation procedure for this particular commodity. Procedures must be compatible with the particular hazardous material.
- Careful dilution of the ammonia remaining in the car was done under the direction of the chemical company experts and was successful in reducing the hazard.
- Some of the residents were allowed to return home the day after the accident. Procedures were not indicated as to why or how this decision was made. Presumably, the release had been stopped. Procedures for assessing the safety of such situations with hazardous materials remaining in damaged containers are currently non-existent or inadequate.
- These same residents were again evacuated two days later, while cars were being rerailed because there was a possibility of additional release during these operations. The evacuation was a good mitigation procedure. Nothing was said of precautionary procedures used to determine if rerailment was advisable before cargo transfer or for assuring that personnel involved would be adequately protected in the event of another release. There is a need for assessment and decision procedures to determine whether to lift loaded tank cars or transfer cargo beforehand. There is a risk of performing any operation on loaded damaged cars. A break during lifting operations would probably be severe. Transfer operations can be hazardous, but a leak during transfer would be less hazardous than a rupture in moving a tank car. This whole procedural area needs to be studied.

H.8.3 Wreckage Removal Procedures

- The Director of Pensacola Civil Defense authorized removal of wreckage. Nothing was found that indicated how this decision was reached or what procedures were to be used, including precautionary procedures. This is an area of vital concern and guidelines are badly needed.

H.8.4 Cleanup & Disposal Procedures (Including Product Transfer)

- This release did not result in a significant liquid spill, so cleanup from this standpoint was not involved. There was a significant amount of water sprayed to dilute and disperse ammonia vapors. Nothing was indicated as to the disposition of this runoff or to determine if the concentration was harmful to the environment. No transfer operations were conducted on other hazardous materials, nor was mention made of what was done with the aqueous ammonia solution in the one tank car. The emergency response plan needs to include procedures dealing with disposal. Accident reports should also mention whether or how actions were accomplished.

**H.9 ASSESSMENT OF PROCEDURES RELATED TO THE FEBRUARY 22, 1978
TRAIN DERAILMENT AT WAVERLY, TENNESSEE**

The accident involved the release of propane (LPG) resulting in numerous fatalities during product transfer operations. The unknown and critically weakened integrity of one propane tank car offset the many other correct emergency procedures utilized.

H.9.1 Emergency Response Procedures

- Members of the State emergency response organization were on hand at the accident site eight hours after the accident occurred. The state and local plan needs to assure prompt involvement.
- According to the NTSB, "after initial injuries were removed by ambulance, ambulances were kept south of the emergency command post to reduce congestion near the firefighting activities, and to protect vehicles in case the second tank exploded." This was a sound procedure.
- The LPG accident occurred in the middle of town, subsequently Waverly Fire Department issued an immediate evacuation order.
- The police and fire departments of Waverly stated that at the time of the accident they had no written disaster plan. This shows lack of knowledge of

the State Plan issued 1-1/2 years earlier. A community plan with written response procedures is vital.

- The State Civil Defense (CD) representative was not sure whether or not a plan was on file with the State CD office. This indicates a lack of communication procedures.
- The local hospital had a detailed emergency medical plan that was implemented. Such procedures are invaluable.
- Based on prior training and study, the Waverly Fire Department located the train's waybill (consist and hazardous materials identification information - one of the LPG tank cars was incorrectly stenciled "anhydrous ammonia"). Local plans should contain procedures for obtaining this information.
- The State Civil Defense Office was notified by local police nearly seven hours after the accident occurred. Procedures are needed for immediate alerting.
- A decision was made to upright the two tank cars and let them stand overnight, however prior to this, a wider evacuation of residents and turning off of utilities was ordered. The latter actions were good.
- The evacuation procedures were not expeditious, because less than 30 minutes before the blast a bus came within 100 yards of the accident. Procedures must be prompt.
- The train tracks in the opposite direction were reopened and operational at the time of the explosion. Operating procedures must assure that the emergency has been terminated before traffic resumes.
- The OSC, Waverly Fire Commissioner, the fire chief and his deputy were killed by the blast. The assistant fire chief took over command at a post 300 yards from the accident scene. The emergency procedures need to assure that the command post is beyond any possible damage area.
- The assistant fire chief increased the evacuation radius to one mile. (See preceeding item).
- The telephone company set up direct lines between Waverly Police Department, the hospital and State Emergency Operations Center (EOC). The plan needs to have procedures which assure complete communications are established immediately.

H.9.2 Hazards Mitigation Procedures

- The explosion and fire disabled most on-scene fire department personnel, as well as destroyed hoses and equipment (since the fire was advancing towards the second tank car, reinforcements concentrated on preventing the second tank car from exploding). Procedures need to assure that assessment is correctly made as to whether this effort should be attempted.
- The tank cars were vented and water pumped into the tank car as a means to force the remaining LPG into transfer tanks.

H.9.3 Wreckage Removal and Cleanup/Removal Procedures (Includes Transfer)

Very little was available on these procedures. They have been touched upon briefly in the previous sections. The catastrophe occurred during these operations and are vivid evidence that thorough assessment and operating procedures are required for wreckage removal, cleanup and disposal and transfer operations.

H.9.4 Salient Features of the State of Tennessee Emergency Response Plan

- Nearly one and one-half (1-1/2) years prior to the accident, the Governor of Tennessee established an executive order authorizing the "State Division of Civil Defense and Emergency Preparedness" as the Agency of State Government best equipped to perform a function of planning for preparedness, response and recovery, as related to accidents involving hazardous materials; for coordination and emergency response by State agencies and political subdivisions; and for coordination and liaison with related agencies of the Federal Government and such agencies of other States and concerned private agencies.
- If an accident occurred under this order, representatives from 17 state offices, shippers and three Federal agencies were to be contacted. Details of both the use and accessibility of the Chemical Transportation Emergency Center (CHEMTREC) and Pesticide Safety Team Network (PSTN) by emergency responders were detailed in the State's response plan.
- The responsibilities for each responding organization at the accident site were outlined in the State order;
- The plan covered such response areas as direction and coordination for State government response, medical care for the injured at the scene of a hazardous materials accident, water sampling, air sampling, waste disposal, traffic rerouting around the scene, personnel to stop leaks or repair damage

in order to stabilize conditions until a contractor or factory representative arrives on the scene, providing personnel to assist in crowd control and establishing a communications network.

- When local emergency responders cannot adequately control the hazards, they have jurisdiction to contact State emergency agencies.
- "Requests for personnel, equipment and supplies will flow through the Emergency Operations Center (EOC) to ensure a coordinated effort as well as the most judicious use of personnel, equipment and supplies needed to cope with the hazardous materials accident."
- "Emergency service organizations respond to emergencies involving hazardous materials and perform assigned functions using locally available resources. An appraisal of the situation should be forwarded to State EOC through established Civil Defense channels."
- Local governments may request assistance from CHEMTREC, PSTN, or other jurisdictions with which the local government has mutual aid agreements or from the State Governor and the Federal Government through the State Office of Civil Defense and Emergency Preparedness.
- Emergency responders will be equipped with coveralls, airpacks, respirators, nonsparking tools, toxic vapor detection equipment, etc.
- Upon occurrence of a hazardous materials incident, the control of the situation will be determined by State Civil Defense Operations until the arrival of the Area Operations and Training Officer. The Operations and Training Officer will be the on-scene coordinator until the Hazardous Materials Coordinator (HMC) arrives. Upon arrival at the scene of an accident, the HMC is the coordinating authority for all State government response.
- The duties of each organization with respect to hazardous materials accidents are:
 1. Office of Civil Defense and Emergency Preparedness
 - coordinate the overall effort
 - formulate plans and procedures to deal with the accident
 - maintain mutual aid agreements with surrounding states
 - conduct periodic tests and exercises to evaluate the proficiency of personnel and the adequacy of operational procedures

2. Department of Public Health
 - provide emergency medical service personnel
 - provide back-up communications
 - provide laboratory services for the analysis of hazardous materials
 - provide information on the disposal of hazardous materials
 - take samples of air, water, etc., to test for the presence of hazardous materials
 - advise state and local governments of the potential damages of various materials and necessary corrective actions
 - enforce safe storage, transportation, treatment and disposal of hazardous materials wastes
3. Department of Agriculture
 - provide laboratory tests involving pesticides and insecticides and various hazardous materials
 - provide necessary corrective actions
4. Public Service Commission
 - regulate the transportation of hazardous materials
 - provide personnel to determine whether the shipper has conformed with Public Service Commission regulations
5. Department of Transportation
 - provide materials to block highways
 - provide heavy equipment to remove damaged vehicles carrying hazardous materials and clear the highways of debris
 - reroute traffic around the area of the hazardous materials accident
 - provide restrictions on the hauling of hazardous materials
 - provide back-up communications; and
 - provide personnel with mechanical training to assist Civil Defense in stopping leaks or repairing damage in order to stabilize conditions until a contractor or factory representative arrives on the scene
6. Department of Safety
 - control traffic
 - provide security at the accident scene and control access
 - provide back-up communications
 - assist the Office of Civil Defense and Emergency Preparedness in warning and evacuating people, as the situation requires
 - investigate the accident to determine possible infractions of the law
7. Department of Conservation
 - warn and evacuate all campers and other persons from state parks if necessary
 - control forest or grassland fires caused by hazardous materials accidents
 - provide back-up communications
 - assist the Department of Safety in crowd control and in evacuation efforts
8. Tennessee Wildlife Resources Agency
 - warn and evacuate all fishermen and boaters if necessary
 - block the flow of river traffic if necessary

- collect water samples for the Departments of Public Health or Agriculture, if necessary
- provide back-up communications
- assist the Department of Safety in crowd control and evacuation efforts

9. Tennessee National Guard

- assist the Department of Safety in securing the scene and in crowd control;
- provide equipment and personnel for evacuation, if necessary;
- provide vehicles for transporting people and property, if necessary; and
- provide back-up communications.

10. Department of Labor

- obtain air samples to detect the presence of hazardous materials in an industrial environment.

H.10 ASSESSMENT OF PROCEDURES RELATED TO THE FEBRUARY 26, 1978 TRAIN DERAILMENT AT YOUNGSTOWN, FLORIDA

This accident involved the release of chlorine and other hazardous material; necessitated the evacuation of roughly 1,500 persons; and resulted in eight deaths and 133 injuries, all of which were attributed to chlorine gas inhalation.

H.10.1 Emergency Response Procedures

- The most glaring deficiency was the lack of an emergency action plan for Youngstown and the adjacent areas. The first notification of the emergency was to the Sheriff's office. This was almost one-half hour after the derailment occurred. These first minutes are recognized as the most vital for effective response. The time might have been even longer if an off-duty Deputy Sheriff had not been travelling in the area. The conductor phoned in almost at the same time, but this call for assistance could have been delayed if no phone had been in the proximity of the accident.
- The train crew had portable two-way radio equipment so they could communicate with each other or contact the local railroad dispatcher. There was no one on duty in the dispatcher's office. A procedure is necessary to assure that a dispatcher can be reached at all times, either by having someone on duty or in the vicinity of the dispatcher's office having a receiver with them, anytime a train transporting hazardous materials in the consist is moving through the area. The NTSB recommended that the railroad maintain a 24-hour radio communications monitoring capability

between trains and communications bases. This should become an integral part of the communications network established in the community's emergency action plan.

- There were indications that the crew's communication systems were not functioning properly. The rear brakeman made several calls to the engine crew before he got a reply. Also, it was mentioned that the engineer's transmission, while he was in the swamp, was sporadic. A procedure is needed to assure that communications equipment is maintained, frequently tested and operating properly at all times.
- The engineer encountered chlorine almost immediately as he attempted to head toward the caboose. He notified the conductor and then attempted to escape by running toward the prevailing wind. In retrospect, his procedure should have been reversed, albeit they were both good. What is lacking is the requirement that train crews have procedures other than walking toward opposite ends of the train to inspect the situation. They should have and utilize self-contained breathing apparatus if there is any suspicion that a gaseous or volatile liquid hazardous material might have been released, and protective boots and clothing if poisonous or corrosive materials could be involved. A portable detector to indicate the presence of such hazardous materials should be carried — technology is not yet developed for detecting all hazardous materials but there are detectors for several materials. In this case the engineer could have made good use of a compass and strong light.
- The conductor and rear brakeman awakened area residents and notified police. Both these procedures were correct. In this case, the phone call was a substitute for notifying the railroad dispatcher by radio.
- No mention was made of the presence or location of the waybills and consist information. They should have been on the train — normally with the conductor. Procedures should require them in both the engine and caboose of the train.
- Crew members stopped southbound motorists on the highway. This procedure probably prevented more deaths and injuries as did the efforts of the head and rear brakemen who made repeated trips into the chlorine cloud to stop and warn motorists. Entering a toxic vapor cloud is not advisable without proper protective equipment. As mentioned in an earlier paragraph,

procedures are needed to assure that crew members have and utilize appropriate breathing apparatus and protective clothing and gear in these situations.

