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Classification of Hazardous Materials in Rail Transportation

PREPARED FOR FEDERAL RAILROAD ADMINISTRATION OFFICE OF RESEARCH AND DEVELOPMENT

JUNE 15, 1987

BDM/MCL-87-0489-TR

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16. Abstract

The regulations pertaining to the classification of hazardous materials in rail transportation were examined for their robustness in identifying hazards, the classification of hazardous materials, and the utility of these classifications to those who must deal with rail accidents involving hazardous materials. This analysis is accompanied by a technical analysis of 100 frequently-shipped hazardous materials for which hazard profiles were developed. The outcomes of the technical analysis illuminate and support conclusions of the regulatory analysis. Both conclusions drawn from these analyses and implementing recommendations are presented. Appendices containing technical and other data used in the technical analysis, and a summary of remote sensing capabilities are also presented.

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CHAPTER I

EXECUTIVE SUMMARY

A. INTRODUCTION

The definition, evaluation and classification of hazardous materials are usually related to in-plant production and use, to transportation and handling, and to final disposal. Those hazardous materials regulations pertaining to routine railway transportation and handling can be improved in two ways. First, the regulations pertaining to multiple risks (e.g., chlorine toxicity and corrosiveness) are not well identified by single-hazard placards. Second, the assessments of hazardous materials has generally been made in terms of loading, unloading, and over-the-road containers, but not for spill mitigation and handling. There are related issues of inconsistency in the definition and classification protocols for hazardous materials.

This report documents an investigation of the regulations pertaining to the identification, classification, and recognition of hazardous materials in rail transportation. The perspectives for the investigation were an examination of the regulations (Title 49, Parts 171 through 174 of the Code of Federal Regulations) and a technical analysis of the hazards of 100 hazardous materials. For the analysis of hazardous materials, the materials with the highest tank car shipping rates were identified and their regulatory hazard class determined. Near-duplicate entries were deleted and several materials substituted, broadening the range of materials and hazards.

B. REGULATORY ANALYSIS

The regulations apply to all phases of the transportation of hazardous materials, including:

- Identification and classification of hazardous materials;
- identification of containers authorized for the shipment of each hazardous material;
- approved loading and unloading procedures;
- authorized hazard recognition marks (markings, labels and placards) and shipping paper requirements;
- authorized movement standards, including switching requirements for rail cars of hazardous materials and the assembly of these cars into trains.

Pertinent to this study are the identification and classification of hazardous materials. Because they communicate the outcomes of the identification-and-classification process, hazard recognition marks and shipping papers were also examined. Other aspects are summarized and reported without extensive analysis.

Because of the very large quantities of materials involved, bulk shipment cars of hazardous materials present the largest potential problems and perils in accidents. Further, examination of the USDOT train wreck data base reveals that approximately 90% of all rail accidents involving hazardous materials in the time period 1971-1984 involved bulk shipments of hazardous materials. For these reasons, this study focused on those regulations pertaining to large containers. The term large containers refers to those shipments subject to placarding standards, and includes tank cars and other receptacles capable of transporting large quantities of bulk materials by rail such as truck trailers on flat cars (TOFC) and portable tanks and freight containers on flat cars (COFC). Additionally, TOFC and COFC service are the most rapidly growing aspects of rail freight operations, and specialized equipment are being developed in response to this growth. Analyses reported here carefully trace the border between large and small containers.

For identification and classification of hazardous materials the key step is the determination of the proper shipping name in the Hazardous

Materials Table (49 CPR 172.101). Considerable care must be exercised to select the most appropriate proper shipping name for each material. In the Hazardous Materials Table are:

- Specific names, such as ETHYL ALCOHOL or DENATURED ALCOHOL, which are fully descriptive of materials;
- commodity-class names, such as ALCOHOL, N.O.S., which describe groups or classes of materials in terms of common physical or chemical properties;
- hazard-class names, such as FLAMMABLE LIQUID, N.O.S., which describe materials in terms of the hazards presented by the materials during transportation.

Specific names, because of the fullness of their descriptions, are the most preferable and commodity-class names are preferred to hazard-class names. The regulations do not make these formal distinctions, and this is regarded in this report as an area where improvement could be made in the regulatory process. Commodity-class and hazard-class shipping names may be thought of as generic shipping names.

If a suitable specific or commodity class shipping name cannot be found in the Hazardous Materials Table, then the material must be subjected to testing or evaluation to determine whether the material meets the defining criteria of one of the hazard classes. If the material does, in fact, satisfy the criteria of one of the hazard classes, that hazard class determines the proper shipping name. If the material conforms to the definition of two or more hazard classes, reference is made to the hierarchical preference table (49CFR 173.2) to determine the hazard classification for the material, and the associated hazard class shipping name. However, if one of the hazard classes to be selected from in the classification process is a poison class, and if another class is indicated by the hierarchy as the hazard class, there are multi-hazard generic shipping names to be selected from. Requirements and options, however, are not clearly prescribed in the regulations.

There is another consideration in selection of a proper shipping name that is a commodity-class name--the hazard class associated with the name must be consonant with the properties of the material. For example, ALCOHOL, N.O.S. may be either a flammable or a combustible liquid. Selection of a proper shipping name and hazard class effectively prescribes all aspects of the rail shipment of the material.

Examination of the defining criteria for the hazard classes reveals concerns about the definitions for oxidizers, corrosives and poisons.

Oxidizers are presently defined in terms of materials capable of participating in oxygen transfer chemical reactions. Modern chemistry defines oxidizing materials in terms of electron transfer reactions. This definition is very broad, encompassing many subclasses of reactions including the very prominent oxygen-transfer reaction subclass. Another prominent subclass, galvanic corrosion reactions such as rusting generally reacts with much less vigor than oxygen-transfer reactions.

Vigor of reaction is determined by reaction velocity (materials consumption rates) and heat production. The most vigorous reactions of chlorine resemble ordinary combustion processes. A change is recommended below.

The increasing shift to lightweight container construction materials such as aluminum to reduce the tare weights of containers and rail cars suggests that the materials evaluated by corrosiveness testing should include aluminum as well as steel. The former is very reactive with caustics; the latter, acids.

The current regulations defining toxic or poisonous materials appear to be qualitatively graduated from the most severe hazard (Poison A-lethal gases) through less severe hazards (Poison B-dangerous or lethal liquids and solids; Irritants) to least severe (ORM-A-noxious nuisances). The graduation of the continuum is uneven and phrased in somewhat inconsistent terms. Poison B materials, qualitatively described as "hazardous to health," have the only quantitative criteria, and materials meeting these quantitative criteria can be described as highly lethal. Both Poison A and Poison B materials are described in terms of toxicity, a word with a range of meanings including unhealthful, injurious, and lethal. That is, there are degrees of toxicity ranging from incapacitation to death. Temporary or permanent incapacitation, seems to have been neglected in the poison continuum. Recommended changes are outlined below.

The hierarchical preference table, used to classify hazardous materials exhibiting properties of two or more hazard classes, appears to be more or less determined by historical consideration of cargo and equipment losses. It is not at all clear that this is the most appropriate basis for a classification scheme that should be intended to prevent accidents and protect the public.

C. TECHNICAL ANALYSIS

The technical analysis of the hazards of hazardous materials was conducted using Commodity Sheets developed to support this study, and are found in Appendix B. These Commodity Sheets, one for each of the 100 hazardous materials, contain a summary of chemical and physical properties as well as summaries of hazard, spill cleanup, and toxicity data obtained from material safety data sheets (MSDs), various emergency response guidelines (ERGs), and other sources.

The objective of the technical analysis was to examine the properties of hazardous materials to determine the range of hazards presented by hazardous materials, and to develop hazard profiles for each of the 100 hazardous materials. A three-part process was developed to conduct the analysis.

The first step consisted of developing a hazard spectrum for each of the 100 hazardous materials by noting those aspects of the Commodity Sheets, MSDs, and ERGs which indicated the capability for presenting a hazard in an accident-mitigation-cleanup situation. There are two parts to each spectrum: those hazards corresponding to hazard definitions in the current DOT Regulations, and those obtained from accident mitigation and cleanup operations guidance.

Part 2 of the analysis consisted of a computer-based examination of the available train accident data for large containers from the Office of Hazardous Material Tansportation. The data pertained to reports in which at least one rail car left the rails. There are no reports involving only failed or ruptured equipment. Because there was a sharp mismatch between the list of 100 hazardous materials and those contained in the data base, analyses are reported by hazard classes rather than specific materials. The principal outcomes of this analysis, applicable only to cars that leave the rails, include:

- deaths were found only for flammable and non-flammable gases,
- injuries are reported only for flammable gases, liquids and solids, poison B materials, and corrosive materials;
- the "average accident" in which rail cars of compressed gas leaves the track will produce about three injuries per rail car;
- flammable gases are involved in explosions for 15 percent of all accidents; for poison B and flammable solid materials the explosion rate is about 5 percent while the rate is approximately 1 percent for corrosve materials, non-flammable gases, flammable liquids, oxidizing materials, and combustible liquids;
- the frequency of accidents involving two or more rail cars of hazardous materials is less than 5 percent of that for single-car accidents.

Other findings are discussed in Chapter IV.

The third phase of the technical analysis consisted of the development of the hazard profiles from analysis of the data base results and the hazard spectra followed by consolidation of the various hazard spectral elements into profile categories. Both the accident experience and the hazard spectra (and their supporting Commodity Sheets) indicated that explosion and toxicity hazards were strongly influenced by the occurence or absence of fire at an accident scene. Accordingly, these two elements of the hazard profiles have necessarily been dichotomized for fire.

The elements of a hazard profile are:

- ignition hazard-comparable to flammable and combustible materials as currently defined in the regulations, as well as pyrophoric materials;
- oxidation hazard-more or less comparable to the current regulatory definition of oxidizing materials, with the recommended change (below);
- corrosion hazard-includes those materials rapidly producing a deleterious or destructive effect on the structural materials steel and aluminum; this does not correspond exactly to the current regulatory definition of corrosive materials;
- environmental hazard-including those materials identified as producing a harmful or fatal effect on either terrestrial or aquatic animals;
- water hazard-identifies those materials which, when contacted by water, produce undesirable events or dangerous conditions;
- safety hazard-categorizes those hazards not identified in other hazard elements, and includes suffocant and cryogenic materials as well as skin, eye, and respiratory irritants and materials that degrade the performance of the components of protective clothing and other items typically found at an accident scene;
- explosion hazard-dichotomized by fire-including vapor trail flashback, unconfined vapor cloud explosion, rapid polymerization and other violent processes as well as those materials currently classified as explosives;
- toxicity hazard-dichotomized by fire-identifies those materials capable of producing an incapacitating or lethal effect, or requiring the use of breathing apparatus or other protective clothing.

The hazard associated with each element of all 100 profiles was evaluated on a four-point scale: severe, moderate, slight, none. The profiles are presented in Chapter IV.

The profile hazard categories identified above do not formally correspond to the regulatory hazard classes in all particulars. Table I-1 shows the regulatory hazard classes formally associated with each profile

TABLE I-1. RELATIONSHIP BETWEEN HAZARD CLASSES AND PROFILE CATEGORIES

PROFILE CATEGORY	FORMALLY INCLUDED HAZARD CLASS
Ignition Hazard	Flammable Liquids Combustible Liquids Flammable Gases Flammable Solids Pyrophoric Materials
Oxidation Hazard	Oxidizing Materials;Peroxides
Corrosion Hazard	Corrosive Materials
Water Hazard	Dangerous-When-Wet Flammable Solids; ORM-B
Explosion Hazard (No Fire)	Explosives, Blasting Agents
Toxicity Hazard (No Fire)	Poisons; Irritants; ORM-A Materials
Explosion Hazard (Fire)	Flammable Gases Nonflammable Gases Flammable Liquids (esp. polymerizables)
Toxicity Hazard (Fire)	All

category. Not present in the table are several hazard classes defined in the DOT Regulations in terms of physical or other properties not directly related to the formally-recognized hazards such as ORM-C, D and E. Radioative materials, not present in the list of 100 hazardous materials, represent the only missing profile hazard; the absence of this category is a defect of the list of 100 materials.

The most striking outcome of the technical analysis is that, except for materials identified by hazard class names, the hazard profiles for all materials showed multiple hazards. In fact, the presence of two or more severe hazards is the norm for these materials and one-fifth exhibited three or more severe hazard ratings. Since the profile categories of Ignition and Oxidation are mutually exclusive in a chemical sense, one should not expect a material to have a rating in all profile categories.

D. RECOMMENDATIONS

There are recommended changes in all three of the areas considered: hazard identification, hazard classification, and hazard recognition. Hazard identification issues deal with the definitions of hazards and hazard classes while hazard classification, in the current DOT Regulations, pertains to the assignment of a hazard class to a material exhibiting properties of two or more hazard classes. Hazard recognition regulations deal with the communication of hazard information to interested parties including railroad employees, carloaders and unloaders, and accident scene emergency responders.