- Some people reportedly drove to the scene out of curiosity; while others were simply driving by. There is an urgent need for an effective program to reach the general public and advise them of simple precautionary procedures to follow in case they encounter a hazardous material emergency. Continued efforts to provide crews and drivers with procedures, training and guidelines is needed as is improvement in the quality of such training materials. !
- The Sheriff's office alerted the Civil Defense organization, the Florida Highway Patrol and Tyndall Air Force Base. The Air Force rescue helicopter was in the air to begin the search just under 5 hours from the time of the accident. The duty officer did not get the call and alert the pilot until 2-1/2 hours after the accident. Whether the Air Force had capability for night search and surveillance is not known, but the fact that it took so long for the contact shows a lack in communications and coordination at the accident scene. Also, it took 70 minutes for the other roads in the area to be blocked off due to the late alerting of the Florida Highway Patrol.
- When advised of the accident, the Civil Defense Director recommended immediate evacuation of a 5-mile area downwind from the derailment scene. An evacuation shelter was set-up at the Panama City Armory and two in Mariana, 25 miles south and 35 miles north of Youngstown, respectively. This procedure was sound and is a good one to incorporate in a community emergency action plan.
- Aerial surveillance was utilized to track the cloud and is a procedure which is necessary for all such emergencies. Having a night time aerial surveillance procedure as well as one during daylight hours is strongly recommended.
- Further evidence that communication procedures and planning were inadequate was the fact that ambulances were not requested until 50 minutes after the accident. The initial word was that there was a gas leak with no mention that the gas was or might be chlorine. Thus, the first ambulance driver arrived without self-contained breathing apparatus and had to turn back because he became ill. These poor communication procedures resulted in precious time being lost and the needless exposure of a medical

responder. Emergency medical procedures by the same token need to assure that all ambulances are equipped with proper protective equipment before they arrive at any hazardous materials emergency. Complete, correct information must be conveyed. Also, the neighboring ambulances were on different radio frequencies than local ones, so they could not communicate by radio. Emergency procedures must provide for a central communications and operations control center. One report implied that a statewide emergency medical service radio system was being installed. This procedure is a positive step forward.

- It was not indicated how the chlorine manufacturer's representative was alerted but he and the Chief Engineer of the railroad arrived about five hours after the accident. They inspected the hole in the chlorine car to see if it could be plugged and noted the identifying numbers of other cars so they could check contents against bills of lading. This was the first real attempt at assessing whether hazardous materials were present or might be leaking, and the first positive identification that the cloud was chlorine. This shows that either emergency forces did not have procedures to identify what hazardous materials were present and involved or they made no attempt to find out. The situation can best be described as one of confusion and lack of effective communications, coordination and training.

H.10.2 Hazards Mitigation Procedures

- Evacuation of a five-mile downwind area was ordered by the Director of Civil Defense. Later this was extended to ten miles. Evacuation is an effective procedure for reducing exposure and resultant injuries and deaths. It is extremely important that procedures be pre-planned and that the situation is correctly assessed so that this action does not result in people being exposed during the operation.
- Aerial surveillance proved to be a valuable procedure for assisting with evacuation and restricting access to the area. There is a need for a night time aerial surveillance procedure for hazardous materials clouds.
- The successful air rescue of the engineer demonstrated the value of this procedure in reducing the potential for additional injuries and deaths.
- Procedures that assure the availability and use of proper breathing apparatus, protective clothing and gear, portable lights, hand compasses and the like are sure means for mitigating the exposure of persons involved in

hazardous materials emergencies. The train crew, ambulance driver and others risked their lives by actions taken when they had not been properly equipped or protected. One motorist used the air from his portable diving tank and recommended everyone should carry one in their car. That is a possible mitigation procedure that the general public could use. However, there are certain inherent hazards in filled compressed air cylinders that must be considered.

- Establishing roadblocks immediately is an effective mitigation procedure. In this case, it took 70 minutes to accomplish.
- It is impossible to mitigate the hazards in a hazardous materials accident effectively if the hazards are not known. In this case it took five hours to determine them, namely, until the Chief Engineer and chemical manufacturer's representative arrived. Procedures must assure that this is done as quickly as possible. The nose is a useful detector, but is neither accurate nor foolproof. Detection instruments and other means of identifying the particular hazardous materials present are needed (e.g., waybills, consist information and placards.)
- Educating the public to recognize a dangerous situation and to take simple safety precautions (e.g., get away from the area) can do much to mitigate the seriousness of the incident.

H.10.3 Wreckage Removal, Cleanup and Disposal Procedures (Including Product Transfer)

- No specific procedural information was obtained on wreckage removal.
- Caustic soda was spilled from one ruptured car. Caustic soda was used to neutralize chlorine remaining in the ruptured chlorine car.
- Very little in the way of procedures for handling cars containing hazardous materials was found. LPG was transferred from the damaged car to an intact one after "a close inspection of the car disclosed that the product could be transferred". The procedures used to make the safety assessment and conduct the transfer were not mentioned. Both are extremely important.
- Nothing was found on if, or how, an assessment was made to determine that it was safe to perform wreckage removal, etc. The chlorine manufacturer's representative undoubtedly had procedures for dealing with the chlorine car.

but no indication was found that comparable expertise was available to provide procedures for handling the other hazardous materials. These types of assessment and handling procedures are an absolute necessity for safely conducting the post-accident operations.

- The Situation Report, prepared by the State of Florida Department of Community Affairs, clearly states the problem as being a need for special tools and equipment for patching tank cars and transferring materials to other cars that most communities do not have, could not afford to buy and maintain without State or Federal assistance. The Chlorine Institute has specially trained response teams and patching equipment strategically located around the country to assist in chlorine emergencies. The vinyl chloride manufacturers are developing a response system. Community hazardous materials emergency action plans need to incorporate procedures for reaching and utilizing such expertise.

APPENDIX I

ANNOTATED BIBLIOGRAPHY

CLEANUP AND DISPOSAL

1. Environmental Protection Agency, Office of Solid Waste. Environmental Impact Statement, "Criteria for Classification of Solid Waste Disposal Facilities and Practices." Washington, D.C.: Government Printing Office, September 1979.

This handbook contains comments from private and public agencies concerning waste disposal.

2. Environmental Protection Agency. Federal Register, "Hazardous Waste Management System: General." Part II, Volume 45, No. 98, Washington, D.C.: Government Printing Office, May 1980.

This document contains revisions to final rule and interim final rule and request for comments.

3. Environmental Protection Agency. Guidance Manual for the Classification of Solid Waste Disposal Facilities, Draft. Washington, D.C.: Government Printing Office, November 1979.

The purpose of this report is to assist states in evaluating existing solid waste disposal facilities to identify the facilities which do not comply with the "criteria."

4. Environmental Protection Agency. Model State Hazard Management Act (Annotated), Report No. SW-635, Washington, D.C.: Government Printing Office, 1977.

This document tells the kind of legislative authority the state may find useful in developing an effective hazardous waste management program.

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This report contains insights into those factors which give rise to public opposition to siting and operation of hazardous wastes management facilities and the actions taken to try to reduce or overcome that opposition.

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This document contains information on 64 hazardous waste management facilities known to Environmental Protection Agency as of August 1974, and to provide guidance to hazardous waste generators who request assistance concerning proper waste handling procedures.

11. Geswein, A. J., Liners for Land Disposal Sites, An Assessment Report No. SW-137, Washington, D.C. Environmental Protection Agency. 1975.

This report discusses the use of natural soils, asphalt treatments, polymeric membranes, and treated soils to line land disposal sites.

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The information in this guide assists the holders of small batches of wastes in determining if the waste contains hazardous components, and if so, how should it be handled and disposed of safely.

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In this report, processes have been developed using molten salts for the purpose of disposing propellants. During this process propellants can be disposed of safely and in a non-polluting manner by combustion in contact with molten alkali metal carbonates at 800° C. Of the two combustion modes developed, one is combustion of the propellant beneath the surface of the melt (submerged combustion), and is suitable for halogen containing propellants. The second is combustion on the surface of the melts and is most suitable for propellants containing organic NO₂ and NO₃ groups.

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The waste disposal subcommittee of the Environmental Protection Committee for the Safety and Environmental Group of the Joint Army, Navy, NASA and Air Force have been surveying Propellants, Explosives, and Pyrotechnics (PEP) Waste Disposal Technology. Long-term retention of some PEP waste materials (meaning from one year to decades) will always be in need. Although there is a vigorous program currently underway attempting to neutralize or recycle all PEP wastes, there are some which are expected to resist all methods of treatment. Long term retention will also occur when various systems are declared obsolete for use.

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This document contains a digest of the most useful technical and economic information known to the Office of Solid Waste Management Programs of the Environmental Protection Agency.

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This pamphlet describes the National Strike Force personnel team and their capabilities during a hazardous material spill.

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This booklet explains the EERU capabilities in situations where the use of complex cleanup equipment and techniques are required.

22. U.S. Testing Co., Inc. Environmental Services/Biological Services Division.

This advertisement booklet explains that the U.S. Testing Co., Inc. is an independent lab that provides services and products in the fields of testing, research, engineering, product development, inspection, certification and testing instruments.

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24. Graphics Management Corporation. Proceeding of the 1972 National Conference on Control of Hazardous Materials Spills. Sponsored by Environmental Protection Agency, March 21-23, 1972.
25. Proceedings of 1980 National Conference on Control of Hazardous Material Spills. Sponsored by Environmental Protection Agency, April 11-13, 1978.
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27. Association of American Railroads, Bureau of Explosives. Emergency Handling of Hazardous Materials in Surface Transportation. September 1977.
28. Department of Transportation, Chemical Propulsion Information Agency, Applied Physics Laboratory. Hazardous Material Response Guide, DRAFT, February, 1979.

This guidebook was developed for use by firefighters, police and other emergency services as a guide for initial action to be taken to protect themselves and the police when they are called to handle incidents involving hazardous materials.

29. Department of Transportation, Research and Special Programs Administration and NHTSA, Emergency Action Guide for Selected Hazardous Materials. 1978.

This booklet contains 44 selected hazardous materials shipped in bulk that are gaseous or highly volatile liquids with poisonous or extremely flammable properties.

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31. Department of Transportation, United States Coast Guard, Chemical Hazards Response Information System, A Condensed Guide to Chemical Hazards, January 1974.

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32. Department of Transportation, United States Coast Guard, Office of Research and Development, Chemical Hazards Response Information System for Multimodal Accidents (CHRISMA), Final Report. April, 1975.

This report examines the need for improved technical and other information for meeting emergencies connected with the transportation of hazardous materials, particularly actual or potential chemical discharges of

mode. The Chemical Hazards Response Information System (CHRIS), under development by the U.S. Coast Guard to furnish in-depth guidance during emergencies involving waterborne transport, was seen as a likely prototype for other modes as well. A reevaluation of CHRIS has been conducted to determine the desirability of enlarging its scope to include all modes of transportation. It is agreed that an expanded system would be beneficial in reducing losses to life, property and the environment. This information system would be a decentralized organization providing response guidance on request to local emergency services personnel, a computerized hazard assessment system operated at Headquarters, and three reference manuals furnished to all response organizations.

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34. Department of Transportation, United States Coast Guard. CHRIS Hazardous Chemical Data, Volume 2. Report No. CG-446-2. January 1974.
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This manual is Volume IV of our volumes that provide timely decision-making information for use by Coast Guard personnel and others involved in responding to and mitigating the effects of hazardous material discharges. It can be properly used only in conjunction with the other manuals of the CHRIS system.

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HANDLING, STORAGE, TRANSPORTATION

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This booklet explains the good and bad points of hazardous materials, the way hazardous materials are transported, and what the chemical industry is doing to prevent accidents and maintain safety during the transport of hazardous materials.

98. Association of American Railroads, Bureau of Explosives. Illustrating Approved Methods for Loading and Bracing Trailers and Less Than Trailer Shipments of Explosives and Other Dangerous Articles Via Trailer-on-Flatcar (TOFC) or Container-on-Flatcar (COFC).

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This document is the result of a study performed by the Bell System regarding the methods, procedures and problems encountered in the aftermath of a railroad accidents involving hazardous materials.

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109. Association of American Railroads, Bureau of Explosives, Recommended Practice for Handling Incidents Involving Hazardous Materials, September, 1977.

In this pamphlet, contains the materials and their properties concerning hazardous materials, and other information useful in training and preplanning exercises.

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This report was written under Section 7 of the Occupational Safety and Health Act of 1970 to develop guidelines for the implementation of the Act with respect to Hazardous Materials.

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The purpose of this report is to establish new national regulatory programs for the control of hazardous wastes as required by the Resource Conservation and Recovery Act of 1976.

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This report contains suggested procedures for control of hazardous material spills using improvised treatment processes. This manual includes: notification procedures on inventory of information sources; methods for spill identification and assessment; a thought guide for determining the best method of handling a spill; suggested treatment schemes for 303 designated hazardous chemicals; a limiting factor system design approach, and design construction, and operation steps for each of the five treatment processes applicable to improvised systems.

115. Environmental Protection Agency, Office of Research and Monitoring. Control of Hazardous Chemical Spills by Physical Barriers. Prepared by J. V. Friel, Marshall Hiltz M.D., March 1973.

In this report, the MSA Corporation (MSAR) has been associated with two programs to study the problems of hazardous chemical spills in unconfirmed areas. The first was concerned with the spill of liquid rocket fuels in field complexes, the second, with spills or leaks of chemical warfare agents during transportation or in the field. In both of these studies, it was clear that immediate action had to be taken if there was any hope of containing or controlling spills at all. Three basic steps were considered.

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This report contains an in-depth evaluation that was conducted of potential response techniques for ameliorating the vapor hazard from discharges of hazardous chemicals that float on water.

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wide variety of hazardous liquids. This blend, called Multipurpose Gelling Agent (MGA) has been optimized to obtain a balanced formulation that will effectively gel and immobilize most spilled hazardous liquids within minutes. The current formulation consisting of four powdered polymers and one organic powder has the ability to immobilize spilled liquids with the least amount of material in the shortest amount of time, but evaluation of alternate materials is still in progress.

120. United States Coast Guard. Explosive Hazards Associated with Spills of Large Quantities of Hazardous Materials, Phase I, Prepared by C.D. Lind, Department of the Navy, Naval Weapons Center, October 1974.

This report documents the results of Phase I of a program whose object is to quantify the explosion hazards of large quantities of hazardous materials such as liquefied natural gas (LNG), a liquefied petroleum gas (LPG), or ethylene. The principal results are a phenomenological description of a spill, an examination of the detonation properties of methane, a qualitative theory on non-ideal explosions and a plan for Phase II of the study.

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This report describes the selection and testing at the Oil and Hazardous Materials Simulated Test Tank of several commercially available oil spill control devices for use in controlling spills of hazardous materials which float.

122. Environmental Protection Agency, Office of Research and Development. Treatment of Hazardous Material Spills with Floating Mass Transfer Media, Prepared by B. W. Mercer, A. J. Shuckrow, A. J. Dawson, September, 1973.

This document approaches the treatment of spills and soluble hazardous polluting substances that was developed and demonstrated on a field scale for a static body of water.

123. Environmental Protection Agency. Feasibility of Plastic Foam Plugs for Sealing Leaking Chemical Containers, Prepared by R.C. Mitchell, C. L. Hamermesh, J.V. Lecce, Edison Water Quality Research Laboratory May 1973.

In this report a program was conducted to evaluate the feasibility of methods for plugging leaks in damaged chemical containers by application of suitable plastic barriers. This system is valuable in helping to prevent water pollution from spilled hazardous chemicals. To conduct this study, candidate sealants were evaluated in laboratory screening tests. Included were: urethane foams, polystyrene and polyvinyl acetate instant foams; filled and unfilled epoxy systems, and polysulfide, butyl, neoprene, and silicone rubber systems; the urethane foams having the most promising results. Additional tests were made including the sealing and application to leaks both under water and in air, and sealing of leaks in 55-gallon containers.

124. "Monitoring Structural Integrity by Acoustic Emission", ASTM STP 571, American Society for Testing and Materials, 1975.

125. Environmental Protection Agency. Oil and Special Materials Control Division, Office of Water Program Operations, Oil Spills and Spills of Hazardous Substances

The objective of this document is to describe some of the more significant spill incidents and mechanisms, both managerial and technological, and to protect water quality through the prevention.

126. Environmental Protection Agency, Office of Research and Development, Industrial Environmental Research Laboratory. Effect of Hazardous Materials on Spills on Biological Treatment Processes, Prepared by A. P. Pajak, E. J. Martin, G. A. Brinsko and F. J. Erny. December 1977.

This report develops and demonstrates new and improved methodologies for a more efficient pollution control system.

127. Radon, J.C., and Pollach, A.A., "Acoustic Emission Methods for Flow Detection in Steel Highway Bridges, Phase I", Report No. FHWA-RD-78-97, March 1975.

128. Steele, A.B., Duggan, J.J., "Safe Handling of "Reactive" Chemicals", Chemical Engineering, 1959.

This article embodies the combined thinking of the individuals and departments within Union Carbide concerning "reactive" chemicals.

129. "Tank Car Structural Integrity After Derailment", NTSB-SIR-80-1

130. Texas Transportation Institute, Texas Engineering Extension Service, Hazardous Materials Spills - Management Review, DRAFT

This report is a study funded by the American Petroleum Institute and undertaken by the Texas Transportation Institute and the Texas Engineering Extension Service to identify and alleviate deterrents to safe and efficient hazardous materials transportation. These deterrents include a lack of harmonious international, federal, state and local regulatory controls; the lack of coordinated training for all persons involved in hazardous materials transportation, especially shippers, carriers and emergency response personnel; a lack of clarification on the part of governmental and private agencies of individual legal responsibilities, and a lack of public awareness of the problems and the attempts being made to solve them.

131. Williams, R.S., Closed Loop, The Magazine of Materials Testing "Modeling of Elastoplastic Fracture Behavior Using Acoustic Emission Methods", Volume 10, No. 2, 1980.

132. Environmental Protection Agency, Office of Drinking Water, Ground Water Protection Branch. A Guidance for Protection of Ground Water Resources From the Effects of Accidental Spills of Hydrocarbons and Other Hazardous Substances, Prepared by J. T. Yang, W. E. Bye, July 1979.

The purpose of this document is to assist state, regional, and industrial personnel by providing guidance on spill prevention and cleanup methods, as they relate to ground water contamination.

133. Environmental Protection Agency, Office of Drinking Water, Ground Water Protection Branch. Methods of Preventing, Detecting, and Dealing with Surface Spills of Contaminants Which May Degrade Underground Water Sources for Public Water Systems. Prepared by J. T. Yang, W. E. Bye.

The purpose of this study is to prepare guidelines and technical

documents that can be utilized by industry, federal, state and local governmental agencies to assist in eliminating, or minimizing the efforts of spills of contaminants that might adversely affect underground water systems.

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APPENDIX J

ORGANIZATIONAL ACTIVITIES AT A HAZARDOUS MATERIALS TRANSPORTATION EMERGENCY

Introduction

Procedures for handling chemical and propellant spills can be generally categorized as preventive and corrective. Preventive procedures are those which are applied to prevent further worsening of an accident, while corrective procedures are utilized to eliminate or control the hazards resulting from an accident. Preventive and corrective procedures can be used independently or in conjunction with one another. Additional support procedures, such as providing sustenance and housing for evacuees, are also important. However, within the scope of this study, only preventive and corrective procedures are being considered, even though all necessary procedures ought to be addressed in the development of a comprehensive emergency action plan.

In terms of emergency response, hazards mitigation, cleanup and disposal and wreckage removal, corrective and preventive procedures are needed to deal with: (1) communications which alert, inform, obtain help and coordinate activities; (2) assessments of risk and hazards with respect to hazardous materials identification, container integrity, personnel, equipment and material requirements, resources available and effectiveness of actions; (3) decisions appropriate to deal with the hazards and effectively utilize resources on-scene; (4) actions to alleviate the hazards, and carry out evacuation and rescue attempts; and (5) actions to protect on-scene personnel from further hazards.

When an accident occurs, many industry groups, service organizations and governmental agencies become involved in the emergency response. This is particularly true of transportation accidents involving hazardous materials because of the significant risk implications involved. Given the hazards and potential risks in working in any capacity at an accident scene, it is imperative that every person involved fully comprehend his or her responsibilities and the ramifications of their actions upon themselves and other personnel.

The on-scene activities of various groups or experts require specialized procedures addressing every aspect of emergency response, product transfer, wreckage removal and cleanup and disposal.

Many procedures that currently exist have been developed piecemeal, from accident to accident keeping those methods that worked, discarding those which were not

successful. However, a more systematic approach to developing improved procedures is necessary especially to address some of the most critical technical issues posed at every accident site. To improve procedures or develop procedures where none currently exist, criteria must be organized as the basis for such development.

The activities of several of the organizations, groups and specialists which respond to accidents have been catalogued to identify lines of responsibility during all phases of spill handling. Some overlap in activities for different organizations is inevitable. However, there must be specific delegation of authority, responsibility and decision-making or important functions could be forgotten or overlooked thus creating great hazard to the public, property and the environment as well as to those responders at the scene. The organizations for which activities have been specified include:

- USCG National Response Center
- train crew
- rail carrier
- railyard personnel
- truck driver
- highway carrier
- fire service
- law enforcement
- civil defense/disaster preparedness agencies
- shipper
- trade association response teams
- cargo transferer
- cleanup contractor
- disposal contractor
- environmental protection response teams
- military installations
- emergency medical services
- news media
- civilian population

The following section discusses the general activities for each of the above groups.

J.1 Activities of the USCG National Response Center (NRC)

The USCG National Response Center serves an extremely important function in all hazardous materials accidents by providing technical information to response organizations on toxicity, flammability and other hazardous properties of involved materials. To ensure that accurate information is transmitted and proper activities are performed on-scene the USCG NRC should perform and participate in the following activities:

1. assure that they receive prompt notification of an incident;
2. activate emergency communications network;
3. inform concerned organizations such as the FHWA/BMCS, FRA, EPA, CHEMTREC, FEMA, NTSB, shipper, carrier and others of the accident conditions on-scene and problems encountered;
4. establish communications with the on-scene coordinator as well as organizations involved in emergency response, product transfer, wreckage removal, cleanup and disposal operations;
5. identify hazardous material(s) involved;
6. identify other information needed as input to execute HACS and its vapor dispersion submodels;
7. provide technical/safety information for use on-site by all response groups;
8. perform hazard/risk analyses from monitoring data;
9. determine what equipment, materials and personnel are needed on-site;
10. assist in locating additional needed equipment, materials and personnel;
11. assure that the standard operating procedures of emergency response, wreckage removal, product transfer, cleanup and disposal organizations will adequately handle the technical and safety requirements of the accident;
12. assure that deployed teams are trained and are equipped with personal protective clothing and equipment; and
13. provide recommendations concerning disposal location (i.e., on-site or off-site), potential disposal sites and feasible modes of transportation to be used in disposing of the material.

J.2 Activities of the Train Crew

Once a hazardous material train accident occurs, the crew should:

1. report the accident to the local dispatcher;
2. provide information about the specific hazardous materials involved;
3. provide manifest and waybills to emergency responders;
4. maintain radio communications with the communications command post (CCP);
5. provide technical information, if known, about the designs of containers involved including appurtenances, safety relief devices, valves, hoses, fittings, pumps, etc;
6. provide factual accident information to responders and others;
7. provide information regarding the quantity of the materials involved and estimated amount released;
8. identify any crew deaths or other fatalities which have resulted and assist in moving them outside the "danger area";
9. call for special equipment and expertise needed to handle the accident situation;

10. report the presence of fire, vapor cloud, noise of escaping gas, etc.;
11. indicate whether the spill appears to be controllable; and
12. evaluate proposed product transfer, wreckage removal, cleanup and disposal methods to the extent that train crew is involved in these operations.

Procedures must also be established which will assure that the train crew follows the company's emergency procedures for a hazardous materials accident, rescuing oneself and initiating rescue of other crew members when their safety is not endangered, and utilize personal protective clothing and gear.

J.3 Activities of the Rail Carrier

Communications procedures for rail carriers should be established to facilitate notification of the USCG National Response Center/CHEMREC, shipper, consignee, etc. after an accident. The rail carrier should also provide information to responding groups on hazardous material identification, shipment quantities and other commodities being transported on the train. They should also provide status reports to these groups as well as provide technical assistance on tank cars. The rail carrier should contact wreckage removal, cleanup, disposal and product transfer contractors for their specialized services at the accident site.

At the accident site, the rail carrier should assess:

1. the severity of the accident and any further assistance that may be needed;
2. condition of train crew and their ability to assist on-scene personnel;
3. safety, practicality and necessity for moving cars before cargo transfer or vice versa;
4. proposed product transfer, wreckage removal, cleanup and disposal operations for technical feasibility; and
5. container integrity.

In terms of post-accident decisions by the rail carrier, they must decide:

1. whether the crew remains at the accident site;
2. whether to dispatch a company representative to the site;
3. authorize or reject proposed product transfer, wreckage removal, cleanup and disposal operations for safety and other reasons; and
4. logistics of these operations interacting with each other.

Actions by the rail carrier should include:

1. contracting with wreckage removal, product transfer, cleanup and disposal crews;
2. cooperating with the on-scene coordinator and other on-scene response personnel;

3. advising crew members as to their role in the accident response; and
4. providing compliance with DOT and other regulations.

J.4 Activities of Railyard Personnel

When a hazardous materials transportation accident occurs in a railyard, its personnel can be used in restoring an area to normal. However, prior to deploying personnel to an accident scene, they should have adequate training to fulfill the jobs in which they will serve. To ensure that these personnel will be adequately trained and utilized, procedures need to be developed which will allow for the following:

1. immediate notification of the yardmaster by personnel of any detected leaks, fires, smoke or any other signs of an accident;
2. warning of other yard personnel by audio devices;
3. notification of local emergency response groups so they can activate the community response network;
4. yardmaster contacting railroad officials, dispatcher, etc.;
5. establishing and maintaining communications with the on-scene coordinator and groups involved in the emergency response, product transfer, wreckage removal, cleanup and disposal operations;
6. track signalling to approaching trains to stop or slow traffic;
7. contracting for product transfer, wreckage removal, cleanup and disposal organizations;
8. determining if uninvolved cars can be moved safely away from the car(s) involved in the accident;
9. identifying optimal methods for protecting individuals involved in the response operations and the surrounding communities;
10. noting and assisting in monitoring any vapor clouds, and runoff;
12. ensuring that DOT-approved containers are used for product transfer and disposal of the material;
13. assuring that all equipment and materials used are compatible with the cargo;
14. deciding whether to evacuate work area, what individuals should be allowed on-scene and reviewing standard operating procedures of the various response groups for technical feasibility and safety benefits based on the particular accident conditions;
15. having the yardmaster control rail traffic in the yard to assist response operations and having him decide at what time should non-impacted cars be moved from the accident area to minimize their potential loss of cargo and other damage;
16. deciding whether or not to attempt to put out any fires prior to arrival of the fire service; and
17. providing for response groups access to rail properties.