1. Hazard Identification Changes

Changes are recommended in the definitions of three hazard classes: Oxidizing materials, corrosive materials, and poisons.

a. Oxidizing Materials

Oxidizing materials should be defined in terms of vigorous electron transfer reaction capability. This corresponds to the modern chemical definition of oxidizing materials. The vigor-of-reaction qualification is required to recognize that some oxidation reactions can occur that have negligible consequences at an accident scene; rusting is a readily recognized example.

b. Corrosive Materials

Aluminum is finding increased use in railcar construction to reduce tare weights and maintenance costs. Because the corrosion properties of this material are so different from those of steel, the definition of corrosive materials should reflect this change in construction materials. Aluminum should be subjected to corrosion tests similar to steel. Corrosiveness to tissues is a toxicity property and should be dealt with as such.

c. Poisons

The definitions of poisons are in serious need of major overhaul to remove inconsistencies. The intent of the recommendations is to classify as toxic those harmful materials generally likely to produce harmful, nonlethal effects if released at an accident scene as well as materials producing lethal effects. The recommendations also attempt to recognize that the physical form of the material (solid, liquid, or gas) and the route of entry into the body (inhalation, ingestion, or skin contact) are important factors in the overall hazard assessment. Quantitative criteria, below, are proposed as the only standards, thereby eliminating ambiguity in the qualitative definition of toxicity. A toxic material, it is proposed, would satisfy any one of the following criteria (for definitions, see Appendix A):

- Inhalation toxicity criterion has two parts
  - LC_{50} less than 5000 ppm, and
  - for volatile liquids, LD_{50} less than 10 times saturated vapor pressure
- Oral toxicity LD_{50} less than 500 mg/kg
- Skin toxicity LD_{50} less than 1000 mg/kg
- Etiological agents

Consideration might be given to LC_{50} values for the inhalation toxicity of dusts and mists, and to differentiation of LD_{50} values for oral toxicity of liquids and solids. Volatile liquids are those liquids deemed to be compressed gases (49 CFR 173.300(a)), neglecting the flammable requirement.

2. Hazard Classification Changes

An alternative classification table has been developed, Table I-2, based on prior accident experience and unpredictable events associated with accident damage mitigation and cleanup activities. The formulation of this table utilizes the proposed definitions above, consolidates the ORM subclasses, and identifies pyrophoric (self-igniting) materials as the most hazardous of the flammable materials. The extensive rationale for the alignment of the eight major classes is presented in Chapter V.

While more commendable than the current hierarchy (49 CFR 173.2), this alternate scheme suffers the drawback of the present regulatory hierarchy, namely it has the ultimate effect of identifying only one hazard for most materials and not presenting complete information about all other hazards. Technical analysis, Chapter IV, indicates that many of the most heavily shipped materials present multiple hazards not recognized by the current labeling requirements.

Careful consideration of the need for any hierarchical classification scheme reveals that it is only one of several alternative approaches applicable to the structuring of regulations pertaining to hazardous materials transportation. An alternative, avoiding the hierarchical structure and its shortfalls, is the Hazard Designation System (HDS) in which all hazards are identified. The heart of the HDS is the ensemble of hazard definitions and the hazard designators, Table I-3. Hazard designators, physical state descriptors, and supplemental designators are selected to fully describe the hazardous material. The designation may be in clear text or use the unique symbols. Thus a corrosive flammable liquid that produces toxic combustion products could be coded CIL3 for "corrosive ignitable liquid with toxic combustion products."

The hazard designator system is intended as a replacement for, and not a supplement to, hierarchical classification. This would entail

TABLE I-2. ALTERNATE PREFERENCE TABLE CLASSES AND SUBCLASSES

1. Radioactive Materials
2. Explosives
   A. Equivalent to current Explosives A
   B. Equivalent to current Explosives B
   C. Equivalent to current Explosives C
   D. Equivalent to current Blasting Agents
3. Compressed Gases
   A. Gases that meet the proposed inhalation toxicity criteria
   B. Equivalent to current Flammable Gases
   C. Equivalent to current Non-Flammable Gases
4. Flammable Materials
   A. Pyrophoric Materials
   B. Equivalent to current Flammable Liquids
   C. Equivalent to current Combustible Liquids
   D. Equivalent to current Flammable Solids
5. Poisonous Materials
   A. Liquids meeting any of the proposed toxicity criteria
   B. Solids meeting any of the proposed toxicity criteria
   C. Etiological Agents
6. Oxidizers and Peroxides
7. Corrosive Materials
8. Other Regulated Materials
   A. Dangerous, irritating, and noxious materials as described
   B. Hazardous Waste
   C. Materials unfit for transportation unless regulated

extensive restructuring of the regulations, a laborious task of writing, with few new developments--except for hazard recognition issues.

TABLE I-3. HAZARD DESIGNATOR TABLE

Hazard Designator (Symbol)	Physical State (Symbol)
Corrosive (C)	Compressed Gas (G)
Explosive (E)	Liquid (L)
Ignitable (I)	Solid (S)
Non-Flammable (N)	Volatile Liquid (V)
Oxidizing (O)	
Pyrophoric (P)	
Radioactive (R)	
Toxic (T)	

Supplemental Designators

1. Hazardous When Wet
2. Explosive in a Fire
3. Toxic Combustion Products

3. Hazard Recognition Changes

There are four requirement areas intended to foster transmission of hazard information or hazard recognition: marking, labeling, placarding, and shipping papers.

Labeling regulations are applicable to small containers and, as such, would be outside the scope of this study dealing with hazards of bulk shipments of hazardous materials. However, the Hazardous Materials Table (49 CFR 172.101) identifies the requirements for affixing labels to small containers. Inspection of the Table reveals numerous materials which must be shipped under multiple labels, and in most cases one of the two required labels is a poison label. Extension of the labeling requirements so that they become labeling and placarding standards is the short term change that would most significantly strengthen the DOT Regulations.

a. Marking Changes

Marking requirements pertain to the display of the identification number from the Hazardous Materials Table and, for some materials, the display ("stenciling") of the commodity name on the side of the railcar.

The identification numbers are useful only if a multipage table is available to actually identify the material. Such numbers are not unique for each material, and one (1993) identifies 19 materials--many of them generically named. Because of this, the utility of such a strategy is questionable, and the display of a text identifier (stenciling the name) should replace it as a universal requirement.

Identification numbers, if required, should be only on the rectangular panel format. Use of the placard format to display identification numbers is undesirable, especially where the placard format is not uniquely colored. There are several groups of placards with identical coloration and hazard pictorialization, and covering the hazard-recognition lettering of these placards with a number requiring special information significantly reduces the quantity of information transmitted. The identification numbers, if retained, should not appear on the placards.

b. Placarding Changes

In addition to the placarding changes recommended above, it is recommended that a distinctive placard be developed for pyrophoric (self-igniting) materials so that they may be readily identified. This is in recognition of the unique potential danger these materials present at an accident scene.

c. Shipping Paper Changes

To complement the use of multiple placards, the shipping papers should reflect this practice with multiple placard endorsements and notations.

The shipping papers should, for waste materials, identify by name and number those materials in the CERCLA, CAA, and CWA cross-index lists at the end of 49 CFR 172.101. This will help insure that proper steps are taken during mitigation and cleanup of an accident to protect the environment.

4. <u>Extensions to the DOT Regulations</u>

There are schemes used in Great Britain and continental Europe for extended marking requirements beyond those used in the U.S. The British system, in addition to the placard and identification number, identifies the shipper, a source of emergency information (CHEMTREC in the U.S.), and suitable actions for first responders.

It is recommended that hazard designations and the CHEMTREC telephone number be displayed on each large container, and that serious consideration also be given to inclusion of guidelines for first responders.

CHAPTER II

SELECTION OF 100 HAZARDOUS MATERIALS

A list of 100 rail-shipped hazardous materials has been developed for use in the following ways:

- To assist in the analysis of current regulations and to illustrate any shortcomings that may be found from this analysis
- To assist in the development, and illustrate the outcomes, of any recommendations that may be developed to address the shortcomings.

The list of materials is based principally on shipping rate information contained in "1983 Hazardous Material Carloads by Tank Car Volume," obtained from the Association of American Railroads (AAR). To broaden the range of hazard classes, materials were considered in the 1979 version of the list, as well as several materials identified in a recent Notice of Proposed Rulemaking.[1] The final list of 100 materials, Table II-1, contains 94 commodities in 11 hazard classes described in the current regulations and six generically-named materials frequently used to identify rail-shipped hazardous materials. This resulting list provides a broad spectrum of properties that are of concern when dealing with hazardous materials. The materials are grouped by their hazard classes; the order of the classes is the order of their description in the regulations.

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[1]Notice of Proposed Rule Making, 50 FR 5270-5279.

TABLE II-1. 100 HAZARDOUS RAIL-SHIPPED COMMODITIES

Tank Cars	Commodity (STCC Name in parentheses)
	Flammable Liquids
3713	Acetaldehyde
2347	Acetone
ND	Acrolein, Inhibited
5303	Acrylonitrile
2311	Benzene
745	Butyl Alcohol (2-Butanol)
1345	Carbon Bisulfide or Carbon Disulfide
925	Chloroprene, Inhibited
2405	Cyclohexane
3677	Denatured Alcohol
ND	Epichlorohydrin
875	Ethyl Acetate
1194	Ethyl Acrylate, Inhibited
5513	Ethyl Alcohol
1335	Ethyl Benzene
1166	Ethyl Chloride
5000	Ethylene Oxide
638	Flammable Liquid, N.O.S. (Rosin Solution)
4801	Fuel, Aviation, Turbine Engine
745	Gasoline (Gasoline, Blended)
1461	Gasoline (Gasoline, Casing Head)
1250	Hexane
1844	Isopropanol
19907	Methyl/Alcohol (Methanol)
2204	Alcohol, N.O.S. (Methanol, Contaminated)
1394	Methyl Ethyl Ketone
ND	Methyl Isocynate
2714	Methyl Methacrylate Monomer, Inhibited
1206*	Naphtha
3273	Petroleum Naphtha
7865	Petroleum Oil, N.O.S. (Petroleum, Partially Refined)
5011	Propylene Oxide
5585	Styrene Monomer, Inhibited
1597	Toluene
3866	Vinyl Acetate
2578	Xylene

TABLE II-1. 100 HAZARDOUS RAIL-SHIPPED COMMODITIES (CONTINUED)

Combustible Liquids

1384	Alcohol, N.O.S. (Octyl Alcohol, other than perfumery grade)
1548	Combustible Liquid, N.O.S. (Butyl Acrylate)
1114	Combustible Liquid, N.O.S. (Creosote, Coal Tar)
2259	Formaldehyde Solution (Formaldehyde, Liquid)
24878	Fuel Oil, No. 1,2, 4, or 5
2693*	Naphtha
6445	Petroleum Distillate (Petroleum Distillate Fuel Oil, not for illuminating purposes)

Flammable Solids

ND	Calcium Carbide
3233	Phosphorus, White or Yellow, in water
877	Sodium, Metallic

Oxidixing Materials

ND	Ammonium Nitrate Fertilizer, not more than 0.2% carbon
1571	Hydrogen Peroxide Solution, over 52% peroxide
ND	Nitric Acid, Fuming
ND	Potassium Nitrate
ND	Sodium Chlorate
ND	Sodium Nitrate

Corrosive Materials

3399	Acetic Acid, Glacial
2022	Acetic Anhydride
782*	Corrosive Liquid, N.O.S. (Caustic Soda and Caustic Potassium, mixed, in solution)
1728	Ferric Chloride Solution, Crude, at least 50% water
5683	Hexamethylene Diamine Solution
11165	Hydrochloric Acid
961	Hydrofluosilicic Acid
2008	Hydrogen Fluoride, Anhydrous
2549	Oleum
23947	Phosphoric Acid (Phosphatic Fertilizer Solution)
2458	Potassium Hydroxide, Liquid or Solution
1268	Sodium Hydrosulfide, Solution
27735	Sodium Hydroxide, Liquid
37158	Sodium Hydroxide, Liquid or Solution, at least 48% water
42640	Sulfuric Acid
3233	Sulfuric Acid, Spent

TABLE II-1. 100 HAZARDOUS RAIL-SHIPPED COMMODITIES (CONTINUED)

	Flammable Gases
7412	Butadiene
5520	Butene Gas, Liquefied
1006*	Ethylene
31775	Liquefied Petroleum Gas
10536	Liquefied Petroleum Gas (Butane)
5354	Liquefied Petroleum Gas (Isobutane)
3166	Liquefied Petroleum Gas (Isobutane, for further refinery processing)
1254	Liquefied Petroleum Gas (Isobutylene)
26882	Liquefied Petroleum Gas (Propane)
2844	Liquefied Petroleum Gas (Propylene)
1448	Methyl Chloride
18773	Vinyl Chloride
	Non-Flammable Gases
37097	Anhydrous Ammonia
6175	Carbon Dioxide, Liquefied
37870	Chlorine
2910	Sulfur Dioxide
	Poison A
ND	Cyanogen Chloride, less than 0.9% water
866	Hydrocyanic Acid, Liquefied
ND	Phosgene
	Poison B
928	Aniline Oil, Liquid
6916	Carbolic Acid or Phenol
3458	Motor Fuel Antiknock Compound
6916	Phenol
2515	Toluene Diisocynate
	ORM-A
1100	Carbon Tetrachloride
976	Maleic Anyhydride
	ORM-E
790	Dinitrotoluene

TABLE II-1. 100 HAZARDOUS RAIL-SHIPPED COMMODITIES (CONTINUED)

Generics

1060*	Alcohol, NOS (Flammable Liquid)
1411	Alkaline Liquid, NOS
2343	Combustible Liquid, NOS
1653	Corrosive Liquid, NOS
1785	Flammable Liquid, NOS
846*	Poisonous Liquid, NOS

* 1979 Data   ND: No Data

CHAPTER III
FEDERAL REGULATORY ISSUES

Hazardous materials are (49 CFR 171.8) those substances or materials which have been determined and designated by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce.