J.5 Activities of the Truck Driver

When a hazardous materials accident involving a highway vehicle occurs, the driver should perform the following activities:

1. immediately contact local emergency response groups so they can quickly respond;
2. notify the carrier/dispatcher;
3. provide shipping papers to emergency responders and identify hazardous material being transported as well as quantity being shipped;
4. if civilian population comes near accident site prior to arrival of emergency responders, the driver must warn these individuals of the potential dangers of remaining in the area;
5. provide factual accident information to the OSC;
6. identify the damage to the tank and vehicle and estimate the size and quantity of any material spilled;
7. assure that disposal will be in accordance with shipper's desires;
8. based on the driver's training, he should make an attempt to assess the feasibility of proposed wreckage removal and cleanup operations;
9. provide assistance to emergency responders in the location of valves, controls and other aspects of the tank;
10. shut off engine immediately so that no released flammable material that is ignited; and
11. advise wreckage removal contractor of the location to ship vehicle wreckage.

J.6 Activities of the Highway Carrier

Once a highway carrier has been informed that a hazardous materials accident has occurred, the company should:

1. activate the company's emergency communication system;
2. establish a communication link with the on-scene coordinator at the command post;
3. contact the shipper and consignee about the situation;
4. identify the hazardous material involved and the quantity released;
5. report accident to the NRC and other agencies as required; and
6. provide information to a product transfer contractor on the design and operation of the vehicle to assist in transfer operations

At the accident site, highway carriers must assess the accident situation in terms of:

1. the nature of the accident and potential assistance which may be needed;
2. condition of driver and his capability to assist on-scene response personnel;

3. the container integrity prior to product transfer and wreckage removal operations; and
4. "Standard Operating Procedures" (SOP's) of product transfer, wreckage removal, cleanup and disposal contractors prior to initiating specific operations.

J.7 Activities of the Fire Service

When a call about a hazardous materials accident is received, the following are activities that the fire service might be called upon to perform on-scene:

1. activate a communications network;
2. contact local authorities, USCG/NRC, CHEMTREC, shipper, carrier, DOD, DOT, hospitals and public health officials, state officials, news media and others indicated in the emergency response plan;
3. obtain technical information about the hazardous material being transported, its potential dangers (i.e., flammable, toxic, explosive, etc) and monitor the area for these levels;
4. provide factual information about the accident status;
5. advise news media of the status of the situation;
6. provide two-way radio links to groups involved in response activities;
7. act in the capacity as the on-scene coordinator;
8. obtain and utilize meteorologic information for firefighting;
9. search for fatalities, injuries and exposures;
10. identify presence of vapor cloud and its direction;
11. decide whether to approach scene, fight fire, attempt rescue, remain at reasonably safe distance, withdraw personnel, allow hazardous material to burn, vent or discharge;
12. decide what personnel should be present during specific operations;
13. establish command post;
14. seek train crew or truck driver for consist or bill of lading;
15. decide whether to perform firefighting activities such as extinguishing fires, suppressing vapors, containing runoff to prevent contamination to waterways, closing valves of damaged tank to stop release; and
16. keep any sources of ignition away from transfer operations, cool container if needed, place protective barriers and stand by on alert in case of an unforeseen event.

J.8 Activities of Law Enforcement Personnel

Law enforcement personnel should perform the following activities at hazardous materials accidents:

1. receive notification of the accident;
2. make contact with local fire department, carrier dispatcher, shipper and other local officials;
3. provide communications backup;

4. determine alternative traffic routes around hazard area;
5. assess and implement measures needed to secure the area allowing only response individuals into the area and keeping unauthorized personnel out;
6. establish and monitor roadblocks and other barriers;
7. assist with evacuation of residents;
8. assist in removal of fatalities, injuries and exposures;
9. assume control, if authorized, of community plan; and
10. reestablish normal traffic flow after accident is considered stabilized.

J.9 Activities of Civil Defense/Disaster Preparedness Agencies

The communications activities of civil defense/disaster preparedness organizations are very important because it is these groups which can serve to coordinate communications channels among all of the responding parties. A communications network needs to be activated immediately after initial notification of the accident, so that Federal, state and local authorities, shippers and any other necessary response group will be informed of the situation. Information such as hazardous materials identification, meteorologic conditions and other requested information should be collected and disseminated to various response groups by civil defense organizations in the communications command post.

In terms of assessing the accident situation, this group should assist with monitoring vapor clouds and vapor concentrations to provide data to the on-scene coordinator for decisions concerning evacuation of civilian population and protection of on-scene personnel.

Decisions need to be made and actions implemented by the civil defense with respect to evacuation of population and command post location.

J.10 Activities of Shippers

Shippers should provide hazardous material identification information and a toll-free 24-hour response number on all shipping documents. Also, they should provide technical assistance at the accident site as requested by response groups.

Once on-site, the shipper should assist in developing and assessing the plans for product transfer, and cleanup and disposal of the specific hazardous commodity shipped. The basis for assessing the feasibility of these operations should be: (1) the availability of trained personnel on-site and; (2) adequate equipment and soundness of standard operating procedures for performing these tasks so they will not increase the potential risks for personnel engaged in these operations.

The shipper should make such decisions as whether or not to send a technical team to the accident site, which type of DOT container should be used for transferring the material and whether the hazardous material waste ought to be disposed of by burning, neutralization, dilution, burial or evaporation or returned for recovery.

The shipper should be responsible for the following:

1. responding to requests of the USCG National Response Center/CHEMTREC, carrier, etc.;
2. providing any special equipment or materials; and
3. providing technical advice on-site.

J.11 Activities of Trade Association Response Teams

When a trade association is notified of a hazardous materials accident, their response team should perform the following activities:

1. activate their emergency response network;
2. establish communications with shipper, on-scene coordinator, USCG/NRC, CHEMTREC, etc.;
3. obtain detailed accident-specific information such as nature of the spill, geographic location, types of container(s) involved, types and quantity of materials and equipment on-site, local topography, hazardous materials involved and on-scene phone number and contact;
4. provide technical assistance to emergency response, wreckage removal, product transfer, cleanup and disposal groups;
5. identify what tools, materials and equipment are needed on-site;
6. evaluate the alternatives of stopping the leak, controlling spill, product transfer, cleanup and disposal methods;
7. monitor the atmospheric wind speed and direction as well as estimating the downwind vapor concentration;
8. assess the integrity of the container;
9. assess the risks and safety benefits of moving the container prior to cargo transfer operations or visa versa;
10. assess proposed product transfer, wreckage removal, cleanup and disposal operation "plans of attack" to handling their various operations for technical feasibility and safety aspects;
11. assure that personal protective clothing and equipment is used on-scene;
12. assist in deciding what equipment, materials and personnel should be deployed to the accident scene;
13. assist in the decision to stop leak, let burn, cool tank, put out fires etc;
14. assist in the identification of personnel to be permitted in the accident area;
15. assist in emergency response, wreckage removal, product transfer, cleanup and disposal operations as requested by these groups;

16. assist in deciding whether or not to move the container before or after cargo transfer; and
17. ensure that DOT-approved containers are used for product transfer and disposal.

J.12 Activities For Cargo Transfer Contractor

Communications with organizations involved in cargo transfer operations should provide up-to-the-minute information on the accident status so they will arrive on-scene with properly trained personnel and adequate equipment. The information to be supplied to the responding cargo transfer contractor should include details of the hazardous materials involved, the quantities of these materials spilled or remaining in the tank truck or tank car, container design and orientation, meteorologic conditions, topography at the accident site and equipment available on-site provided for use by other organizations. Cargo transfer groups should maintain constant communications through the command post with wreckage removal, cleanup and disposal organizations because any of these services might be performed in some part during cargo transfer operations. To ensure that a safe working environment is maintained during the entire post-accident operation, constant communication is necessary.

Once a cargo transfer contractor or other specialist arrives on-scene, he should conduct a preliminary assessment of the available resources (personnel and equipment), container integrity and potential risks based on the situation at hand and accident information supplied to him prior to arrival. The entire duration of cargo transfer operations should be monitored for toxic and flammable vapor levels and container integrity. Personnel need both the heavy and personal protective equipment necessary to handle the hazardous situation.

Decisions have to be made by cargo transfer contractors as to:

1. accepting or declining a job;
2. selecting proper equipment and trained personnel to meet the job requirements;
3. logistics of moving equipment to the accident location; and
4. what, if any, technical assistance will be required during the cargo transfer operations that might be beyond the capabilities of the contractor.

If the job is accepted, the cargo transfer contractor should identify the proper course of action to be taken based upon the actual accident environment. A listing of the types of actions which must be instituted by a cargo transfer group include:

1. movement of equipment and personnel to the accident site;
2. finalization of contractual agreements between parties;

3. initiation of cargo transfer operations based on standard operating procedures or approved modifications;
4. utilize existing internal cargo pressure gravity flow or pumping to transfer materials;
5. maintain closed loop transfer and avoid applying external pressure; and
6. transfer to DOT-approved container for the particular material involved.

J.13 Activities of Cleanup Contractor

A communication link needs to be established between the cleanup contractor (shipper team or other group) and command post at the accident site. Prior to arriving at the accident, the cleanup contractor must be notified of the hazardous material involved so he can bring trained personnel and adequate equipment for handling the situation. Communications should be maintained on-scene between the cleanup contractor and other related response organizations (i.e., wreckage removal, product transfer and disposal) through the CCP.

The cleanup contractor should make sure that the required equipment and manpower are available to respond to the accident site, so that cleanup of the spilled material and its byproducts can be performed in a timely manner. During assessment, continuous monitoring for toxic and flammable vapors should be conducted so that no personnel will be endangered. All personnel should be provided with protective clothing and gear.

Once a plan of attack has been identified for cleaning up the hazardous materials, the plan must be activated. Prior to activating the plan, materials, inventory and personnel should be collected centrally. As soon as the materials, inventory and personnel are collected, they should be deployed. At the same time, access to this central collection area should be restricted to required personnel. Materials cleaned up from the accident site should be placed in DOT-specified containers.

J.14 Activities of Disposal Contractor

When responding to a hazardous materials accident, the disposal contractor or other disposal group should perform some activities in-transit as well as on-site:

1. communications need to be established and maintained with the on-scene coordinator and shipper/carrier as well as organizations involved in emergency response, product transfer, wreckage removal and cleanup operations;
2. receive and use up-to-the-minute information on the quantity and type(s) of hazardous material(s) involved, location, condition and other information necessary to conduct disposal;
3. advise regulatory/government agencies about disposal plans and obtain necessary approval;
4. provide standard operating procedures and other information required

- prior to initiating disposal;
- 5. receive accurate meteorologic data;
- 6. assess the situation in terms of equipment, materials and personnel required and deploying these to the accident site;
- 7. continuously monitor for high concentrations of toxic and flammable vapors as well as any unusual conditions;
- 8. assure integrity, adequacy and operability of personal protective clothing and equipment;
- 9. continuously observe personnel for any indication of toxic exposure or any oxygen deficiency; and
- 10. monitor effluent gas from any incineration operation and content of waste water being discharged into waterways to ensure compliance to EPA pollution standards.

J.15

Activities of Environmental Response Groups

Activities of environmental response groups include:

- 1. receive initial notification of accident by either federal or state environmental response groups which in turn notify appropriate other jurisdictional counterparts;
- 2. participate in emergency response communications network;
- 3. prior to arrival obtain accident-specific information such as nature of spill, location, hazardous material(s) and quantity involved, topography, local meteorology, equipment and materials available on-site;
- 4. provide technical assistance in terms of recommended techniques, equipment, materials, procedures, suppliers, specialists and regulations which may provide help to the groups involved in the response activities;
- 5. contact and arrange for specialized equipment, materials and environmental specialists;
- 6. establish and maintain communications with on-scene coordinator as well as emergency response, product transfer, wreckage removal, cleanup and disposal contractors;
- 7. conduct an assessment of environmental contamination;
- 8. continuously monitor the atmosphere, meteorologic conditions, aquatic environment and actual behavior of the spill;
- 9. evaluate possible and proposed spill control, cleanup and disposal methods, equipment, materials and procedures;
- 10. provide predicted downwind vapor dispersion concentration information;
- 11. participate in deciding what cleanup and disposal operations can be initiated before containment is complete;
- 12. assist in assessing wreckage removal, product transfer, cleanup and disposal standard operating procedures and their potential application to this accident;
- 13. interpret monitoring and analytical data as needed by the on-scene coordinator;

14. respond to requests for assistance related to environmental protection; and
15. ensure that all involved personnel are adequately equipped with personal protective clothing and equipment.

J.16 Activities of Military Installations

Military installations involved in the shipment of hazardous materials should have procedures identified to assist emergency response, product transfer, wreckage removal, cleanup and disposal groups at the accident site. The following activities of military installations personnel include accidents both on and off-site:

1. activating the military hazardous material emergency response network;
2. alerting response teams on-base or in immediate vicinity;
3. establishing communications with the on-scene coordinator and other local officials;
4. conducting radar tracking of the vapor cloud in the area;
5. establishing and maintaining direct communication between on-scene coordinator and any surveillance aircraft that might be deployed;
6. providing meteorologic information to all groups;
7. obtaining detailed information of the location, nature, identity and quantity of all hazardous materials spilled;
8. providing environmental monitoring to all groups;
9. establishing and maintaining communications with emergency response, product transfer, wreckage removal, cleanup and disposal organizations;
10. identifying the extent of fatalities, injuries and exposures;
11. identifying the resources needed for various operations versus what is immediately available;
12. assisting in determining which personnel should be permitted in the accident area;
13. assisting in assessing the hazards and risks of moving the container prior to cargo transfer and vice versa;
14. deciding if personnel involved in all aspects of response to the accident are equipped with proper personal protective clothing and equipment;
15. assisting in deciding whether standard operating procedures of wreckage removal, product transfer, cleanup and disposal contractors can safely be applied to the actual accident conditions;
16. assisting or taking charge of the response operation, if on-site (this delegation of authority can be identified through pre-planning between military installations and local jurisdictions);
17. deploying equipment, materials and personnel to the scene as well as once on-scene deciding whether to dike/dam/ditch the spilled material and whether to plug tank or close valves; and
18. assisting in preventing access to area by non-essential personnel.

Procedures also need to be established for a military installation located close to an accident whether involved in the shipment or not. Once a call for assistance or to alert is made to the installation, responding personnel should immediately link their communication system into that being used by other responding organizations. Some supporting activities that a nearby military installation could fulfill include:

1. coordinating communications between all military facilities;
2. monitoring meteorologic conditions;
3. conducting aerial and radar surveillance;
4. monitoring vapor cloud concentration and direction;
5. assisting in emergency response, product transfer, wreckage removal, cleanup and disposal operations as deemed necessary by the on-scene coordinator; and
6. providing specialized equipment which many local jurisdictions would not have available.

J.17 Activities of Emergency Medical Services

Communications activities of emergency medical services should have: (1) the capability for receiving information on hazardous materials and exposures and for relaying this information to other responding units, and (2) the capability to provide secondary communications support.

These services must have procedures for first aid to victims and transporting them to hospitals. Also, emergency medical personnel should:

1. have the training and equipment needed for transporting injured persons out of remote areas or rugged terrain;
2. assist in evacuation; and
3. assist in personal decontamination.

Duties for members of the medical service other than emergency medical services should include the following:

1. establishing communications with mobile emergency units and hospitals;
2. obtaining information on the numbers and types of injuries, fatalities and exposures;
3. determining the type(s) of hazardous materials involved;
4. contacting needed medical specialists;
5. assessing the adequacy of the facility to treat victims;
6. determining what if any, additional help or facilities will be needed;
7. deciding what facilities are capable of handling victims with specific injuries or exposures; and
8. contacting hospitals so they can prepare for the arrival of the injured victims.

J.18 Activities of the News Media

Procedures need to be established which will safeguard and provide accurate information to members of the news media when they arrive at a hazardous materials accident. Members of the news media should:

1. establish communications with the on-scene coordinator or official spokesman by telephone or radio;
2. communicate via radio, television and newspaper warnings to the public to remain out of the area and other self-protection instructions and information;
3. report only factual information to the public;
4. provide communications support as requested by the on-scene coordinator or other authorities; and
5. avoid the temptation to perform technical assessment.

J.19 Activities of the General Public

When an accident occurs the general public should:

1. notify the telephone operator, local fire department, police, railroad office or shipper;
2. assist with "ham" or CB radio communications to the extent requested by the on-scene coordinator;
3. be informed as to whether they should evacuate, remain indoors and what actions should be taken for each of these situations;
4. keep out of the accident area; and
5. pre-plan evacuation strategies and routes for maximizing their personal safety.

APPENDIX K

NTSB-INVESTIGATED ACCIDENTS RELATED TO WRECK-CLEARING OPERATION

Some safety problems associated with wreck-clearing operations are illustrated in the derailment of L & N Train No. 584 at Waverly, Tennessee on February 22, 1978 and the subsequent rupture and explosion of a tank car (UTLX 83013) containing liquefied petroleum gas. The events leading to the explosion, which resulted in 16 fatalities and 43 injuries, are described in the following excerpts from Railroad Accident Report NTSB-RAR-79-1.

Included in the derailed cars were two tank cars -- UTLX 83013 and UTLX 81467 -- loaded with liquefied petroleum gas (LPG). An inspection of the tanks disclosed no leakage. Because the tank cars were damaged, L & N management involved in clearing the wreckage decided to move the tank cars from their positions in the wreckage to a position alongside the track structure, where the lading could be transferred into highway tank trucks. The derailed freight cars, which were obstructing the tank cars as a result of the derailment, were removed before the tank cars could be relocated. Cable slings were placed around the north end of tank car UTLX 83013 and, using the opposite end as a pivot, it was moved about 12 feet eastward. Wooden crossties supported the north end of the tank while the remainder of the tank rested on the ground. The other tank was similarly moved, and the relocations were completed by 2:15 p.m., February 23. Gas detection devices indicated no leakage of product following the moves.

The L&N's wrecking crew continued to remove the derailed cars, and the main track was opened to rail traffic by 8:00 p.m., February 23. Tank trucks were ordered to unload the LPG from the relocated tank on the south end, since that car appeared to be the most severely damaged. An empty tank car was ordered so that the second tank could be unloaded on Friday morning, February 24. A semitrailer/tank motor truck arrived at Waverly about 1:00 p.m. on February 24. A supervisor from the truck firm, who was familiar with handling LPG, and the truckdriver were on site but had not started the transfer, when about 2:53 p.m. UTLX 83013, the northernmost tank car, ruptured and allowed LPG to enter the atmosphere. Seconds later, the cloud of vaporized LPG was ignited by an undetermined source and burned explosively.¹

In its analysis of the accident, NTSB indicated that movement of the car may have contributed to the rupture by stressing a crack originally caused during the derailment:

¹Railroad Accident Report NTSB-RAR-79-1, Waverly, Tennessee, February 22, 1978.

Apparently, tank car UTLX 83013 was damaged mechanically when it was side swiped by another derailed car. The side damage to the tank appeared to have been inflicted by a wheel or other truck component. Head shields or shelf couplers on this tank car probably would not have prevented the tank damage. The consensus of railroad officials, Waverly Fire Department Officers, and representatives of the State Civil Defense who examined the damage was that this tank appeared to be the least damaged of the two.

Raising one end of the loaded tank car while using the opposite end as a pivot to move the car from the track structure could have provided additional stresses in the damaged area of the tank, causing the crack in the weld area to propagate. Any unequal support of the tank after being moved also could have stressed the damaged area. This pivoting method is the conventional method used by many railroad wrecking crews, however, if a method which produces less stress in a tank can be employed, it should be used.

The rupture of the tank before the safety valve operated indicated that the failure occurred at a pressure below 300 psig, well below the bursting pressure of 1,000 psig. This definitely indicated a failure in the steel of the tank. Calculations of pressure and temperature increases indicated that, from the time of the derailment to the time of rupture, there could have been as much as a 50 percent increase in pressure, but still pressure remained well below 300 psig. The additional pressure was, however, sufficient to pop out the indentation of the tank to some degree, and could cause the crack in the weld to propagate, and finally the tank to rupture.²

NTSB concluded that "the rupture resulted from stress propagation of a crack which may have developed during movement of the car for transfer of product or from increased pressure within the tank." Even though it was not possible to state conclusively which of these factors was the predominant cause of the rupture, it was clear that improved assessment of tank car damage and improved car handling are needed in the future. This is reflected in the NTSB recommendation that the AAR: "Provide guidelines to railroad employees to aid them in an assessment of tank car damage and procedures for proper handling of tank cars. (Class II, Priority Action) (R-79-5)"³

Another example of the hazards to personnel during wreck clearing operations can be found in the derailment of L & N Freight Train No. 403 near Crestview, Florida on April 8, 1979. There were a total of 29 derailed cars in this accident, including 26 tank cars containing hazardous materials. Anhydrous ammonia and other hazardous materials

²Ibid.

³Ibid.

were released into the atmosphere throughout the nine days of the emergency, through ruptures and punctures in the sides of the tank cars. Fourteen persons were injured and treated for inhalation of toxic fumes, including ten persons who had been clearing the wreckage. This is described in the following excerpt from Railroad Accident Report NTSB-RAR-79-11.

Despite the use of self-contained breathing apparatus and short work shifts to limit exposure, 10 wreck-clearing workers were overcome by fumes. Some of these workers were hospitalized. Other workers complained of nausea, dizziness, and eye and pulmonary irritation at the site during the operation. In addition to ammonia and chlorine, fumes from the carbon tetrachloride, acetone, methyl alcohol, and carbolic acid cars, and possible residues or reactions of byproducts from the mixing or burning of the escaping chemicals, existed at the scene. Physicians were uncertain about the medical treatment for exposed employees. Doctors were aware only of injuries from "chlorine or some toxic fumes" when admitting patients during the 9-day period of the emergency. They were uncertain about the additive effects of these gases in combination or reinforcing each other and possibly aggravating chemical exposures. For example, certain gases (carbon monoxide, alcohol, etc.) produce increased respiratory activity resulting in increased ingestion and ultimately greater toxicity.⁴

With regard to wreck-clearing operations, NTSB reached the following conclusions: "Injuries sustained by wreck-clearing personnel indicate a need for wreck-clearing guidelines. There are no procedures for local or Federal public safety officials to control wreck-clearing operations involving hazardous materials."⁵

As a result of its investigation, NTSB recommended, among other things, that the Federal Railroad Administration:

Analyze risks to wreck-clearing personnel during wreck-clearing operations involving hazardous materials releases to determine needed health safeguards, operating precautions, and medical treatment capabilities for hazardous materials exposures, and establish appropriate safety requirements based on its findings. (Class II, Priority Action) (I-79-13)⁶

⁴Railroad Accident Report NTSB-RAR-79-11, Crestview, Florida, April 8, 1979.

⁵Ibid.

⁶Ibid.

The preceeding examples are indicative of safety problems that can occur during wreck clearance in railroad accidents involving cars containing hazardous materials. On a smaller scale, similar problems can occur in highway accidents involving trailers containing hazardous materials. In both types of accidents, improved equipment and procedures are required to facilitate quick and safe removal of wreckage.

APPENDIX L

INNOVATIVE MEANS FOR ASSESSING TANK CAR STRUCTURAL INTEGRITY

The purpose of this appendix is to suggest improved techniques for the assessment of the potential for "Boiling Liquid/Expanding Vapor Explosions" (BLEVES) in railroad tank cars after collision or derailment. The present status of risk assessment of damaged tank cars shows that the state-of-the-art is very unsophisticated. As an example, estimates of pressures necessary for permanent deformation and rupture of a damaged tank car made by a group of eight experts on the scene of the test were completely incorrect.¹ A number of examples of expected ruptures during wreck clearing operations, such as the rupture and explosion that occurred at Waverly, Tennessee, (February, 1978) in which 16 lives were lost, also illustrate strongly the need for improved assessment methods.

A number of possible new approaches to the problem were examined and it was concluded that acoustic emission (AE) monitoring shows considerable promise for application to damaged tank cars. AE technology is presently in a very active state of development and it has been successfully utilized as a precursor of fracture in a number of applications, some of which will be briefly discussed in this report. This approach possesses two very significant advantages in that AE detectors can be quickly and easily attached, and the structure can then be monitored remotely. In spite of these advantages, AE technology has apparently not been employed to assess the danger of explosions associated with damaged tank cars. In order to provide a reasonable assessment of the potential applicability of AE technology to this problem, many of its characteristics will be discussed, emphasizing the advantages and disadvantages associated with the method.

L.1 Introduction to Acoustic Emission Concepts

Acoustic emission is the name given to the rapid release of energy through transient elastic waves spontaneously produced within a material under stress. These elastic waves propagate at approximately 3000 meters/second in steel and are detected most effectively in the 30 to 800 kHz frequency range (visually 100-250 kHz).