The rail transportation of hazardous materials is regulated in all its aspects. This chapter summarizes the regulations pertaining to the classification and preparation of shipments of hazardous materials.

Most of the regulations pertinent to this study are found in Title 49, Subtitle B, Chapter I, Subchapter C of the Code of Federal Regulations (49 CFR), hereafter, the DOT Regulations. Other regulations will be identified in the appropriate places.

A number of terms defined in 49 CFR, and others used in this report, are given in Appendix A. Terms discussed extensively in this report are defined below. For other terms a lay definition is adequate for purposes of this study. The word "carrier" always means rail carrier.

In this or any evaluation of regulations the abstract standard for judgement is this: do the regulations do what they should do without being an inhibitive burden to the regulated activity. Since the regulations are silent about their purposes and goals it is necessary to assume them as a vantage point from which to judge the regulations.

It is assumed that the purposes and goals of the regulations are fourfold:

- To provide safety and protection to the general public and to workers from shipments of hazardous materials
- To provide shippers and receivers reasonable assurance that hazardous materials shipments will arrive at their destination in good condition.
- To provide shipping container owners reasonable assurance that their equipment will not be damaged or destroyed by shipments of hazardous mateials.

- To provide emergency response workers, in the event of an accident, adequate information so they can provide protection for the public arising from accidents involving hazardous materials.

The first and last of these are directly linked to the DOT hazardous materials classification scheme, the focus of this report. The second and third (and to some extent the first) goals are associated with the selection of a proper shipping container, loading and unloading procedures, and consist and handling standards.

The regulatory analysis below will focus on the identification and classification of hazardous materials. To judge the adequacy of the regulations in addressing the first and last goals, it is also necessary to evaluate the hazard recognition issues: marking, labeling, placarding, and shipping paper requirements.

A. IDENTIFICATION OF HAZARDOUS MATERIALS

Part 172 lists and classifies those materials which the U.S. Department of Transportation (USDOT) has specifically designated as hazardous materials to be regulated in transportation (49 CFR 172.1). The classification scheme permits implicit extension of the regulations to materials not specifically listed (49 CFR 172.101(c)(13)(iii)). If it is determined that a material is not in the list of hazardous materials, and if the material does not satisfy the definition of one or more of the hazardous materials classes, then that material is not subject to the DOT Regulations (49 CFR 172.101(c)(13)(iv)).

Part 172.101 provides an extensive tabular list of identified hazardous materials in the Hazardous Materials Table, hereafter referred to as the Table. In addition there are several other lists. The CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act) list identifies specific chemical wastes as well as chemicals listed by the U.S. Environmental Protection Agency (USEPA) under the Clean Water Act and the Clean Air Act. Some materials in these tables also appear in the

Hazardous Materials Table, and all others that are not forbidden and do not satisfy one or more of the hazard class definitions are not subject to the DOT Regulations (49 CFR 172.101(c)(13)(iv)).

There is also an Optional Hazardous Materials Table (49 CFR 172.102) useful for materials in international commerce. The principal use of this table is to interface the DOT Regulations with those of the International Maritime Dangerous Goods (IMDG) Code which regulates international maritime commerce involving hazardous materials. The optional table does not designate materials as hazardous, nor does it specify packaging requirements, exceptions or limitations. Materials are "listed in the interest of providing consistency with those standards and to alert persons offering or accepting these materials for transportation that the materials may be subject to regulation in international transport." While the general subject of international transport is beyond the scope of this study, several points should be recognized. Materials in international transport must comply with the DOT Regulations while being transported in the U.S., including the containers and packaging for these materials. When foreign materials, containers, and packaging issues may arise, they will be noted if pertinent to domestic regulatory issues. Otherwise, foreign commerce will be ignored.

The Table identifying specific hazardous materials consists of eight major columns containing information as follows. Column 1 may contain one or more of four symbols used to modify the interpretation of other columns in the table. The "plus" symbol (+), (49 CFR 172.101(b)(1)) fixes the proper shipping name (column 2) and the hazard class (column 3) for that commodity even if it does not satisfy the definition for that hazard class. The letter "E" in this column (49 CFR 172.101(b)(4)) designates materials which are subject to the DOT Regulations regardless of the hazard class or mode of transportation. The default hazard class for materials not meeting other criteria is ORM-E (discussed below), which includes hazardous wastes and any material not included in any other hazard class but subject to the regulation. The letter "A" in column 1

(49 CFR 172.101(b)(2)) restricts their application to transportation by aircraft, while the letter "W" restricts their application to transportation by vessel (water). The combination symbols involving "E" with "A" or "W" modify the meanings of the latter two in ways not clearly specified in the Regulations.

Column 2 of the Table lists the proper shipping name for materials subject to the DOT Regulations (49 CFR 172.101(c)). The proper shipping name must appear on the shipping papers, even though the commodity may be more clearly specified by other words. It is noted here that there are numerous generic proper shipping names (e.g., Alcohol, N.O.S. and Poisonous Liquid, N.O.S.), and that there are numerous authorized or required modifications to the proper shipping name. Proper shipping names, and associated matters, are discussed in detail below in conjunction with the regulations pertaining to shipping papers. Also in column 2 may be found a pair of italicized numbers preceded by the letters "RQ". These numbers specify (49 CFR 172.101(c)(9)), in pounds and kilograms, the minimum reportable quantity of the material (excluding water and other formulating materials). The regulations imply but do not clearly state (49 CFR 174.45, 49 CFR 171.15, 16, 17) that if this amount (or more) is involved in a spill or discharge (called an "incident"), then certain actions must be undertaken in addition to cleanup of any spill or discharge. Such actions, described in detail in the regulations cited, involve written and immediate telephonic notification of various Federal agencies. If waste material is spilled or discharged, USEPA requires (40 CFR 263.30(c)(1), (2)) compliance with 49 CFR 171.15 and 49 CFR 171.16.

Column 3 contains (49 CFR 172.101(d)) a designation of the hazard class corresponding to the proper shipping name or the word "Forbidden". Forbidden materials may not be offered or accepted for transportation (49 CFR 172.101(d)(1)) unless the materials are (1) diluted, stabilized, or incorporated into devices and (2) satisfy the definition of one or more of the definitions of the hazardous materials classes. Materials classified as ORM's in this column, but having a flash point of 100°F to 200°F and in packaging of 110 gallons or more are reclassed as combustible liquids.

The hazard class assignment determines which regulations for packaging, labeling, marking, and placarding shall be applied to the material, although this does not appear to be explicitly stated. Exemptions for combustible liquids in containers of 110 gallons or less are in 49 CFR 173.118a(b).

Column 3(a), the fourth column, lists (49 CFR 17.101(e)) the six-character identification number associated with the proper shipping name. The first two characters are either "UN" or "NA". The former identifies proper shipping names considered appropriate for international as well as domestic shipments, while the latter are not recognized for international shipments except to and from Canada. The last four characters are the unique commodity number used to satisfy marking and placarding requirements discussed below. For some commodities (e.g. explosives such as BLACK POWDER and HIGH EXPLOSIVE) there is no identification number, and these presumably can not be transported to or from Canada. Numbers in the "NA9000" series are subject to domestic but not Canadian regulations. Most of the commodities in this numeric series that are not ORM-E hazards (a hazardous waste and catch-all category) fall into one of the other ORM (miscellaneous and consumer commodity) hazard classes. The number in this column is referred to in this report as the DOT ID Number, and may be referred to as a 4-digit number or a 6-character number. In the former case the last 4 numeric characters are signified while the latter implies that the prefix "UN" or "NA" is included. Some commodities do not have unique identification numbers.

Column 4, the fifth column, specifies the label or labels that must be applied to each small package, subject to additional requirements in 49 CFR 172.402 and discussed below.

Column 5, the sixth column, references the appropriate regulatory text pertaining to packaging requirements and packaging requirement exemptions. These regulations will be discussed below.

Column 6, the seventh column, lists maximum net quantities permitted in one package for passenger-carrying rail cars and passenger-carrying aircraft (column 6(a)) or cargo aircraft (column 6(b)). Column 7, the last column, pertains only to shipments by water.

The Hazardous Materials Table information that will be of interest here includes:

- the proper shipping names in column 2
- the hazard classes in column 3
- the identification number in column 3a
- the modifying marks in column 1

The labeling standards for small containers, column 4, and how they differ from placarding requirements will also be examined. It will also be necessary to examine the definitions of hazard classes because they affect hazard classification and the selection of the proper shipping name from column 2.

Materials not listed in the Hazardous Materials Table may still be hazardous. If they satisfy the criteria of one or more of the definitions of hazardous materisls, they are subject to these regulations as if they were listed in the Table. Thus the definitions of hazards constitute an important element in the identification of hazardous materials.

B. DEFINITIONS OF HAZARDOUS MATERIALS

Each hazardous material in the regulations is placed in a broad hazard category and this category is presented in the regulations in a subpart separately from all other categories and classes of hazardous materials. That grouping scheme will be followed here.

1. Explosives and Blasting Agents

An explosive is (49 CFR 173.50) any chemical compound, mixture, or device, the purpose of which is to function by explosion, i.e., with substantially instantaneous release of gas and heat, if not otherwise specifically classified in the DOT Regulations. A number of explosives are identified (49 CFR 173.51) as forbidden, and may not be transported unless diluted, stabilized, or incorporated into devices (49 CFR 172.101(d)(1)). There are three classes of acceptable explosives in the DOT Regulations. There are no explosives among the 100 Hazardous Commodities listed in the previous chapter.

a. Class A Explosives

Class A explosives are defined in terms of 9 types, and the essential qualities and examples of these types are shown in Table III-1, Characteristics of Class A Explosives Types. Physical form, whether the material undergoes instantaneous burning or explosion, and how the material behaves in the Bureau of Explosives (BOE) Impact Test Apparatus are the principal criteria for typing Class I Explosives. The BOE Impact Test involves dropping an 8-pound weight on the subject material or device from predetermined heights under fixed conditions. Combustion velocities define the differences between detonation and explosion (49 CFR 173.21(d)); these are consistent with those used by the explosives industry.

b. Class B Explosives

Class B explosives are (49 CFR 173.88(a)), in general, those explosives which function by rapid combustion (deflagration) rather than by detonation. Class B explosives are regarded as less dangerous than Class A explosives, and Class B explosives are considered more of a flammability hazard rather than a detonation hazard, especially when shipped in bulk. Class B explosives, though less dangerous than Class A explosives, represent a serious explosion hazard when present in a train.

Unlike Class A explosives, there are no tests for identifying Class B explosives which are identified only by categories of goods:

- ammunition for cannon (49 CFR 173.88(b))
- rocket ammunition (49 CFR 173.88(c))
- special fireworks which are (49 CFR 173.88(d)) manufactured goods designed to produce audible or visual pyrotechnic effects by combustion or explosion (not to be confused with common or Class C fireworks, below)
- jet thrust (JATO) units (49 CFR 173.88(e))
- propellant explosives (49 CFR 173.88(f))

TABLE III-1. CHARACTERISTICS OF CLASS A EXPLOSIVES TYPES

TYPE NUMBER	TYPE NAME[1]	CHARACTERISTICS	EXAMPLE
1	Solid	Deflagrates in contact with spark or flame (such as safety fuse or electric squib) but not detonatable by a No. 8 test blasting cap.	Black powder; low explosives
2	Solid; Liquid Ingredient	When unconfined can be detonated with a No. 8 test blasting cap; or at least 50% explosion rate in the BOE Impact Apparatus[2] with a drop of 4 inches or more but with an explosion rate of 50% or less in the same equipment with a drop of less than 4 inches	High explosives; commercial dynamite a liquid ingredient
3	Solid; No Liquid Ingredient	Same as Type 2 (above)	TNT; amatol; pentolite, picric acid; tetryl
4	Solid	Detonated by spark or flame (such as safety fuse or electric squib) or meets the BOE Impact Test (above) described for Type 2 (above).	Initialers; primers; lead azide; fulminate of mercury
5	Desensitized Liquid	Detonated separately, or when absorbed on absorbent cotton, by a No. 8 test blasting cap; but not exploded in BOE Impact Apparatus (above) for a drop of less than 10 inches. There are also restrictions on desensitizer characteristics.	Desensitized nitroglycerine
6	Liquid	Explodes in the BOE Impact Apparatus (above) with a drop of less than 10 inches.	Nitroglycerine

TABLE III-1. CHARACTERISTICS OF CLASS A EXPLOSIVES TYPES (CONTINUED)

7	Initiating Device	Metal or plastic casing containing initiating or priming explosives (Type 4, above) either with or without other explosives, and activated by any one of several means, including an electrical pulse, a flame, a shock, or detonation wave, percussion, pressurized gas or high-intensity light beam.	Various blasting caps, including some with delay connectors; detonating primer devices; Class A detonating fuses
8	Solids or Liquids, Mixture or Device	Not included in above types but which may be so designated and examined by BOE and approved by DOT's Associate Director for Hazardous Materials Regulation.	Military ammunition, grenades, mines, bombs, and torpedoes; JATO and rocket motors.
9	Propellant Explosives	Function by rapid combustion of successive layers controlled by composition, size, and grain form; solid chemicals or solid mixtures; 20% detonation rate when tested in transportation packaging and by an electric squib.	Smokeless powder, certain propellants for jet thrust (JATO) units.