The acoustic signals emitted by materials under applied load were first studied in a systematic way in Germany in the early 1950's. During this time it was proven that most material deformation processes, such as dislocation motion, twinning,

¹"Tank Car Structural Integrity After Derailment", NTSB-SIR-80-1.

martensitic transformations and all types of structural defects represent sources of AE. Extensive improvements in instrumentation during the last 20 years have led to the development of AE systems which are capable of picking up important AE emissions and discriminating between them and other acoustic signals in the structure. These developments have led to the identification of AE sources as either active (the emissions are associated with primary failure processes in the structure) or passive (all other acoustic waves transmitted through the structure). Considerable additional efforts have been directed toward the recognition of different types of active sources and the progress made has been impressive. Several introductory or review papers on the status of AE technology have been published, with the lead papers in two recent ASTM special technical publications deserving particular mention.^{2,3}

L.2 Present Acoustic Emission Applications

An extensive assessment of present applications of AE technology, primarily to pressurized structures, has recently been published.⁴ In this paper it has been shown that AE applications can be categorized as follows:

- Pre-service (proof) testing,
- In-service (requalification) testing,
- On-line monitoring of components and systems,
- In-process weld monitoring,
- Mechanical property testing and characterization, and
- Geographical applications.

A further indication of the range of AE technology is indicated in Table L-1 which includes applications up to July 1978⁵. Although the range of applications indicated in Table L-1 is quite extensive, it is noted that no reference to rail tank cars, either damaged or undamaged, are included. Considerable additional investigation has not located any applications of AE technology to tank cars, with the exception of some limited and unpublished investigations of weld integrity of new tank cars. It appears that

²Lipton, R.G., Harris, D.O., and Tatro, C.A., Acoustic Emission "An Introduction to Acoustic Emission, ASTM STP 505, 1972, pp. 3-10.

³Spanner, J.C., Acoustic Emission Monitoring of Pressurized Systems, "Acoustic Emission-Some Examples of Increasing Industrial Maturity," ASTM STP 697, 1979, pp. 2-34.

⁴Ibid

⁵Ibid

at present, no systematic applications of AE technology to hydrotests of new or damaged rail tank cars have been made.

TABLE L-1. SUMMARY OF PRESENT AE APPLICATIONS

<u>Type of Structure</u>	<u>Shop Hydrotest</u>	<u>Preservice (Installed)</u>	<u>Inservice (Requalification)</u>
Chemical/petroleum vessels ^a	12	2	226
Chemical/petroleum components and piping ^b	30		41
Chemical/petroleum systems			40
Nuclear reactor vessels	17	2	2
Nuclear components and piping ^b	4	14	6
Nuclear primary systems		18	9
Structures (bridges, cranes, etc.)		2	68
Storage tanks			41
Rocket motor cases	200		
Heat exchanger tubing (ft.)	210,000		
Liquid and gas pipelines (ft.)			467,3000

^a Excludes experimental units

^b Tested separately from system test

L.3 Status of Existing AE Systems

At present, acoustic emission systems are available in two basic types: (1) small systems involving a few (usually 1 to 5) detectors, and (2) large systems employing many (typically 5 to 100) detectors and controlled by a minicomputer. An estimate of the number of AE systems in existence as of July, 1978, is given in Table L-2⁶, which excludes one-of-a-kind developmental systems assembled by user organizations.

⁶Ibid

TABLE L-2. ACOUSTIC EMISSION EQUIPMENT SALES

<u>Equipment Sales</u>	<u>Small Systems</u>	<u>Large Systems</u>
United States ^a	1,110	83
Europe ^b	70	5
Japan ^b	20	3

^a Total sales figures provided by U.S. equipment suppliers

^b Estimated sales provided by U.S. equipment suppliers

The small systems usually utilize one active instrumentation channel for each detector and are employed primarily for counting AE events with some possible signal waveform analysis for the purpose of identifying the type of AE source (i.e., microplasticity effects, microcrack initiation, crack growth, impacts, etc.). These systems have been employed in conjunction with standard materials testing and it has been observed that each basic type of material and most types of structures provide characteristic outputs which have become known as the AE "signature" for that material or structure. It has also been shown that such systems can serve as precursors of structural changes in AE output at various points approaching the structural failure. An example application for a large pipe is seen in Figure L-1.

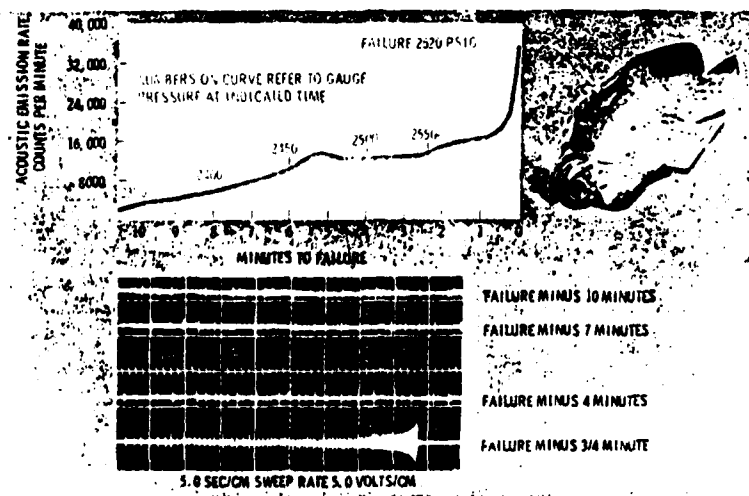


FIGURE L-1. ACOUSTIC EMISSION OUTPUT DURING PRESSURE TESTING OF A 24-INCH DIAMETER PIPE

Large AE systems have been developed with widely varying capabilities but are usually identified by the use of a minicomputer to receive and analyze the AE data. A block diagram of one system capable of monitoring 24 detectors is seen in Figure L-2.

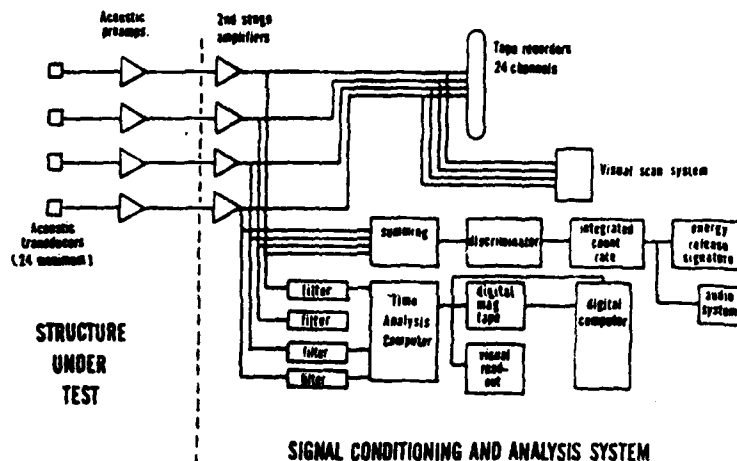


FIGURE L-2. SCHEMATIC ILLUSTRATION OF A TYPICAL LARGE AE SYSTEM

These systems can perform all of the functions of the small systems with the additional capability of locating the position of various active sources in the structure. In some cases, these systems have demonstrated the capability to monitor several potentially critical sources simultaneously and to provide output messages indicating the criticality of each, Figure L-3⁷. The characteristics of both types of systems, especially those pertinent to rail tank cars will be discussed further in the next section.

⁷Kishi, J., and Mori, Y., "Evaluating the Severity of Rocket Motor Case During Burst Test Using Acoustic Emission", Acoustic Emission Monitoring of Pressurized Systems, ASTM STP 697, 1979, pp. 131-148.

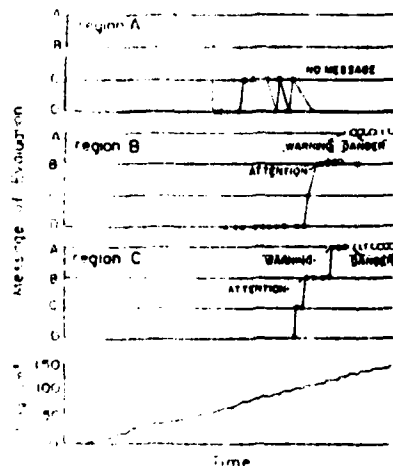


FIGURE L-3. OUTPUT OF LARGE AE SYSTEM MONITORING SEVERAL REGIONS SIMULTANEOUSLY

L.4 Important AE Equipment Capabilities

In consideration of the application of AE technology to assessing tank car integrity, several important characteristics of AE systems will be discussed. Two important criteria for assessing the applicability to damaged tank cars are (1) ease of making the installation, and (2) capability of remote sensing. Both of these criteria can be quite easily satisfied by existing AE equipment. For example, AE detectors can be attached by a number of ways including (1) elastic bands⁸, (2) electrical tape⁹, and (3) magnetic attachment¹⁰. It has also been determined that the detectors can be used with a couplant (usually some form of grease) or dry (although the output is usually reduced by

⁸Williams, R.S., "Modeling of Elastoplastic Fracture Behavior Using Acoustic Emission Methods", Closed Loop, The Magazine of Materials Testing, Vol. 10, No. 2, 1980, pp. 15-23.

⁹Keledy, F.C., and Hartman, W.F., "Some Examples of Evaluating Structural Integrity by Acoustic Emission Monitoring During Pressure Testing", Acoustic Emission Monitoring of Pressurized Systems, ASTM STP 597, 1979, pp. 35-46.

¹⁰Hutton, P.H., "Acoustic Emission Applied Outside of the Laboratory", Acoustic Emission, ASTM STP 505, 1972, pp. 114-126.

two-thirds for dry attachments)¹¹. It thus appears to be likely that the detector or detectors can be attached very quickly and possibly remotely with the use of a hand-held boom, if it appeared to be dangerous to approach the damaged tank car. If it were desirable to employ multiple detectors, it would probably be necessary to attach them to the tank car by hand. Once the detector or detectors have been attached, it appears to be a simple matter to establish a remote sensing station, since monitors have already been employed at distances of 200 meters from the detectors.¹²

A third area of concern in applying AE methods to damaged tank cars, is the problem of obtaining an appropriate level of acoustic emissions from the tank cars. It appears that there will be no problem in obtaining adequate signals since virtually all structures under load produce an abundance of signals. For example, during AE evaluation of a nuclear reactor during pressurization, it was possible to detect drops of water falling on the reactor and possibly the cracking of a brittle layer of paint on a pump.¹³ It is felt that the greater difficulty would be preventing "false alarms" of impending fracture which would reduce the credibility of such a system. An example of the AE signals emitted from a minor flaw and a critical flaw are seen respectively in Figures L-4 and L-5. While this question cannot be resolved without actual experience on damaged tank cars, the experience of other applications to pressurized systems strongly suggests that, with some experience, reliable predictions of critical conditions can be made.^{14,15,16,17}

¹¹Smith, J.R., Rao, G.V., and Gopal, R., "Acoustic Monitoring for Leak Detection in Pressurized Water Reactors", Acoustic Emission Monitoring of Pressurized Systems, ASTM STP 697, 1979, pp. 177-204.

¹²Ibid

¹³Votava, E., and Jax, P., "Inspection of Nuclear Reactors by Means of Acoustic Emission during Hydrostatic Test", Acoustic Emission Monitoring of Pressurized Systems, ASTM STP 697, 1979, pp. 149-164.

¹⁴Op.Cit, 7

¹⁵Op.Cit., 10

¹⁶Hutton, P.H., Dawson, J.F., and Kurtz, R.J., "Acoustic emission Measurements: HSST V-7B Intermediate Vessel Tests", Acoustic Emission Monitoring of Pressurized Systems, ASTM STP 697, 1979, pp. 106-130.

¹⁷Carlyle, J.M., "Imminent Fracture Detection in Graphite/Epoxy Using Acoustic Emission", Experimental Mechanics, Vol., 18, 1978, pp. 191-195.

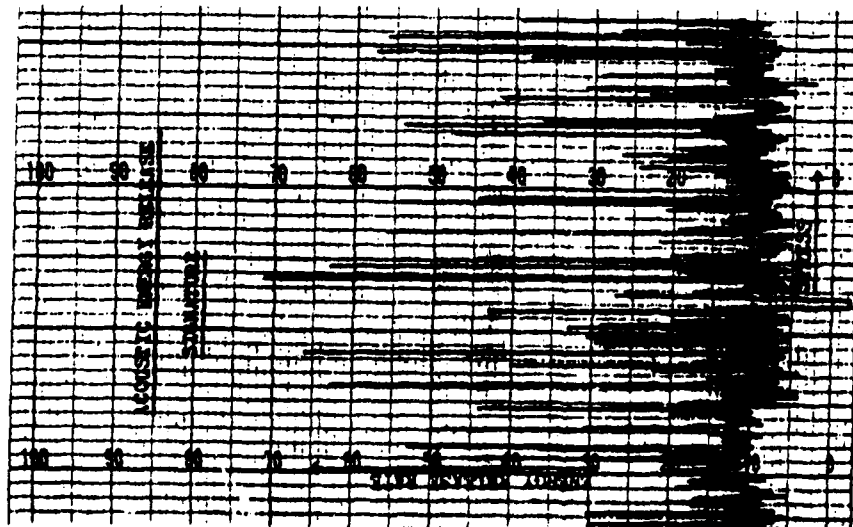


FIGURE L-4. TYPICAL EMISSIONS FROM A MINOR FLAW

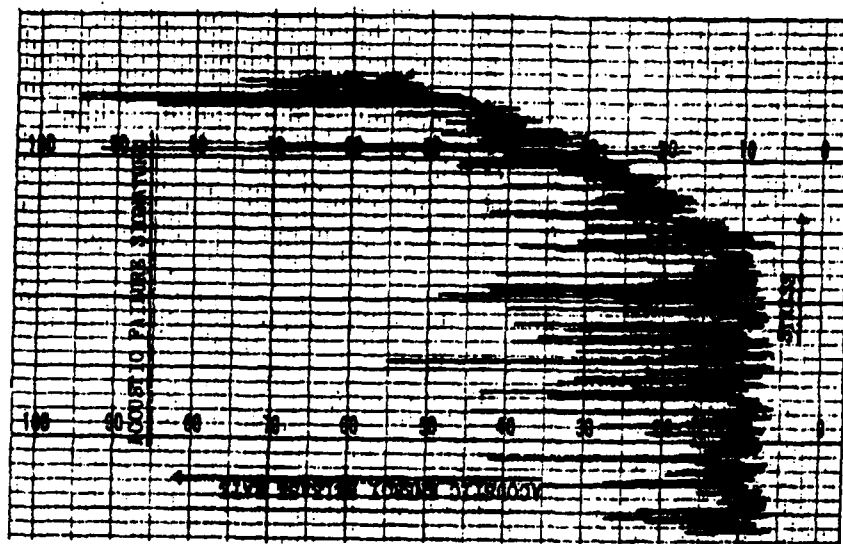


FIGURE L-5. TYPICAL EMISSIONS FROM A SIGNIFICANT FLAW

In summary, it appears that application of AE methods to the assessment of damaged tank cars can represent a significant improvement in on-scene evaluations of the risk of rupture. Acoustic emission methods possess one additional advantage that has not yet been mentioned. This advantage is the low cost associated with the systems, since both equipment and manpower costs are generally much lower than other nondestructive inspection methods. In order to provide an idea of the viability of AE methods, a proposed test plan is included in the next section.