Notes: (1) The type name is not called out as such in the Regulations, but reflects certain essential attributes embedded in the description. Deflagration is rapid (but not instantaneous) burning, and is substantially slower than detonation or explosion, both of which are more violent than deflagration because they are essentially instantaneous. Differences between detonation and explosion are unclear.

(2) The BOE Impact Test involves dropping an 8-pound weight on the tested material or device from predetermined heights under fixed conditions.

- explosive power devices (49 CFR 173.88(g))
- jet engine starter cartridges (49 CFR 173.88(h))
- liquid-fueled rocket engines (with fuel) (49 CFR 173.88(i)).

These are condensed specifications of the categories. For example, "ammunition for cannon" is also found under examples of Class A explosives. Examination of the full descriptions under the two classes reveals that the ammunition projectile (warhead) of a Class A munition contains an explosive while those that are Class B may be empty, inert-loaded, or solid projectiles.

c. <u>Class C Explosives</u>

Class C explosives are (49 CFR 173.100(a)) certain types of manufactured articles which contain Class A or Class B explosives, or both, as components but in restricted quantities, and certain types of fireworks. Like Class B explosives, this class is defined in terms of classes of commodities. There are 31 such categories and most of these may be further categorized, with examples, as follows:

- small arms ammunition including practice ammunition
- explosives activators including igniters, squibs, igniter cord, fuses, detonators, and primers.
- power devices including explosive rivets, jet engine starter cartridges and explosive cable cutters
- various smoke and signal devices
- novelty items including toy caps, toy propellant and smoke devices, common fireworks, cigarette loads, and trick matches.

The definitions for the three classes of explosives are stated clearly in terms of tests to be applied, and in terms of decision criteria based on the testing outcomes. Listings of specific groups of commodities further strengthen the definitions of the explosives classes.

2. <u>Flammable, Combustible, and Pyrophoric Liquids</u>

The flash point of a material is the principal criterion for distinguishing members of this class of hazardous materials. The flash point of a liquid is (49 CFR 173.115(d)(1)) the minimum temperature at which a liquid evolves vapor within a test vessel in sufficient concentration to form an ignitable mixture with air near the surface of the liquid. For a liquid mixture (49 CFR 173.115(d)(2)) or homogeneous single-phase liquid having a viscosity less than 45 Saybolt Universal Seconds (ASTM D88-56 method) (49 CFR173.115(d)(1)(i)) the approved testing procedures are (49 CFR 173.115(d)(1)(i)) the Tag Closed Tester (ASTM D56-79) or the Setaflash Closed Tester (ASTM D3278-78). For all other liquids either the Pensky-Martens Closed Tester (ASTM 93-80) or the Setaflash Closed Tester shall be used (49 CFR 173.115(d)(ii)). On the basis of experience or other data, DOT may ignore or over-rule hazard classifications derived from these tests (49 CFR 173.115(g)).

The closed cup flash point values are an attempt to establish a measure of the hazards presented by liquids in closed containers. It is not a perfect measure because the test procedure subjects an entire liquid sample to the test procedures while rail tank cars involved in accidents are not always fully engulfed in flame; accidents frequently involve localized heating of only one part of a tank. Closed cup test results are not strictly applicable when liquids are discharged from tanks in an accident; open cup values are more suitable here. Open and closed cup test results are included in the Commodity Sheets (Appendix B) to provide a more reliable measure of discharge hazard.

There are 39 flammable liquids and 8 combustible liquids among the 100 Hazardous Commodities identified in the previous chapter.

a. Flammable Liquids

A flammable liquid is (49 CFR 173.115(a)) any liquid having a flash point below 100°F, with the following exceptions:

- any liquid meeting one of the definitions specified in 49 CFR 173.300 (pertaining to compressed gases)
- a mixture with one or more components that: (1) are present to at least 99 volume percent and (2) have a flash point of at least 100°F.

Distilled spirits of 140 proof or lower are considered to have flash points not lower than 73°F (49 CFR 173.115(a)(2)). There are exceptions and requirements for materials with a flash point of at least 73°F when shipped in packagings of 110 gallons or less and properly marked (49 CFR

173.118(b)). The 73°F (23°C) breakpoint appears to be related to international commercial requirements.

b. Combustible Liquids

A combustible liquid is (49 CFR 173.115(b)) any liquid that (1) does not meet the definition of any other hazard in the DOT Regulations, and (2) has a flash point of at least 100°F but less than 200°F, with the following exceptions:

- any mixture with one or more components that: (1) are present to at least 99 volume percent, and (2) have a flash point of at least 200°F is not deemed a combustible liquid
- an aqueous solution containing 24 volume percent alcohol or less is deemed to have a flash point not less than 100°F if there are no other constituents subject to the DOT Regulations
- an aqueous solution containing 24 volume percent alcohol or less is deemed to not be a combustible liquid if (1) the solution contains at least 50 percent water, and (2) there are no other constituents subject to the DOT Regulations.

The regulations are not more specific about alcoholic solutions. The technical term alcohol refers to a broad class of well-characterized chemicals with widely varying properties. Methanol (methyl alcohol) is the simplest member of this class and has a pure-liquid closed-cup flash point of 54°F, and flammable limits of 6% to 36%. Examination of tabular and graphical data[1] for alcohol-water mixtures temperatures of about 102°F suggests that aqueous solutions of methanol at lesser compositions than 24 volume percent may not satisfy the definition of a combustible liquid.

c. Pyrophoric Liquids

A pyrophoric liquid is (49 CFR 173.115(c)) any liquid that ignites spontaneously in dry or moist air at a temperature of 130°F or less. On the basis of the generic shipping name "Pyrophoric Liquid, N.O.S." these materials do not appear to be a distinct subclass of flammable liquids; no specific passage to this effect was found in the DOT Regulations.

There are several concerns with the definition of combustible liquids. Because of the greatly increased hazards presented to accident scene cleanup workers (discussed in Chapter IV), the 200°F cap on combustible liquids seems unjustifiably low. The spreading of fire to spilled materials with higher flash points causes additional potential hazards that should be quickly recognized by these workers. The other concern is with the exemption of alcoholic solutions. Some of these materials will support combustion and this also should be recognized at an accident scene. Problems with the use of the unqualified term "alcohol" have been discussed above.

3. Flammable Solids, Oxidizers, and Organic Peroxides

This group is, more or less, a solids counterpart to the liquids classes above. There are three flammable solids and six oxidizers among the 100 Hazardous Commodities listed in the previous chapter.

a. Flammable Solid

A flammable solid is (49 CFR 173.150) any solid, other than one classed as an explosive, which, under conditions normally incident to transportation is liable to cause fires through friction, retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to creat a transportation hazard. Included in this class are spontaneously combustible and water-reactive materials.

Note that there are two alternative criteria for flammable solids; solids satisfying either criterion satisfies the definition.

b. Oxidizer

An oxidizer is (49 CFR 173.151) a substance that yields oxygen readily to stimulate the combustion of organic matter.

The definition of an oxidizer as a supplier of oxygen in a reaction is a traditional definition the inadequacy of which is demonstrated by the classification of materials such as chlorine trifluoride as oxidizers. Chlorine trifluoride and chlorine, for example, are oxidizers of some potency, but a lack of oxygen in their composition means that they are at variance with the definition of oxidizers. A more modern definition could be cast in terms of electron transfer reactions or gross phenomenological terms. Combustion would be a crucial word in such a definition as this sets oxidizers apart from galvanic corrosive materials which participate in similar chemical processes, but at much slower rates.

c. Organic Peroxide

An organic compound containing the bivalent -O-O-structure, and which may be considered a derivative of hydrogen peroxide where one or both of the hydrogen atoms have been replaced by organic radicals, must be classed as an organic peroxide (49 CFR 173.151a(a)) unless:

- the material meets the definition of an explosive A or explosive B (above), in which case it must be classed as an explosive,
- the material is forbidden in the Table or 49 CFR 173.21,
- it is determined that the predominant hazard of a material containing an organic peroxide is other than that of an organic peroxide,
- material on file with the USDOT Office of Hazardous Materials Transportation supports a determination that the material does not present a hazard in transportation.

4. Corrosive Materials

A corrosive material is (49 CFR 173.240(a)) a liquid or solid that causes visible destruction or irreversible 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.

As a practical matter, the skin corrosion criterion is regarded (49 CFR 173.240(a)(1)) as equivalent to the outcome of an exposure of 4 hours or less to the intact skin of an albino rabbit. Additional testing procedure details are found in Appendix A to Part 174. The National Association of Corrosion Engineers (NACE) standard procedure TM-01-69 producing a corrosion rate greater than 0.250 inches per year in SAE1020 steel at 130^{o}F is regarded as a positive steel corrosion test (49 CFR 173.240(a)(2)).

It is useful to compare these standards with those from the US Environmental Protection Agency (USEPA). In addition to the steel corrosion test above, the USEPA specifies that a material is corrosive if it is extremely acidic (pH less than 2.0) or is extremely alkaline (pH greater than 12.5); this is a very rapid, inexpensive test that could readily supplement the current regulations.

With the increased use of aluminum as a construction material to reduce freight car tare weight, extension of corrosion testing to this material is appropriate. The reaction of aluminum with alkaline solutions produces flammable hydrogen gas.

There are 16 materials classified as corrosive among the 100 Hazardous Commodities in the previous chapter.

5. <u>Compressed Gases</u>

There are two subclasses of compressed gases. There are 12 flammable gases and four non-flammable gases in the list of 100 Hazardous Commodities identified in the previous chapter.

The classes of compressed gases are as follows.

a. <u>Compressed Gas</u>

A compressed gas is (49 CFR 173.300(a)) any material or mixture having, in the container, any of the properties:

- a pressure greater than 40 p.s.i.a. at 70°F
- a pressure greater than 104 p.s.i.a. at 130°F
- any liquid flammable material having a vapor pressure greater than 40 p.s.i.a. at 100°F (ASTM Test D-323).

This last criterion in particular complements the definition of a flammable liquid (c.f. 49 CFR 173.115(a)(i)).

b. <u>Flammable Compressed Gas</u>

A flammable compressed gas is (49 CFR 173.300(b)) a compressed gas with any of the following properties:

- a 13 volume percent (or less) mixture with air forms a flammable mixture; or the flammable range of the mixture with air is wider than 12 percent for any lower flammable limit (49 CFR 173.300(b)(1))

- when tested in the BOE Flame Projection Apparatus, the flame projects more than 18 inches beyond the ignition source with the valve fully open, or the flame flashes back and burns at the valve with any degree of valve opening (49 CFR 173.300(b)(2))
- when tested in the BOE Open Drum Apparatus there is any significant propagation of flame away from the ignition source (49 CFR 173.300(b)(3))
- when tested in the BOE Closed Drum Apparatus, there is any explosion of the vapor-air mixture in the drum (49 CFR 173.300(b)(4))

The BOE test apparatus and procedures are not described in the DOT Regulations. Other definitions appropriate to compressed gases follows.

c. Non-Liquefied Compressed Gas

A non-liquefied compressed gas is (49 CFR 173.300(c)) a gas, other than a gas in solution, which is entirely gaseous at 70°F for the charge pressure.

d. Liquefied Compressed Gas

A liquefied compressed gas is (49 CFR 173.300(d)) a gas which is partially liquid at 70°F for the charge pressure.

e. Compressed Gas in Solution

A compressed gas in solution is (49 CFR 173.300(e)) a non-liquefied compressed gas (above) which is dissolved in a solvent.

f. Cryogenic Liquid

A cryogenic liquid is (49 CFR 173.300(f)) a refrigerated liquefied gas having a boiling temperature colder than -130°F at one atmosphere, absolute.

g. Refrigerant Gas or Dispersant Gas

The terms refrigerant gas and dispersant gas apply (49 CFR 173.300(i)) to all flammable or non-flammable, nonpoisonous refrigerant gases or dispersant gases (fluorocarbons) identified as such in the Table, or in parts 172.101, 173.304(a)(2), 173.314(c), 173.315(a)(1), and

173.315(h) of 49 CFR, and mixtures thereof, or any other compressed gas having a vapor pressure not greater than 260 p.s.i.g. that meets one of the following:

- a non-flammable mixture containing at least 50 percent fluorocarbon content
- a flammable mixture containing at least 50 percent fluorocarbon and not over 40 percent of a flammable component.

These definitions are clear, simple, and workable. The materials subject to regulation are identified and dealt with as individual elements in tables. The flammability of anhydrous ammonia, a non-flammable gas, presents problems that should be considered further.

6. <u>Poisonous Materials, Etiological Agents, and Radioactive Materials</u>

This class of materials is sufficiently diverse that is convenient to break it into its three components.

a. <u>Poisonous Materials</u>

Poisonous materials are divided into three classes: Poison A materials, Poison B materials, and Irritating Materials. Extremely dangerous poisons, Class A, are (49 CFR 173.326(a)) poisonous gases or liquids of such nature that a very small amount of the gas, or vapor of the liquid, mixed with air is dangerous to life.