L.5 Test Plan Development

In order to apply AE methods effectively to assessing the potential for rupture or explosion of damaged tank cars, a data base including the following information should be collected. First, it would be desirable to monitor the acoustic emissions from a structurally sound tank car during hydrostatic testing. The tests should be performed to rupture so that the entire AE signature could be obtained. Preference would be given to testing a tank car that had been previously proof tested and put into service, since this car would be more typical of a tank car involved in an accident. Since tests of this type are expensive to perform, it would be desirable to instrument the tank car with a large scale as well as a small scale AE system. The output of these systems should show the relative merits of using the large scale system. It may be possible to perform this test in conjunction with a hydrostatic test performed for some other purpose. If the costs were found to be prohibitive this portion of the test plan could be eliminated, although at the risk of having less knowledge about the failure of tank cars.

The second phase of the test program would be to monitor the acoustic signals emitted during a hydrostatic test of one or more damaged tank cars. The AE signal characteristics from these tests should be very valuable in developing the capability to predict pressure associated with impending failures. Depending on the results of the first phase tests, either small or large scale AE systems would be employed. If the phase one tests had not been performed, it would be important to employ both small and large scale systems for these tests. It will be necessary to use considerable care in interpreting these results since the type of damage would be expected to alter the AE output. For example, a damaged tank car having large dents that could deform at lower pressure would be expected to emit considerably more acoustic signals than damaged cars without them.

After the second phase of this test program has been completed, the selected system could then be applied to a damaged tank car at an actual accident site. One additional advantage of the large AE system is that it could be used to monitor several damaged tank cars simultaneously, if there were more than one at a particular accident site.

APPENDIX M

SAMPLE CONTENTS OF FIVE-VOLUME GUIDELINES SERIES ON SPILL RESPONSE PROCEDURES

1. EXECUTIVE SUMMARY
2. INTRODUCTION
 - 2.1 Volume 1 - General Guidelines
 - 2.2 Volume 2 - Initial Response Guidelines and Hazardous Chemical Data
 - 2.3 Volume 3 - Hazard Assessment Guidelines
 - 2.4 Volume 4 - Hazard Mitigation Guidelines
 - 2.5 Volume 5 - Cargo Transfer, Wreckage Removal, Cleanup & Disposal Guidelines
3. DOCUMENT CONTENTS
 - 3.1 Volume 1 - General Guidelines
 - 3.1.1 Precautionary Procedures
 - 3.1.1.1 Training
 - 3.1.1.2 Planning
 - 3.1.1.3 Communications
 - 3.1.1.4 Decision-making
 - 3.1.2 Providing Technical Assistance
 - 3.1.3 Accessing Sources of Information
 - 3.1.4 Using Protective Clothing, Gear and Equipment
 - 3.1.5 Using Specialized Treatment Chemicals and Equipment and Availability of Resources
 - 3.1.5.1 Neutralizing chemicals
 - 3.1.5.2 Sorbents
 - 3.1.5.3 Mixing equipment
 - 3.1.6 Wreckage Removal Contractors
 - 3.1.7 Cleanup and Disposal Contractors
 - 3.1.8 Necessary Equipment and Material Resources
 - 3.1.9 Available Training Courses and Materials
 - 3.2 Volume 2 - Initial Response Guidelines and Hazardous Chemical Data
 - 3.2.1 Initial Response Guidelines
 - 3.2.1.1 Reporting the accident
 - 3.2.1.2 Initiating the response communications network
 - 3.2.1.3 First on-scene responders
 - 3.2.1.4 Identifying hazardous materials (see 3.3 for details)
 - 3.2.1.5 Assuming/changing command
 - 3.2.1.6 Establishing the command post and communications link
 - 3.2.1.7 On-scene coordination
 - 3.2.1.8 Obtaining accident information
 - 3.2.1.9 Hazard Assessment (see 3.3 for details)

- 3.2.1.10 Relaying accident information
- 3.2.1.11 Assessing resources
- 3.2.1.12 Decision-making
- 3.2.1.13 Deploying personnel and resources
- 3.2.1.14 Initiating Rescue
- 3.2.1.15 Controlling access
- 3.2.1.16 Evacuation
- 3.2.1.17 Working with the news media
- 3.2.1.18 Moving the command post
- 3.2.1.19 Requesting additional help/resources
- 3.2.1.20 Status reporting
- 3.2.2 Hazardous Chemical Data
 - 3.2.2.1 Anhydrous ammonia
 - 3.2.2.2 Butadiene
 - 3.2.2.3 Chlorine
 - 3.2.2.4 Ethylene oxide
 - 3.2.2.5 Hydrazine
 - 3.2.2.6 Liquefied hydrogen
 - 3.2.2.7 Liquefied oxygen
 - 3.2.2.8 Monomethylhydrazine
 - 3.2.2.9 Nitrogen tetroxide
 - 3.2.2.10 Propane
 - 3.2.2.11 Unsymmetrical dimethylhydrazine
 - 3.2.2.12 Vinyl chloride
- 3.3 Volume 3 - Hazard Assessment Guidelines
 - 3.3.1 Assessing the Accident Interaction
 - 3.3.1.1 Determining whether hazardous material has been released
 - 3.3.1.2 Identifying hazardous materials released/involved in wreckage
 - 3.3.1.2.1 Sensing methods
 - 3.3.1.2.2 Visual methods
 - 3.3.1.2.3 External communications methods
 - 3.3.1.3 Determining the location, terrain, nature and extent of released chemical or propellant
 - 3.3.1.4 Determining who and what are at risk (e.g., people, environment, property)
 - 3.3.1.5 Determining if there are injured/exposed persons and whether rescue is feasible
 - 3.3.1.6 Ascertaining the extent of damage
 - 3.3.1.7 Determining sources and nature of any fires and their treatment to other containers
 - 3.3.2 Obtaining meteorological data
 - 3.3.3 Estimating of danger area from downwind vapor cloud dispersion (e.g., size, speed, direction and toxicity/flammability)
 - 3.3.3.1 USCG HACS model
 - 3.3.3.2 Shell R&D SPILLS model
 - 3.3.3.3 DDESB slide rule model

- 3.3.3.4 Air Force statistical/empirical model
- 3.3.3.5 Dense gas models
- 3.3.4 Determining container integrity
- 3.3.5 Monitoring the scene for toxic/flammable vapor concentrations
- 3.3.6 Estimation of blast overpressure danger area
- 3.3.7 Estimation of fire danger area
- 3.3.8 Estimation of fragment dispersion danger area
- 3.3.9 Evaporation rates-source strength data
 - 3.3.9.1 Nitrogen tetroxide
 - 3.3.9.2 Aerozene-50 (UDMH-Hydrazine)
 - 3.3.9.3 Liquefied oxygen
- 3.4 Volume 4 - Hazard Mitigation Guidelines
 - 3.4.1 Containment
 - 3.4.2 Vapor suppression
 - 3.4.3 Controlling discharges
 - 3.4.3.1 Containment
 - 3.4.3.2 Handling leaks
 - 3.4.4 Selection of personnel, equipment and materials
 - 3.4.5 Erecting barriers
 - 3.4.6 Firefighting
 - 3.4.7 Evacuation
 - 3.4.8 Self-protection for the public
 - 3.4.9 Choosing among alternative courses of action
 - 3.4.10 Spill handling thought guides
- 3.5 Volume 5- Cargo Transfer, Wreckage Removal, Cleanup and Disposal Guidelines
 - 3.5.1 Cargo Transfer Guidelines
 - 3.5.1.1 Selecting the transfer team
 - 3.5.1.2 Assuring the containers are safe to approach
 - 3.5.1.3 Determining if there is access to the liquid via a fitting
 - 3.5.1.4 Using compatible and connectable fittings and transfer system components
 - 3.5.1.5 Utilizing closed transfer system, inert atmosphere and pump approved for service with the particular chemical or propellant and its particular vapors
 - 3.5.1.6 Using proper equipment grounding
 - 3.5.1.7 Continuous monitoring for leaks, vapor concentration, tank temperature or pressure fluctuations
 - 3.5.1.8 Continuous monitoring of tank structural integrity
 - 3.5.1.9 Controlling transfer rate
 - 3.5.1.10 Providing adequate container capacity and specifications of receiving container
 - 3.5.1.11 Minimizing internal pressure
 - 3.5.1.12 Using tap-in devices

- 3.5.1.13 Reaching the liquid with tank when disoriented
- 3.5.1.14 Communications
- 3.5.2 Wreckage Removal guidelines
 - 3.5.2.1 Selecting the wreckage removal team
 - 3.5.2.2 Decoupling/cutting/welding containers containing flammable liquids or gas
 - 3.5.2.3 Attaching hooks, slings, and cables
 - 3.5.2.4 Identifying permissible force levels/direction in moving and lifting tank cars/trucks
 - 3.5.2.5 Monitoring container structural integrity
 - 3.5.2.6 Selection of personal protective gear and equipment
 - 3.5.2.7 Positioning personnel and equipment
 - 3.5.2.8 On-site technical assistance
 - 3.5.2.9 Communications
- 3.5.3 Cleanup and disposal guidelines
 - 3.5.3.1 Selecting the cleanup/disposal team
 - 3.5.3.2 Dealing with remaining unspilled material
 - 3.5.3.3 Dealing with residuals from spill containment, treatment, mitigation techniques
 - 3.5.3.4 Complying with regulations
 - 3.5.3.5 Continuous monitoring for toxic and flammable vapors
 - 3.5.3.6 Selection of procedures, tools, equipment and receiving containers and materials
 - 3.5.3.7 Use of personnel protection
 - 3.5.3.8 Using communications
 - 3.5.3.9 Identifying recovery versus disposal option
 - 3.5.3.10 Collection of waste
 - 3.5.3.11 Removal of waste
 - 3.5.3.12 Dilution of material
 - 3.5.3.13 Treatment of material
 - 3.5.3.14 Identifying disposal options

APPENDIX N

SAMPLE CONTENTS OF COMMODITY-SPECIFIC PROCEDURES MANUAL

N.1 OPTION A

1. EXECUTIVE SUMMARY
2. INTRODUCTION
3. COMMODITY-SPECIFIC PROCEDURES
 - 3.1 Identifying Thermophysical and Chemical Properties of Material
 - 3.1.1 Material identification
 - 3.1.2 General appearance
 - 3.1.3 Chemical nature
 - 3.1.4 Physical properties
 - 3.2 Assessing Hazards Potential
 - 3.2.1 Health hazards
 - 3.2.2 Fire
 - 3.2.3 Explosion
 - 3.3 Identifying Safety Measures
 - 3.3.1 Trained personnel
 - 3.3.2 Safe clothing, equipment and materials
 - 3.3.3 Respiratory protection
 - 3.3.4 Other safety equipment
 - 3.4 Evaluating Materials and Equipment Requirement for Transfer and Storage
 - 3.4.1 Materials
 - 3.4.2 Equipment
 - 3.5 Assessing Transfer Operations
 - 3.5.1 Safe Handling Procedures
 - 3.5.2 Containers
 - 3.6 Identifying Transportation Requirements
 - 3.6.1 Packaging
 - 3.6.2 Marking
 - 3.6.3 Transportation accident procedures
 - 3.7 Using Emergency Procedures
 - 3.7.1 Spills, leaks and decontamination
 - 3.7.2 Firefighting
 - 3.7.3 First aid and self aid
 - 3.8 Evaluating Cleanup and Disposal Requirements
 - 3.8.1 Disposal options
 - 3.8.2 Personnel requirements
 - 3.8.3 Equipment and material requirements