Class B Poisons are (49 CFR 173.343(a)) those substances, liquid or solid (including pastes and semisolids) other than Class A Poisons or Irritating Materials (below) which are known to be so toxic to man as to afford a hazard to health during transportation or which, in the absence of adequate data on human toxicity, are presumed to be toxic to man because they fall within any one of the following categories when tested on laboratory animals:

- at least half of a group of at least 10 white laboratory rats, weighing 200-300 grams, die within 48 hours of a single orally administered dose of no more than 50 milligrams per kilogram of body weight of the material (49 CFR 173.343(a)(1))

- at least half of a group of at least 10 white laboratory rats, weighing 200-300 grams, die within 48 hours of inhalation exposure of not more than one hour to a concentration of not more than 2 milligrams per liter of vapor, mist, or dust provided such concentration is likely to be encountered by man when the chemical product is used in any reasonable forseeable manner (49 CFR 173.343(a)(2))
- at least half of a group of at least 10 rabbits die within 48 hours of continuous bare-skin contact of 24 hours or less with a dose of 200 milligrams or less per kilogram of body weight (49 CFR 173.343(a)(3))

These are referred to by toxicologists as LD_{50} or LC_{50} criteria for oral, inhalation, and cutaneous toxicity respectively, and are frequently-reported experimental results. There are other quantitative measures of toxicity or hazard.

The foregoing test criteria shall not apply if (49 CFR 173.343(b)) experience shows that the physical characteristics or the probable hazards to humans of the substances will not cause serious sickness or death. Further, neither the outcomes of such testing nor the display of danger or warning labels shall prohibit nor prejudice the exemption of any substance from the provisions of these regulations.

An Irritating Material is (49 CFR 173.381(a)) a liquid or solid substance which, upon contact with fire, or when exposed to air, gives off dangerous or intensely irritating fumes, but not including any Class A Poisonous Material. There are three commodities, chemical ammunition, tear-gas devices, and monochloroacetone, for which containers are specifically provided for. A number of other irritating materials are listed in the table with other hazard classifications. This definition should be compared with that for ORM-A (below).

These definitions apparently attempt to provide a smooth graduation of toxicity classes that are appropriate "in conditions normally incident to transportation" but which should also be appropriate in the event of an accident involving spills of quantities ranging from a spoonful to thousands of gallons or pounds of material. That the Regulations should provide a graduation of hazard classes is open to question. Marking, labeling, and placarding of graduated-class hazards should not only encourage safe handling of toxic materials but should identify the severity of the hazard and the extent of the risk. They should also have the attributes of clarity and utility appropriate to all standards.

Examination of each definition by itself makes it appear wholesome and appropriate, but with unresolved questions. Table III-2 summarizes, for the Poison Classes and the closely-related ORM-A hazard class, the criteria for: physical states regulated; qualitative and quantitative toxicity criteria; toxic mechanism; and the presence of any discretionary regulatory passages. With this table a comparative analysis clarifies the questions and illuminates the ambiguities.

Comparison of the physical states regulated suggests that hazard, expressed as the mobility of the toxic entity, is the basis for regulation, and this does provide a reasonable kind of graduation to the regulations. The qualitative criteria, on the other hand, are cast in terms of toxicity standards, as are the Poison B quantitative requirements. The absence of quantitative standards for any other class is a puzzling absence that will be discussed below. Considerations of toxicity mechanisms in Table III-2 are presumptive and based on the following considerations.

The regulations require (49 CFR 172.101(c)(6)) that the inclusion of the words "poison" and "poisonous" are to be reserved for systemic poisons and not used in conjunction with corrosive poisons. Support for the belief that this mechanistic differentiation underlies the definitions may be found in 49 CFR 172.203(k)(3)(ii) (shipping paper entries) and the prologue of a recent Notice of Proposed Rule Making. The basis for the use of this distinction apparently stems from recommendations contained in a 1969 National Academy of Sciences/National Research Council (NAS/NRC) Conference Report, portions of which are quoted in the NPRM[3]. The role of corrosive poisons is unclear.

TABLE III-2. COMPARISON OF POISONOUS, IRRITATING, AND NOXIOUS MATERIALS*

	POISON A	POISON B	IRRITANT	ORM-A
Physical States	Gases, Liquids	Liquids, Solids	Fumes	N/S
Qualitative Criterion	Very small amount... is dangerous to life	So toxic as to afford a hazard to health	On contact with fire in air gives off dangerous or intensely irritating fumes	Anesthetic, irritating, noxious, toxic; can cause extreme discomfort
Quantitative Criterion	N/S	LD_{50} (ORL) = 50 mg/kg LD_{50} (IHL) = 2 mg/liter LD_{50} (SKN) = 200 mg/kg	N/S	N/S
Mechanism	Systemic Poison?	Systemic Poison?	N/S	N/S
Discretionary	No	Yes	No	No

* N/S: No Specification

TABLE III-3. HODGE-STERNER ORAL TOXICITY SCALE

Experimental LD_{50} Dose/kg	Degree of Toxicity	Probable Lethal Dose (150 Pound Man)
Less than 1 mg	Dangerously Toxic	A Taste
1-50 mg	Seriously Toxic	A Teaspoonful
50-500 mg	Highly Toxic	An Ounce
0.5-5 g	Moderately Toxic	A Pint
5-15 g	Slightly Toxic	A Quart
More than 15 g	Extremely Low Toxicity	More Than A Quart

From "Dangerous Properties of Industrial Materials," N.I. Sax, Editor 6th Edition

The presence of only one discretionary criterion in the four definitions is a bit surprising.

From this piecewise comparative analysis it is seen that the regulations seek to define the Poison Classes in terms of both hazard and toxicity - with the further restriction that only systemic poisons are to be considered seriously. In principle the definition of poisons in terms of both hazard and toxicity is appropriate - if it is properly done. Consideration of toxic mechanisms as a criterion and the quantitative POISON B criteria require further attention.

The quantitative criteria in Table III-2 give rise to two responses. First, the general use of lethality criteria in conjunction with a "hazard to health" rather than a "dangerous to life" qualitative criterion seems to be a gross inconsistency. While it can be abstractly argued that this is a value judgment, it should be observed that the quantitative criteria for POISON B are blatant levels of toxicity more appropriate as quantitative counterparts to the "dangerous to life" qualitative criterion. This assertion might be examined in light of the Hodge-Sterner Toxicity Scale for oral toxicity criteria, Table III-3, which places two degrees of toxicity more severe than those for Poison B. The strength of the assertion can be further evaluated by examining Table III-4 which identifies the toxicity of some hazardous materials. The materials are identified by their proper shipping name and are grouped by the hazard class assigned in the Hazardous Materials Table. Table III-4 and Appendix B contain explanatory information for the entries. All materials listed must bear a POISON label when shipped in small containers.

In constructing Table III-4 every effort was made to select reported results that matched as closely as possible the animals and exposure times called for in the Poison B quantitative criteria, and the doses have been restated to correspond to the criteria units-of-measure. Several very significant limitations must be borne in mind when browsing and making intercomparisons of toxicity data:

TABLE III-4. TOXICITY OF SOME HAZARDOUS MATERIALS

Material	TOXICITY DOSE/EXP/SPEC/EFFECT/ROUTE	TLV (ug/l)
Poison A Materials		
Arsine	0.3/15M/RAT/LCLo/IHL	0.16
Cyanogen	0.74/1H/RAT/LC50/IHL	21.3
Cyanogen Chloride	0.78/7.5M/MUS/LCLo/IHL	--
Germane	---------ND----------	0.6
Hydrocyanic Acid	0.53/5M/RAT/LC50/IHL	11
	10/ND/RAT/LDLo/ORL	
Methyldichloroarsine	0.27/10M/MUS/LCLo/IHL	--
Nitrogen Dioxide	0.165/4H/RAT/LC50/IHL	5.6
Nitrogen Tetroxide	1.18/15M/RBT/LC50/IHL	
Flammable Gases		
Carbon Monoxide	2.1/4H/RAT/LC50/IHL	57
Diborane	0.05/4H/RAT/LC50/IHL	0.1
Hydrogen Selenide	280/10M/GPG/LCLo/IHL	0.16
Hydrogen Sulfide	0.6/ND/RAT/LC50/IHL	13.9
Non-Flammable Gases		
Chlorine	0.85/1H/RAT/LC50/IHL	2.9
Fluorine	0.29/1H/RAT/LC50/IHL	1.6
Flammable Liquids		
Acrolein	0.018/4H/RAT/LCLo/IHL	0.2
	46/ND/RAT/LD50/ORL	
	500mg/24H/RBT/SEV/SKN	
Acrylonitrile	650/ND/RAT/LDLo/ORL	4.3
	1.1/4H/RAT/LCLo/IHL	
	0.9/1H/MUS/LCLo/IHL	
	250/ND/RBT/LD50/SKN	
Allyl Alcohol	64/ND/RAT/LD50/ORL	4.7
	0.4/4H/RAT/LC50/IHL	
	53/ND/RBT/LD50/SKN	
Allyl Chloride	64/ND/RAT/LDLo/ORL	3.1
	0.9/8H/RAT/LCLo/IHL	
	2200/ND/RBT/LD50/SKN	
n-Butyl Isocyanate	600/ND/RAT/LD50/ORL	
	300/ND/RAT/LC50/IHL.	
Dimethylhydrazine	0.64/4H/RAT/LC50/IHL	1.3
Epichlorohydrin	0.38/68/RAT/LCLo/IHL	2
	90/ND/RAT/LD50/ORL	
	515/ND/RBT/LD50/ORL	
Ethylchloroformate	270/ND/RAT/LD50/ORL	--
	145/ND/RAT/LC50/IHL	
	7120/ND/RBT/LD50/SKN	

TABLE III-4. TOXICITY OF SOME HAZARDOUS MATERIALS (CONTINUED)

Material	Toxicity DOSE/EXP/SPEC/EFFECT/ROUTE	TLV (ug/l)
Flammable Liquids		
Ethyleneimine	0.04/8H/RAT/LCLo/IHL	0.88
	15/ND/RAT/LD50/ORL	
	1.8/10M/MUS/LD5/IHL	
	14/ND/GPG/LD50/SKN	
Hydrazine	0.75/4H/RAT/LC50/IHL	0.13
Methylchloroformate	0.34/1H/RAT/LC50/IHL	--
	110/ND/RAT/LD50/ORL	
	7120/ND/RBT/LD50/SKN	
Methylchloromethyl Ether	0.18/7H/RAT/LC50/IHL	--
	817/ND/RAT/LD50/ORL	
Methyl hydrazine	0.14/4H/RAT/LC50/IHL	0.4
	33/ND/RAT/LD50/ORL	
	95/ND/RBT/LD50/SKN	
Nickel Carbonyl	0.24/30M/RAT/LC50/IHL	0.35
Pentaborane-9	0.02/4H/RAT/LC50/IHL	0.01
Oxidizers		
Chlorine Trifluoride	1.5/30M/RAT/LCLo/IHL	0.4
Silver Nitrate	22/ND/MUS/LD50/ORL	--
Flammable Solid		
Phosphorus	12/ND/RAT/LD50/ORL	0.1
Corrosive Liquid		
Hydrogen Fluoride	1/1H/RAT/LC50/IHL	2.4
Poison B		
Aniline Oil	0.95/4H/RAT/LCLo/IHL	7.6
	250/ND/RAT/LD50/ORL	
	820/ND/RBT/LDLo/SKN	
Arsenic Acid	48/ND/RAT/LD50/ORL	9500
Brucine	1/ND/RAT/LD50/ORL	
Carbolic Acid (Phenol)	414/ND/RAT/LD50/ORL	19.7
	850/ND/RBT/LD50/SKN	
Cyanogen Bromide	0.5/10M/MUS/LCLo/IHL	--

TABLE III-4. TOXICITY OF SOME HAZARDOUS MATERIALS (CONTINUED)

Material	Toxicity DOSE/EXP/SPEC/EFFECT/ROUTE	TLV (ug/l)
Poison B - Continued		
Dinitrobenzene		
(ortho-)	-------ND--------	1000
(meta-)	83/ND/RAT/LD50/ORL	1000
(para-)	29/ND/CAT/LD50/ORL	1000
Ethylenechlorohydrin	0.023/1H/RAT/LCLo/IHL	3.3
Hexaethyltetraphosphate	7/ND/RAT/LD50/ORL	--
	15/ND/RAT/LD50/SKN	
Methyl Bromide	12/15M/RAT/LCLo/IHL	19.5
Nitroaniline		
(ortho-)	1600/ND/RAT/LD50/ORL	--
	20/ND/RBT/LD50/SKN	
(meta-)	535/ND/RAT/LD50/ORL	--
(para-)	750/ND/RAT/LD50/ORL	3
Parathion	2/ND/RAT/LD50/ORL	1
	40/ND/RBT/LD50/SKN	
Strychnine	16/ND/RAT/LD50/ORL	150

Notes: Material - Shown is the proper shipping name. Isomeric materials are listed by isomers where data are available; commercial materials may be mixture of indefinite, variable composition or purity.

Toxicity - Dose is expressed in milligrams/kilogram (mg/kg) -the dosage measure used in the DOT Regulations; ppm-values have been restated as mg/kg using standard tables and formula weights. Exposures (EXP) are expressed in minutes (M), hours (H), and no data (ND). Species data reported included rat (oral and inhalation toxicity) and rabit (RBT; skin toxicity) to further mirror the test protocols in these regulations; in their absence data were sought for mice (MUS), guinea pig (GPG), or cat data - generally in that order of perference. Effects reported include LC_{50}, LCLo, and LDLo - all with the usual meaning and defined in Appendix B. SEV efforts for skin toxicity include severe redness or injury-in-depth and severe swelling. Routes of administration or exposure include oral (ORL), inhalation or respiration (IHL), and skin (SKN); other routes of exposure found do not conform to protocols in these regulations. TLV values are maximum acceptable atmospheric concentrations specified by the Occupational Health and Safety Administration (OSHA). Since they are intended for chronic exposure situations such as production and manufacturing, they are not strictly comparable to measures of toxicity; the frequently-employed practice of presenting them with the toxicity data is followed here for the reader's convenience.

- There are no rules or procedures for comparing dosage toxicities involving different animals or exposure times; this is left to the judgment and experience of toxicologists.
- Original reports have not been examined and variation from the stated criteria (e.g., 48 hour mortality assessment) cannot be discerned from the sources; the toxicity information in Table III-4 corresponds to the criteria requirements.

Examination of Table III-4 reveals that the inhalation toxicity of diborane (FLAMMABLE GAS) and methyl hydrazine vapors (FLAMMABLE LIQUID) are more toxic (smaller LC_{50}-values) than nitrogen dioxide (POISON A). Similarly, fluorine (NON-FLAMMABLE GAS) and methylchloroformate vapors (FLAMMABLE LIQUID) have higher inhalation toxicities than cyanogen (POISON A), while chlorine (NON-FLAMMABLE GAS), acrylonitrile vapors (FLAMMABLE LIQUID), and hydrogen fluoride vapors (CORROSIVE LIQUID) are only slightly less toxic. Fluorine, chlorine, and hydrogen fluoride have corrosive toxicity mechanisms; methyl hydrazine, methylchloroformate, acrylonitrile, and hydrogen fluoride would be subject to the provisions of the pending NPRM. It is not clear why diborane is classified as a flammable gas; POISON A seems more appropriate.

Given the tabulated toxicities for the few materials compared above, an important outcome is seen - the apparent suppression of hazard information. This apparent suppression of hazard information arises as a consequence of the use of the hierarchical preference table (49 CFR 173.2) to assign hazard classes to hazardous materials. Multiple-labeling standards for small containers are frequently used to overcome this shortfall in the classification scheme. Multiple-placarding of tank cars is called for much less frequently; toxicity is usually the second hazard identified by multiple placarding. Since large (e.g., tank car sized) spills pose the greatest threat to the general public, it is unclear how the current regulations best serve the general public.

The characterization of toxic materials as systemic or corrosive, though useful in a laboratory or clinical environment, seems inappropriate for regulatory purposes. The goal considered here is the identification, the classification, and recognition of all hazards in bulk rail-shipped commodities. An elaboration, such as systemic <u>versus</u>

corrosive poisons, that makes no significant contribution or (worse) makes a negative contribution invites a simple question: why? Examination of the issue of how, if at all, the systemic versus corrosive toxicity contributes to the goal leads to the identification of several underlying questions:

- who is to be protected by the Regulations?
- from what are they to be protected?
- how are they to be protected?

While the Regulations do not explicity address these questions, they may be answered from implicit evidence: people associated with the normal operations of rail transportation of hazardous materials are to be protected from the primary hazard and any toxic properties if the primary hazard is not a systemic poison. They will be protected by: (1) regulations that identify the primary hazard and any toxic properties if the primary hazard is a systemic poison; and, (2) they will be protected by regulations that require hazardous materials be shipped with properly-annotated shipping papers and in marked, labeled, and placarded containers.

An alternative answer, offered here without support or justification, is that those to be protected, anyone who might be affected by the rail transportation of hazardous materials, should, insofar as reasonably possible, be protected from all possible hazards. Elaboration of this goal, and how it might be attained, will be dealt with extensively in Chapter V.

Another problem with the Poison Class definitions arises from the gulf between the very stringent quantitative criteria for Poison B (taken as equivalent to "hazard to health") on the one hand and the "intensely irritating fumes" of irritating materials on the other. Between these lies a range of toxicities in a continuum from mildly-to-severely incapacitating. Given the quantitative toxicities and the qualitative "hazard to health" criterion in the Poison B definition, it is not clear how much the concept of severe incapacitation might be incorporated into the Poison B Class. The nature and degree of potential incapacitation from toxic materials is of importance to workers engaged in accident damage control, mitigation, and cleanup, as well as people concerned with the welfare of the environment and with the civilian population. This extended range of incapacitating toxicities, too severe to be Irritating Materials and too mild to satisfy the Poison B quantitative criteria are inconsistent with any smooth graduation of toxicity classes that the USDOT/OHMT might have been trying to achieve.

The differentiation of Irritating Materials and ORM-A materials, using the qualitative criteria is at least adequate for regulatory purposes. A stronger endorsement is impossible with the poison class definitions currently in place.

An issue not addressed in the DOT Regulations has to do with the evolution of noxious or toxic fumes from burning materials at an accident scene. Materials containing nitrogen or one of the halogens (fluorine, chlorine, bromine, and iodine) can be expected to produce toxic fumes when burned in a train wreck. In a large burning spill the problem is usually severe enough that accident scene workers require self-contained breathing apparatus and protective garments.

Also not addressed in the regulations are toxic materials that may be released as a consequence of mingling with other hazardous materials. For example sodium bisulfide (NaHS), shipped as sodium hydrosulfide, will release poisonous hydrogen sulfide (FLAMMABLE GAS) when mixed with aqueous solutions, especially acidic ones.

b. Etiological Agents

Etiological agents are (49 CFR 173.386(a)(1)) viable microorganisms or their toxins which cause, or may cause, human disease, and is limited to those agents listed in 42 CFR 72.3 of the regulations of the Department of Health and Human Services (DHHS). Unless other materials contained therein are subject to the DOT Regulations, diagnostic specimens, biological products, and cultures of etiological agents of 50 millimeters or less total quantity are exempt from the DOT Regulations. Non-exempt etiological materials shall be shipped (49 CFR 173.387(a)) in packages containing not more than four liters (ca. one gallon) gross volume. The DHHS regulations provide (42 CFR 72.3(d)), and the DOT

Regulations cross list (49 CFR 173.388(a)) a special etiological materials label. There are no etiological agents among the 100 Hazardous Materials.

c. Radioactive Materials

A radioactive material is (49 CFR 173.403(y)) any material having a specific activity greater than 0.002 microCuries per gram (uCi/g). A radioactive article is (49 CFR 173.403(w)) any manufactured instrument or article having radioactive material as a component. Assignment to the radioactive hazard class is straightforward and subject to only a few exemptions:

- radioactive materials within establishments, except when being moved about.
- radioactive materials contained in a medical device that is implanted in a human being or live animal.
- radiopharmaceutical materials that have been injected into, or ingested by, and are still in human beings or live animals.

Container selection, packaging, marking, labeling, etc. is much more complex because they depend on the nuclide being shipped (radioactive particles emitted), the amount (mass) of material and the radioactivity level of the material. Additional Nuclear Regulatory Commission regulations, pertaining to radioactive materials and found in 10 CFR 71, must also be complied with by shippers and carriers.

Shippers and carriers must consider a variety of factors in addition to radioactivity and quantity before packaging, loading, or transporting radioactive materials.

1) Fissile Materials

A fissile material is any material consisting of or containing one or more of the fissile radionuclides plutonium-238, plutonium-239, plutonium-241, uranium-233, and uranium-235. Neither natural nor depleted uranium are fissle materials. There are special regulations (49 CFR 173.451 to 173.459) for the packaging and transportation of fissile materials, and these are applicable to quantities containing greater than 15 grams (ca 0.5 ounces) of fissile radionuclides. This 15 gram exemption applies to a package or, if transported in bulk, to the rail car.

Special form radioactive materials satisfy both the following criteria:

- it is either a single solid piece or is sealed in a capsule that can be opened only by breaking the capsule (this presumably could contain solids, liquids, solutions, or gases.
- the piece or capsule has at least one dimension greater than 5 millimeters (ca 0.2 inches) in length.

Special form radioactive materials must (49 CFR 173.469) not break or shatter when subjected to the impact, percussion, and bending tests, and must not melt or disperse when subjected to a heat test. After each test the specimen must be tested for leak tightness or indispersibility. Normal form radioactive materials are those radioactive materials which have not been demonstrated to qualify as special form radioactive materials. There are different packaging requirements (49 CFR 173.416) for special form and normal form radioactive materials.

2) Low Specific Activity Materials

Low specify activity (LSA) materials are those that satisfy one of the following:

- uranium or thorium ores and physical or chemical concentrates of those ores.
- unirridiated natural or depleted uranium or unirradiated natural thorium.
- aqueous tritium oxide solutions of concentration not greater than 5 millicuries per milliliter.
- radioactively homogeneous materials for which the estimated average concentration does not exceed: (1) 0.1 microcurie per gram of nuclides for which the listed maximum activity, other than special form or LSA, (the A_2 limit permitted in a type A container) is not more than 0.05 curie; (2) 5 microcuries per gram of radionuclides for which the A_2 limit is greater than 0.05 curie but not more than 1 curie; or (3) 300 microcuries per gram of radionuclides for which the A_2 limit is more than 1 curie.

- objects of non-radioactive material externally contaminated with radioactive materials that are (1) not readily dispersable, and (2) below specified values for various A_2 limits.

Bulk shipments of certain LSA materials shall be (49 CFR 173.425(c)) only in exclusive use closed rail cars, tank cars, and cargo tanks, including: (1) uranium or thorium ores and physical or chemical concentrates of their ores; (2) uranium metal or natural thorium metals and their alloys; (3) materials with radioconcentrations not greater than 1 microcurie per gram and the contribution from materials with an A_2 value (above; 49 CFR 173.435) of less than 0.05 curies shall not exceed 1 percent of the total activity; and, (4) nonradioactive externally contaminated objects. Two types of tank cars (49 CFR 173.425(c)(2)(i)) and several cargo tanks (49 CFR 173.425(c)(2)(ii)) are authorized; TOFC service and air transport (49 CFR 173.425(c)(f)) are not authorized. Shipments must be loaded by the shipper and unloaded by the receiver (49 CFR 173.425(c)(4)). Except for shipments of unconcentrated uranium or thorium ores, the transport vehicle must be placarded (c.f. Part 172, subpart F; 49 CFR 173.425(c)(5)).

3) <u>Multiple Hazard Radioactive Materials</u>

There are special provisions for radioactive pyrophoric (49 CFR 173.418) and oxidizing (49 CFR 173.419) materials as well as empty packaging (49 CFR 173.427). There are packaging and shielding integrity (free drop, penetration, and compression) tests to assure radiation containment during transport (49 CFR 173.462 to 173.467). There are requirements for radiation levels at and near (2 meters) the surface of the outside packaging (49 CFR 173.441). Heat release from the radioactive contents shall not degrade the packaging integrity, and there are surface temperature requirements (49 CFR 173.442).

4) <u>Radioactive Contamination</u>

Contamination controls (49 CFR 173.443) are cast either in general terms or in terms of non-fixed (removable) contamination. The latter is evaluated by wiping 300 square centimeters (ca. 48 square inches) of the container and measuring the radiation on the wiper. If the container is an exclusive-use rail car, the non-fixed contamination may not be, at any time in the trip, more than tenfold greater than the allowed maximum non-fixed contamination value at the beginning of the trip. Emptied rail cars in exclusive-use service shall not be returned to service until a survey of all accessible surfaces shows a radiation dose rate is 0.5 millirem per hour or less and there is no significant non-fixed surface contamination. There are exceptions for closed cars in such service (49 CFR 173.443(c)).

The definitions for radioactive article, radioactive contents, radioactive material, and similar phrases are readily understood and applied. While the packaging and shipping regulations are very complex, they are outside the scope of this report.

There are no radioactive materials among the 100 hazardous commodities in the previous chapter.

7. Other Regulated Materials (ORM's)

An Other Regulated Material (ORM) is (49 CFR 173.500(a)) a material that:

- may pose an unreasonable risk to health and safety or property when transported in commerce, and
- does not meet any of the definitions of the other hazard classes in the DOT Regulations, or
- has been reclassed as an ORM according to the DOT Regulations.

There are five classes of ORM's (A-E) described as follows (49 CFR 173.500(b)).

a. ORM-A Materials

As ORM-A material is a material which has an an aesthetic, irritating, noxious, toxic, or other similar property and which can cause extreme annoyance or discomfort to passengers and crew in the event of leakage during transportation. There are two ORM-A materials among the 100 Hazardous Commodities.

b. ORM-B Materials

An ORM-B material is a material (including a solid when wet with water) capable of causing significant damage to a rail car from leakage during transportation. ORM-B materials meet one or both of the following criteria:

- a liquid that has a corrosion rate (NACE TM-01-69) greater than 0.250 inches per year on nonclad 7075-T6 aluminum
- specifically designated ORM-B in the Hazardous Materials Table.

There are no ORM-B materials in the list of 100 Hazardous Commodities.

c. ORM-C Materials

An ORM-C material is a material which has other inherent characteristics not described as an ORM-A or ORM-B which make it unsuitable for shipment unless properly identified and prepared for transportation. ORM-C materials are specifically identified in the Hazardous Materials Table. There are none among the 100 Hazardous Commodities.

d. ORM-D Materials

An ORM-D material is a material such as a consumer commodity which, though otherwise subject to the DOT Regulations, presents a limited hazard during transportation due to its form, quantity, and packaging. It must be a material for which exceptions are provided in the Hazardous Materials Table (column 5(a)). The list of 100 Hazardous Commodities contains no ORM-D materials.

e. ORM-E Materials

An ORM-E material is a material not included in any other hazard class, but is subject to the DOT Regulations. Materials in this class include hazardous materials as defined (49 CFR 171.8) and hazardous waste.