N.2 OPTION B

- 1. EXECUTIVE SUMMARY**
- 2. INTRODUCTION**
- 3. IDENTIFYING MATERIALS INVOLVED**
 - 3.1 Commodity Identification Tables**
 - 3.1.1 Proper shipping name
 - 3.1.2 STCC number
 - 3.1.3 UN number
 - 3.2 Waybill, Consist or Bill of Lading Documentation**
 - 3.3 Specific Service Stenciling Diagrams**
 - 3.4 Computerization Data Hookup**
 - 3.4.1 Data sources
 - 3.4.2 Required equipment
 - 3.4.3 Equipment operation
 - 3.5 Telephonic Identification Systems**
 - 3.5.1 CHEMTREC
 - 3.5.2 National Response Center
 - 3.5.3 Dispatcher
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 - 4.1 Communicating on-scene
 - 4.2 Establishing a Command Post
 - 4.3 Evacuating an Area
 - 4.4 Identifying Personnel, Equipment and Materials Availability
 - 4.5 Assessing Structural Integrity of Damaged Containers
 - 4.6 Identifying Product Transfer Options
 - 4.7 Identifying Wreckage Removal Options
 - 4.8 Identifying Cleanup and Disposal Options
- 5. COMMODITY-SPECIFIC EMERGENCY PROCEDURES**
 - 5.1 Initial Response**
 - 5.1.1 Identifying duties of first responders (firefighters, law enforcement officials, carrier personnel)
 - 5.1.2 Identifying duties of assistance teams
 - 5.1.3 Identifying duties of emergency medical service personnel
 - 5.2 Hazard Mitigation**
 - 5.2.1 Deciding on firefighting options based on accident site evaluation
 - 5.2.2 Using personal protective equipment
 - 5.2.3 Conducting a site assessment
 - 5.3 Product Handling/Transfer Procedures**
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APPENDIX O

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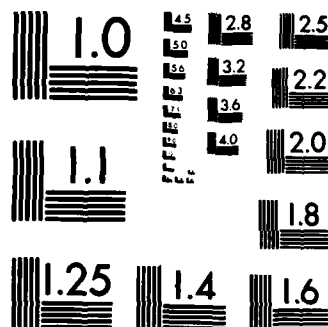
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4.5.3 Decision-Making

- 4.5.3.1 Approving or disapproving of cleanup alternatives
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4.5.4 On-Site Actions

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- 4.5.4.2 Approving the use of disposal standard operating procedures
- 4.5.4.3 Using personal protective clothing and equipment

GLOSSARY

ABSORBENT - (1) Any substance exhibiting the property of absorption. (e.g., substances capable of soaking up a particular HM(s))

ACOUSTIC EMISSION - Rapid release of energy through transient elastic waves, characteristic of structures under stress. (e.g., the characteristic sound waves produced by a structure under stress and which vary with change in stress or appearance of a crack).

AMPULES - Hermetically sealed small bulbous glass vessels used to hold chemicals/solutions.

BERM - A narrow shelf, path or ledge typically at the top or bottom of a slope. (e.g., along side a rail bed or highway).

BILL OF LADING - One type of shipping paper which lists goods shipped and other required identifying information.

BLEVE - The combination of a weakened structure and the buildup of intergal vapor pressure resulting in container rupture or instantaneous release and ignition of the vapor usually with violent effects. An acronym for boiling liquid expanding vapor explosion.

CARBOY - A glass, metal or plastic bottle or rectangular container of about 5 to 15 gallons capacity for liquids.

CARGO TANK - Any tank permanently attached to or forming a part of any motor vehicle or any bulk liquid or compressed gas packaging not permanently attached to any motor vehicle which by reason of its size, construction or attachment to a motor vehicle, is loaded or unloaded without being removed from the motor vehicle and is used for transporting the commodity(ies).

GLOSSARY (cont'd)

CHEMTREC - Abbreviation of Chemical Transportation Emergency Center. A division of the Manufacturers Chemical Association established as an emergency information source for transportation accidents involving hazardous materials (e.g., flammable, toxic or explosives).

COLORIMETRIC - Chemical analytical methods based on measuring the color intensity of a substance or a colored derivative of it compared to a standard color(s)

COMMODITY FLOW - The quantity routing patterns for transportation of an article(s) of commerce (e.g., hazardous materials shipments and routes).

COMMODITY INCOMPATIBILITY - The situation whereby a chemical(s) is (are) capable of interacting with each other to create a hazard or unsafe condition and thus must be handled, packaged, stored and shipped with certain prescribed precautions.

COMMUNICATIONS COORDINATION CENTER - A central facility (mobile or fixed) which functions in the case to interlink and coordinate the different sources of information and communications at and away from the accident scene.

COMPRESSED GAS - Any material or mixture that, when enclosed in a container, has an absolute pressure exceeding 40 psi at 70°F or regardless of the pressure at 70°F, has an absolute pressure exceeding 140 psi. at 130°F; or any flammable material having a vapor pressure exceeding 40 psi absolute at 100°F.

CONSIST - Makeup or composition by classes, types, or grades and arrangement of rail cars in a train.

CONTAINER STRUCTURAL INTEGRITY - The existing condition of the container's structural components with respect to its original design and its capability to safely retain its contents as intended.

CORROSIVE MATERIAL - A solid that causes visible destruction or irreverable alterations in human skin tissue at the site of contact, or in the case of leakage from its packaging, a liquid that has a severe corrosion rate on steel.

GLOSSARY (cont'd)

CRYOGEN - Bases that must be cooled to bring about their liquefaction.

CYLINDER - Pressure vessel designed for pressures higher than 40 psia and having a circular cross section. It does not include a portable tank, multi-unit tank car tank, cargo tank or tank car.

DAM - (1) A barrier preventing the flow of water or of loose solid materials. (2) A barrier to check the flow of liquid, gas, or air.

DENT - (1) A depression or hollow made by a blow or by pressure. (e.g., on a container surface)

DIKE - (1) A bank usually of earth construction used to control or confine water or other fluid. (2) A barrier preventing passage, especially of something undesirable.

DISPATCHER - One who controls the movement of vehicles/persons. (e.g., trains, trucks, fire, police)

EXPLOSIVE - Any chemical compound, mixture or device, the primary or common purpose of which is to function by explosion. (i.e., with substantially instantaneous release of gas and heat).

FLAMMABLE - Capable of being easily ignited and of burning rapidly. See 49 CFR, Part 173 for precise types of flammable liquids and gases.

FLAMMABLE GAS - Any gas that will ignite easily and burn rapidly. See 49CFR, Part 173 for a more precise definition.

FLAMMABLE LIQUID - Any liquid that will ignite easily and burn rapidly. See 49CFR, Part 173 for precise definition of various types.

FLATCAR - A railroad freight car without permanent raised sides, ends, or covering.

GLOSSARY (cont'd)

GAUSSIAN DISTRIBUTION - The normal distribution or a probability density function that approximates the distribution of many random variables. (i.e., usefulness in assessing vapor dispersion patterns).

GAS CHROMATOGRAPHY-MASS SPECTROMETRY - This is a combination of two chemical instrumental techniques. The gas chromatography involves separation and identifying the components of a mixture by volatilizing the sample into a carrier gas stream and passing it through a bed of special packing and comparing the times for these various components to be released from the packing.

GEL - A colloid in which the disperse phase has combined with the continuous phase to produce a viscous, jelly-like product.

GONDOLA CAR - A railroad car with no top, a flat bottom, and fixed sides, that is used chiefly for hauling heavy bulk commodities.

GOUGE - A groove or cavity scooped out.

GRAVITY FLOW - The movement of material without using a driving force like a pump or pressure (i.e., used during product transfer).

HACS - Computerized portion of USCG Chemical Hazards Response Information System (CHRIS). Abbreviation for Hazards Assessment Computer System.

THERMITE GRENADE - A grenade using a mixture of aluminum powder and iron oxide that when ignited evolves a great deal of heat and is used in welding and in incendiary bombs.

HOOKS & SLINGS - Hook: A curved or bent device for catching, holding, or pulling.

Sling: (1) A looped line (as of strap, chain, or rope) used to hoist, lower, or carry something. (2) A device for enclosing material to be hoisted by a tackle or crane.

GLOSSARY (cont'd)

INFARED RADIOMETRY - Absorption of radiation in the infared spectrum (0.78 - 300 microns). Can be used to assess temperature remotely

IRRITATING MATERIAL - Substances which give off dangerous or intensely irritating fumes when exposed to air or upon contact with fire.

LEAK, CONTINOUS - A steady continous loss of substance through an opening.

LEAK, INSTANTANEOUS - A sudden, abrupt loss of substance through an opening.

LIFTING LUG - A provision which allows a hook to be attached to a tank car or tank truck for lifting, rerailing or re-orienting.

LONGITUDINAL AXIS OF CAR - The lengthwise axis of a car.

LOWER EXPLOSIVE LIMIT (LEL) - The lower limit for the range of concentration of a flammable gas or vapor (% by volume in air) in which explosion can occur upon ignition in a confined area.

MASS SPECTROMETRY - A method of chemical analysis in which ions are passed in a vacuum first through an accelerating electric field and then through a strong magnetic field. This has the effect of seperating the ions according to their mass, as they traverse the magnetic field at different velocities (electromagnetic separation).

NATIONAL MOTOR FREIGHT CLASSIFICATION NUMBER - The specific number assigned to commodities being transported over the road.

NATIONAL RESPONSE CENTER - The Coast Guard operated response center that provides telephonic assistance during emergencies and accidents.

NONDESTRUCTIVE MATERIAL - A material that cannot be broken apart or destroyed.

NONFLAMMABLE GAS - A gas that is not easily ignited and does not burn rapidly if ignited.

GLOSSARY (cont'd)

OFF-LOAD - To remove cargo from its container.

ON-SCENE COORDINATOR - The authority at the scene of an accident who directs emergency handling and cleanup operations.

OXIDIZER - A substance that spontaneously releases oxygen at room temperature or upon heating (i.e., nitrogen tetroxide). Can react vigorously with organic and combustible materials.

PASQUILL - Category of air stability based on wind speed and direction.

PIT - A hollow or indentation on the surface of a substance.

PLACARD - Inverted, color-coded flat square placed on vessels transporting hazardous materials. Must be located on all four sides of the vessel, and can be used to aid material identification.

POISON A - A gas or liquid so toxic that an extremely low percentage of the gas or the vapor formed by the liquid is dangerous to life.

POISONOUS GAS - A toxic or irritant gas or volatile liquid that is harmful to living tissues when applied in relatively small doses.

POLYMERIZATION - A chemical reaction, usually carried out with a catalyst, heat or light, and often under high pressure, in which a large number of relatively simple molecules combine to form a chain-like macro-molecule.

PORTABLE TANK - Any packaging (except a cylinder having a 1000-pound or less water capacity) over 110 U.S. gallons capacity and designed primarily to be loaded into or on or temporarily attached to a transport vehicle or ship, and equipped with skids, mounting, or accessories to facilitate handling of the tank by mechanical means.

PRESSURE FLOW - The steady movement of a material by applying a driving force using a pump or flow of gas or liquid.

GLOSSARY (cont'd)

RADIOACTIVE MATERIAL - A material which spontaneously emits alpha or beta rays and sometimes also gamma rays by the disintegration of the nuclei of atoms.

RAIL CAR TRUCK - The structure supporting and attaching the wheels to the body of a rail car or tank car.

REMOTE SENSING - To detect a material property such as temperature or pressure from a distant location.

RERAIL - To realign and put back in place a rail car that had been derailed.

SELF CONTAINED BREATHING APPARATUS - A breathing apparatus with air supply that keeps the individual completely independent of the surrounding atmosphere.

SOLVENT - A substance capable of dissolving another substance (solute) to form a uniformly dispersed mixture (solution) at the molecular or ionic size level. Solvents are either polar (high dielectric constant) or non-polar (low dielectric constant).

SOLUBILITY - The ability or tendency of one substance to blend uniformly with another, e.g., solid in liquid, liquid in liquid, gas in liquid, gas in gas.

SORBENT - A substance that takes up and holds by either adsorption or absorption.

SOURCE STRENGTH - The amount released in a given period of time from a leak source.

SYNTHESIS - Creation of a substance which either duplicates a natural product or is a unique material not found in nature, by means of one or more chemical reactions, or (for elements) by a nuclear change.

TOXIC - Relating to, or caused by poison or toxin.

GLOSSARY (cont'd)

THRESHOLD LIMIT VALUES (TLV) - The upper values of a toxicant concentration to which an average healthy person may be repeatedly exposed to on day after day without suffering adverse effects.

UNIFORM CLASSIFICATION NUMBER - The specific number assigned to commodities being transported by rail.

VAPOR DISPERSION - The movement of vapor clouds in air due to turbulence, gravity spreading and mixing.

VAPOR SUPPRESSION - The process of retaining vapors or preventing them from escaping from a liquid surface.

VENT AND BURN - To release a substance from its container and allow it to burn.

VIAL - A small closable vessel.

VOLATILE - A substance that will readily vaporize at a low temperature.

WAYBILL - A document prepared by the carrier of a shipment of goods that contains details of the shipment, route, and charges.

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