The US Environmental Protection Agency (EPA) regulates hazardous wastes, including certain aspects of their transportation. The DOT Regulations are in addition to those EPA regulations. Hazardous wastes are defined in terms of one or more of the following:

- they are listed in 40 CFR 261.33;
- they are ignitable;
- they are corrosive;
- they are reactive;
- they have extraction toxicity.

Ignitability is measured by (40 CFR 261.21(a)(1)) the material's flash point using the closed cup testers identified above; the flashpoint criterion temperature is 140°F. USDOT flammable gases are USEPA ignitable materials. Corrosiveness for USEPA is (40 CFR 261.22(a)(2)) the same as for the corrosive hazard class above, but is also defined as (40 CFR 261.22(a)(1)) an extremely acidic (pH less than 2.0) or extremely alkaline (pH greater than 12.5) solution. Reactive hazardous wastes are (40 CFR 261.23) those wastes exhibiting one or more of the following:

- It is normally unstable and readily undergoes violent nondetonative change
- It reacts violently with water
- It forms potentially explosive mixtures with water
- It liberates toxic gases when mixed with water
- It is a cyanide- or sulfide-bearing material, which, when exposed to pH conditions between 2.0 and 12.5, liberates toxic gases in amounts sufficient to be a danger to human health or the environment.
- It is detonatable or explosively reactive when subjected to a strong initiating source or to heat while confined
- It is readily capable of detonation or explosive decomposition under ambient conditions
- It is a Forbidden Explosive (49 CFR 173.51), a Class A Explosive (49 CFR 173.53) or a Class B Explosive (49 CFR 173.88).

Extraction Procedure Toxicity is (40 CFR 261.24) a 24-hour extraction process run at pH = 5.0; the leachate (liquid) is then chemically examined for the presence of metals.

While the regulations are structurally very different, the hazardous waste criteria have close analogs in the USDOT hazardous materials criteria. Waste materials with properties satisfying the definition of some other hazard class should be shipped according the standard of, and classified as, that class rather than the ORM-E class. There is one ORM-E material among the 100 Hazardous Commodities.

C. CLASSIFICATION OF HAZARDOUS MATERIALS

Commodities that display the attributes of two or more hazard classes present a significant problem to the classification scheme since the scheme implicitly assumes that a commodity can have only one class. Part 173.2 resolves this problem by providing a ranked list of hazard classes:

(1) Radioactive material (except limited quantities)
(2) Poison A
(3) Flammable gas
(4) Non-flammable gas
(5) Flammable liquid
(6) Oxidizing material
(7) Flammable solid
(8) Corrosive material (liquid)
(9) Poison B
(10) Corrosive material (solid)
(11) Irritating materials
(12) Combustible liquids (in containers of at least 110 gallons capacity
(13) ORM-B materials
(14) ORM-A materials
(15) Combustible liquids (in containers smaller than 110 gallons capacity)
(16) ORM-E

Exceptions to this list include:

(1) Materials specifically identified in The Table by a "+" in column 1 (c.f. 49 CFR 172.101(b)(4))
(2) explosives (c.f. 49 CFR 173.86 and 173.114a)
(3) etiological agents (c.f. 49 CFR 173.386)
(4) organic peroxides (c.f. the Hazardous Materials Table and 49 CFR 173.151a)

Of the several hazards displayed by an unlisted material, the one associated with the hazard class highest in the ranked list determines the hazard class of the material if not subject to the exemptions. The hazard class, in turn, determines which containers are authorized, whether special markings are required on the shipping papers, and what placard is to be attached to the rail car.

For materials listed in the Table, and for materials that may be identified by prefixing a Table listing with the word "Waste," the hazard class is assigned from an associated Table listing - when the correct shipping name has been selected. For materials identified by hazard-class shipping names (based on testing for hazards) the test outcomes and hazard class definitions govern the shipping name selection and hazard classification. If such materials display properties meeting the criteria of two or more hazard classes, the hazard class is first designated from the preference table, and then a generic shipping name is selected from the Table. A careful search of the Hazardous Materials Table is required to find an appropriate generic shipping name reflecting two of the material's hazards. Except for multi-hazard materials not listed in the Table, selection of the proper shipping name effectively classifies the material. For most listed materials, the associated hazard class is harmonious with the preference table.

The order of hazards in the preference table may be, in some instances, open to possible criticism. On balance it must be recognized that the most serious hazards, radioactive materials and most toxic materials fall at the top of list and the least serious hazards, ORM's, fall at the bottom. The relative positions of other hazards are reasonable in the absence of the years of experience justifying their relative positions. Data will be developed in Chapter IV which supports the order of most of the preference table on the basis of operational losses. This is not the only basis for developing such a table, however. While some hierarchical classification scheme might have some initial appeal as a regulatory mechanism, there are some pitfalls that should be examined. First, any hierarchical system has to assume that hazards can be graded in severity of hazard. While it is commonly accepted that

POISON A materials are more threatening than an ORM-A material, other combinations are more difficult to deal with. These more difficult comparisons are judgement calls, and the underlying issues are:

(1) The basis for the relative order, and

(2) the assumption that there must be a hierarchy.

As a practical matter, the order of hazard severity is accident-scene dependent for most hazard classes.

Note that the hierarchical classification scheme plays a significant role in the process of container selection in the current regulations.

D. RECOGNITION OF HAZARDOUS MATERIALS

That a commodity has been identified and classified as an hazardous material must be communicated to numerous people associated with the bulk rail shipment of the material, including those who:

- select shipping containers
- load and unload hazardous material
- perform pickup point switching operations
- assemble rail cars into trains
- accompany trains over the road
- operate classification yards
- perform point-of-delivery switching operations
- perform train inspections at various points in the transportation process
- control and clean up accident scenes involving hazardous materials

This is a diversified group of people with a broad range of informational needs.

Communication of the identification and classification information so that various people recognize the presented hazards is accomplished by two broad groups of requirements: on-container identification and shipping paper notations.

1. On-Container Hazard Recognition

Hazardous materials must be properly marked, labeled and placarded prior to shipment. These requirements are summarized here.

a. Marking

There are two forms of marking: on-container display of the four-digit indentification number (required for all shipments), and display of the proper shipping name or authorized common name (required for designated commodities).

Proper marking of packages, freight containers and rail cars normally is the duty of the shipper (49 CFR 172.300(a)). It appears, however, that the carrier may also exercise this duty (49 CFR 172.300(b)), and this may be very desirable for the marking of rail cars containing less-than-carload shipments not loaded by the shipper. The carrier is responsible for replacing lost or destroyed markings and placards (49 CFR 172.338).

There are two approved forms, panels and placards, for displaying the four-digit identification number from the Table. The panel form is orange, 6 1/4 inches high by 15 3/4 inches wide, with a 9/16 inch black border. The identification number shall be displayed in 4-inch black Helvetica Medium numerals on the orange field.

The placard form for displaying identification numbers has the traditional diamond (square-on-point) shape, 10 3/4 inches along each edge. The four-digit identification number shall be 3 1/2 inch black Alpine Gothic or Alternate Gothic No. 3 on a 4 inch high by 8 1/2 inch wide white field across the center of the diamond. The resulting triangle at the bottom must contain the one-digit United Nations hazard class number as (49 CFR 172.519) a 1 3/4 inch black character except: (1) when on a flammable or non-flammable gas placard or a flammable or combustible placard the character may be white or black; (2) the class number on a CORROSIVE placard must be white; (3) on a COMBUSTIBLE placard with a white lower triangle the class number shall be red or black. Identification number placards may be fabricated by fastening the identification number over a hazard class placard (described below) provided it substantially obscures the hazard lettering (49 CFR 172.332 (c)(6)). The resulting applique-type placard presumably should visually meet the placard style identification number standards.

The required markings may be removed only if (1) the tank is filled with a commodity not subject to the DOT Regulations or (2) the hazard is removed by cleaning and purging.

Tank cars carrying certain commodities, designated in 49CFR 173, must be marked (49 CFR 172.330(a), (b)) on both sides with the proper shipping name or authorized common name using letters at least four inches high on both sides of the car.

Multi-unit tank car tanks must be marked (49 CFR 172.330(c)) with two-inch lettering on two opposing sides with the proper shipping name (or authorized common name) and associated identification number. The transporting rail car must be marked on both sides and both ends with the identification number. Tanks containing chlorine need not show the CHLORINE label prescribed here if Part 172.405(b) (authorized label modifications) is complied with.

There are several issues concerning the use of four-digit numbers to identify hazardous materials. First, the numbers are not always unique. One identification number, 1993, identifies more than a dozen commodities as diverse as liquid wax, refrigerating machines, and ethyl nitrate. In another instance, air may be identified by either 1002 or 1003.

Second, there is no large-scale system associated with the numbers, although there is some short-range system, and undoubtedly there was some structure to the list when first introduced. By contrast, the seven-digit STCC number [2] used by AAR to identify commodities is highly systematic and has the additional advantage that the basis for systemization is the nature of the hazards associated with shipping the material.

Third, the range of numbers used is so large, and the list of associated comodity names so extensive that the number does not identify the material but rather identifies a line in a table that contains the name(s) of the material(s) identified. That is, the material can not be identified without the aid of a table unless the individual is familiar with the particular identification number. The STCC number suffers from the same problem, but knowledge of the systematic numbering scheme does permit identification of associated hazards.

b. Labeling

Where required in the Table, column 4, the shipper shall properly label packages, overpacks and freight containers (49 CFR 172.400). The sizes of these containers may be as small as pint bottles, large enough to hold hundreds of gallons of liquid, or any required size in between; rail tank cars are explicitly excluded. There are two label formats: diamond (square-on-point) and square or rectangular. The diamond format must be at least 4 inches along the edge and comply with content, color, and other fabrication standards. A text description of the hazard represented by the label lies astride or just below the midline connecting the two side points, with a pictorial description of the hazard above the lettering. Coloration further distinguishes the various labels, some of which use three or four colors. There are diamond labels for all the hazard classes and subclasses except etiological agents, which is rectangular. In addition there is a DANGEROUS WHEN WET diamond label, two rectangular warning labels (MAGNETIZED MATERIAL and CARGO AIRCRAFT ONLY) and one square warning label (EMPTY). Subject to size and color restrictions, a label may contain the UN and IMO hazard class number and, if appropriate, IMO division number (discussed in Chapter V). The MAGNETIZED MATERIAL and CARGO AIRCRAFT ONLY labels apply only to shipments by aircraft. There are circumstances for which labeling is not required.

There are provisions for multiple labeling on a package (49 CFR 172.402), for authorized label modifications (49 CFR 172.405), for mixed and consolidated packaging (49 CFR 172.404), and for the proper labeling of radioactive materials (49 CFR 172.403).

c. Placarding

Shippers and carriers both have the duty of complying with the placarding standards (49 CFR 172.500(a)). Etiological agents, ORM-hazards, and materials shipped under Limited Quantities standards of the DOT Regulations are exempt from placarding requirements (49 CFR 172.500(b)).

1) General Placarding Requirements

Freight containers and rail cars containing any quantity of a hazardous material must (49 CFR 172.504(a)) be placarded on each side and each end with the placards specified in Table III-5, General Placarding Guides (summarized from 49 CFR 172.504). The table indicates the placards to be displayed on rail cars containing commodities of the listed hazard classes, subject to some exceptions.

Shippers may not offer, and carriers shall not accept, a rail car containing hazardous cargo for transportation unless the placards required by the DOT Regulations are affixed (49 CFR 172.508).

2) Special Placarding Standards

EXPLOSIVE A, POISON GAS, and POISON GAS-EMPTY placards on rail cars must (49 CFR 172.510(a)) be placed on a black-bordered white background as described in 49 CFR 172.527.

Each domed tank car containing a flammable liquid having a vapor pressure in excess of 16 p.s.i. at 100°F must (49 CFR 172.510(b)) have a DOME placard (49 CFR 173.119(h)) affixed adjacent to the dome where it will be seen during loading and unloading operations.

When a tank car has been emptied of its hazardous cargo, an EMPTY placard corresponding to the placard required for the lading must be placed on the car (49 CFR 172.510(c)) unless the tank car

- contained a combustible liquid
- has been reloaded with a material not subject to DOT Regulations
- has been sufficiently cleaned of residue and purged of vapor to remove any potential hazard.

An EMPTY placard is identical to the placard it replaces except that the pictorial representation of the hazard class in the upper triangle is replaced by a black triangle marked EMPTY in white lettering (49 CFR 172.525). The EMPTY placard presumably can be fabricted as such, or by attachment of a suitable triangular applique to the original placard. An EMPTY placard must be attached when the most recently removed cargo required one of the following placards: NON-FLAMMABLE GAS, OXYGEN, FLAMMABLE GAS, CHLORINE, POISON GAS, FLAMMABLE or its GASOLINE variant, FLAMMABLE SOLID, FLAMMABLE SOLID W (hazardous when wet), OXIDIZER, ORGANIC PEROXIDE, POISON, and CORROSIVE.

The OHMT requires, effective October 1, 1986, (49 CFR 172.510) that EMPTY placards be replaced with RESIDUE placards. Further the RESIDUE mark, white lettering on a black field, must appear in the lower placard triangle rather than in the upper triangular location required for the EMPTY mark where it does not cover the hazard class pictorial information. Other regulatory changes were made to reflect this change. The OHMT has also adopted Rule 35 of the Uniform Freight Classification Tariff which defines an empty tank car as one containing not more than 3 percent of the weight of the car's last loaded movement; the term was previously undefined.

A FUMIGATION placard must (49 CFR 172.510(d)) be attached to or near each door of a freight container or rail car that has been fumigated or treated with a poisonous solid, liquid, or gas prior to shipment. Fumigation of agricultural products to control pests or improve produce merchantability are two examples of fumigation practices.

3) Freight Containers, Cargo Tanks, and Portable Tanks

Container on flat car (COFC) freight containers with a capacity of at least 640 cubic feet (a standard ten-foot container) must be placarded according to the hazard class of the contained material (49 CFR 172.512(a)). However, it appears that if the freight container, and any other container on the rail car, or a trailer on flat car (TOFC)-service container, contains less than 1000 pounds of a material not in the Explosive, Radioactive, or Flammable Solid classes, no placard is required (49 CFR 172.504(c)(2)). Containers of lesser size containing hazardous materials must comply with the labeling requirements rather than placarding standards.

Cargo tanks and portable tanks of 1000 gallons or more rated capacity containing a hazardous material must be placarded (49 CFR 172.514(a)); smaller tanks so loaded need not be placarded if they are labeled in compliance with 49 CFR 172.406(e)(4). Emptied tanks shall remain placarded unless refilled with a material not subject to the Regulations or until cleaned and purged to remove any potential hazard.

4) Hazard Recognition from Placards

The regulatory classification identifies a hazard associated with each regulated material. In the case of commodities exhibiting several hazards the hierarchical scheme (49 CFR 173.2) provides a 'designated primary hazard' that serves to classify the material into a particular class, and provide placarding standards, container selection standards, etc., for any other commodity. With the exception of a few materials which must be shipped with a POISON placard as well as another placard, the 'designated primary hazard' classification requires only one placard. Thus for most materials only one hazard can be recognized from the container or shipping papers unless other supporting information is at hand. Chapter IV shows that most high-tonnage-rail-shipped materials exhibit at least two hazards and that most of these are shipped with only one placard and without the display of the proper shipping name on the rail car. The net effect of the hierarchy is to limit possible recognition of all of the hazards associated with a cargo.

It is interesting to compare the placarding standards for large containers with the parallel labeling requirements for small containers. Multiple labels are required much more frequently for small quantities of a material than are multiple placards for bulk shipment of the material. In most instances the second label required for small-quantity shipments is the POISON label; a POISON placard is the one most frequently found in pairs of placards, though not nearly as frequently as in the small-package labeling counterpart.

2. Shipping Papers

Shippers offering hazardous materials, including hazardous wastes, for transportation must prepare shipping papers describing the hazardous material (49 CFR 172.200(a)). Carriers may not accept for transportation any hazardous materials subject to the DOT Regulations unless a properly prepared shipping paper to accompany the shipment is also received (49 CFR 174.24(a)). Also required from the shipper is a written certification that the goods are properly described, classified, packaged, marked, labeled, and in proper condition for transportation (49 CFR 172.204).

a. Required Information

Shipping papers that accompany a hazardous materials cargo must contain several pieces of information (49 CFR 172.202) including:

- the proper shipping name for the hazardous material as prescribed by the Table
- the hazard class of the hazardous material
- the six-character identification number associated with the hazardous material in the Table
- the total quantity of hazardous material as described on the shipping paper
- placard endorsement near the car number (49 CFR 174.25(a)(2))
- placard notation when the initial movement is a switching operation (49 CFR 174.25(b)(3).

The first three pieces of information must appear together in the order above as part of the description of the shipment (49 CFR 172.202(b)). The name of the placard required for the rail car shall appear on the waybill in a suitably annotated place (49 CFR 172.203(g)(1)).

The entry describing a hazardous material must be identified by either "X" or "RQ" entered in a column captioned "HM"; the letters "RQ" must, in any event, appear (49 CFR 172.203(c)(2)) as part of the description of hazardous material. If the proper shipping name for a hazardous material that is a mixture or a solution does not identify the components which make the material hazardous, the names of such components must be entered (49 CFR 172.203(c)(1)) on the shipping papers; these component names shall be as found in the Table. There are additional provisions (49 CFR 172.203(d)) for radioactive materials. There are several additional, more specific regulations (49 CFR 172.203(g),(j), and (k)).

The USEPA hazardous waste manifest (40 CFR 262) must be complied with (49 CFR 172.205); the manifest may be used as the shipping paper provided all the requirements of the DOT Regulations are satisfied (49 CFR 172.205(h)).

b. Proper Shipping Names

The central element in the implementation of the hazardous materials regulations is the selection of the proper shipping name for the material. The entries in the proper shipping name column of the Table fulfill the following functions.

- properly identifies the commodity
- identifies the hazard class
- identifies the associated 6-character Identification Number (if any)
- identifies (through other parts of the DOT Regulations) markings, labels, placards, and proper shipping containers of various sizes for each mode of transportation

As indicated above, the proper shipping name found in column 2 of the Table is used on the shipping paper; 49 CFR 172.101(c) prescribes how the information there shall be used, as well as authorized modifications to the proper shipping name. The authorized modifications described there include the insertion of the word "waste" in describing hazardous wastes, the proper naming of mixtures involving both hazardous and nonhazardous materials, and commodities for which there is no Table entry. The last is really guidance to generic entries in the Table; and is discussed below.

The proper shipping name should not be confused by a similar set of names, the Standard Transportation Commodity Code (STCC) names[2]. The STCC names, and their associated seven-digit identification numbers, are supported by AAR and, presumably, by the constituent member railroads, and presumably are used in commercial transactions. The 100 Hazardous Commodities list in Chapter II is based, in part, on lists of hazardous commodities supplied by AAR. The lists supplied by AAR, and the list of 100 Hazardous Commodities in Chapter II are based on STCC names. The Commodity Sheets, used in Chapter IV to develop hazard profiles, and found in Appendix B, show both the STCC name and the proper shipping name for each material.

In general, STCC names for single-constituent materials are the same as the proper shipping name and differences, if any, reveal additional clarity in the STCC name that probably is of commercial significance. For example, "Ammonium Nitrate Fertilizer, less than 0.2% Carbon," must be identified on the shipping paper as "Ammonium Nitrate Fertilizer." On the other hand "Octyl Alcohol, Perfumery Grade" and "Octyl Alcohol, Other Than Perfumery Grade" must both be identified in the shipping paper as "Alcohol, N.O.S." The differences between the two grades of octyl alcohol are commercially significant to the cosmetics and manufacturing industries. The proper shipping name "Alcohol, N.O.S." is one of a group of generic names found in both the Table and the list of STCC names. There are several generic commodities among the 100 Hazardous Materials.

The regulations clearly reveal (49 CFR 172.101(c)(13)(ii)) the utility of the generic commodities: they provide a way to classify commodities that are not listed by a technical name. New materials and products, for example, won't be identified by anything but a generic name because of their newness. There are hazardous materials constantly being developed that are new to commercial transportation; the generic shipping name provides a mechanism for making the regulations adaptive.

c. Selection of a Proper Shipping Name

Selection of a correct proper shipping name is the heart of the regulatory strategy. Once a proper shipping name is determined, the hazard class, markings, labels, placards, shipping containers, and a variety of other standards are established for the cargo.

Because of the critical nature of the outcomes of the selection process, examination of the pertinent regulations is imperative. The regulatory guidance for this procedure is contained in 49 CFR 172.101 (c)(13), embedded in the description of the Hazardous Materials Table. This passage indicates that there are different kinds of proper shipping names, and that some are more appropriate than (preferred to) other kinds. A "+" designator in column 1 fixes the proper shipping name and hazard class (49 CFR 172.101 (b)(1)). The most appropriately descriptive proper shipping name is to be selected, presumably guided by the indicated hierarchy.

With this guidance it is possible to develop a formal scheme for extracting a proper shipping name from the Hazardous Materials

Table. Such a scheme, in flowchart form, is shown in Figure III-1. This scheme embodies the preferential nature of proper shipping names but does not necessarily lead to the most preferred. For example, Compressed Gas, N.O.S. shipped with a FLAMMABLE placard appears to be acceptable. The entry for Flammable Gas is associated with the preferential "+" designator and directs the user to the Compressed gas entry mentioned. The purpose for this inconsistency is unclear as is the resolution the user must make. This and similar regulatory problems can be resolved and compliance strengthened by more formally enforcing the hierarchical preferences among proper shipping names.

For this purpose four classes of proper shipping names are designated:

- explosives names
- technical names
- commodity names
- hazard names

Those names grouped under explosives are just those materials that meet the current regulatory criteria for explosives and are shipped with an EXPLOSIVES placard or label. Because these materials do not exhibit properties of other hazard classes to any significant extent, and because most shippers of these materials are not shippers of other hazardous materials, it is convenient to separate this group of names, thereby simplifying for most users the name selection scheme proposed below.

Technical names are those names such as cyclopropane, potassium hydrogen sulfate, and sulfur dioxide which identify individual, essentially pure individual materials whose properties and behavior are well known and understood. Also included in this group are a number of mixtures that are commerically well known, such as cutback asphalt, liquefied petroleum gas, petroleum crude oil, petroleum naphtha, and tankage fertilizer. Such materials are not pure materials but rather are mixtures of variable, usually indefinite composition. They are well known commodities of commerce bought and sold on the basis of one or a few

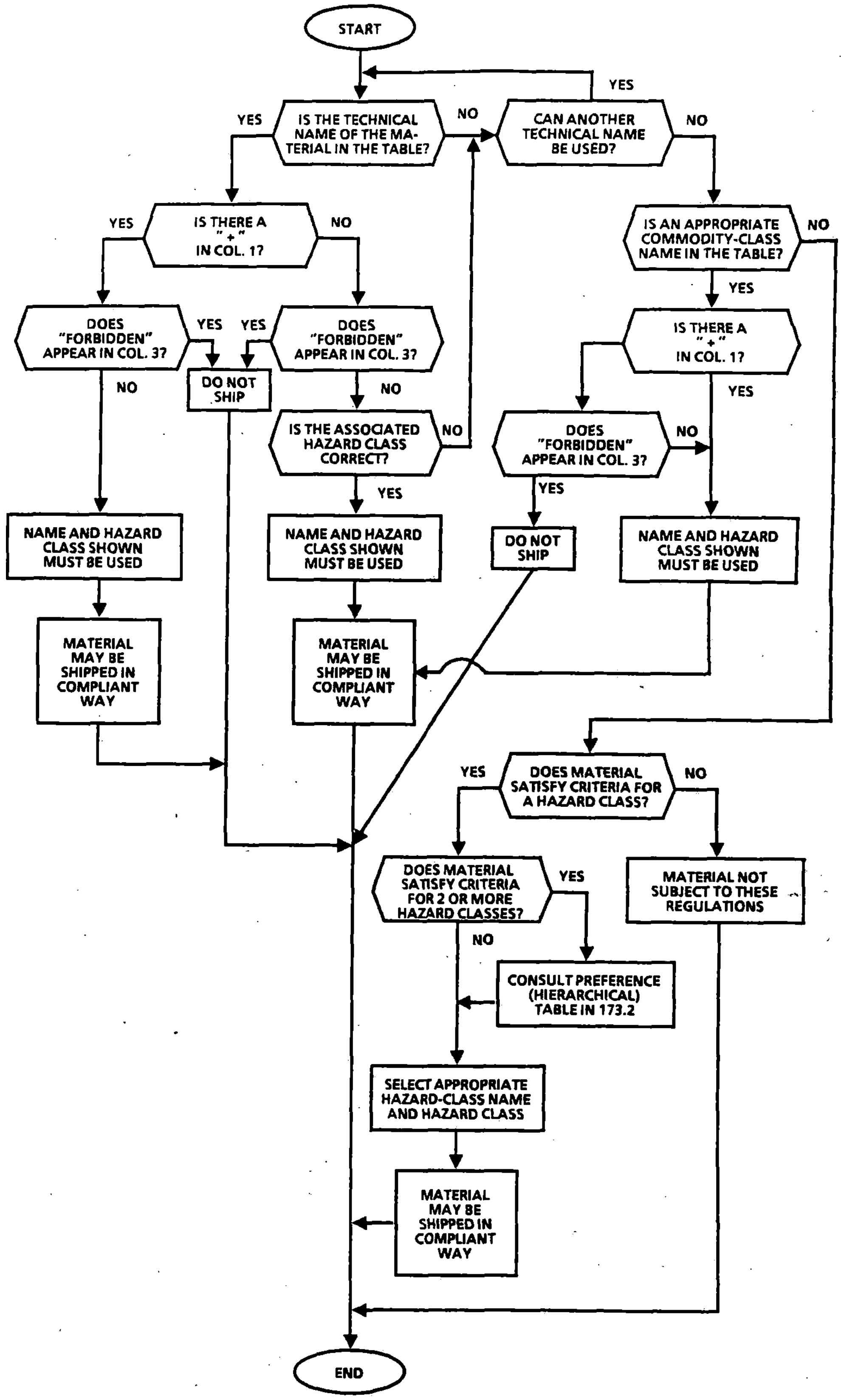

Figure III-1. Procedure for Selecting a Proper Shipping Name important, fairly constant physical or chemical properties such as solvent properties or boiling temperature. As such, refinement of knowledge of the composition and properties of such materials would not significantly improve either merchantability or hazard characterization but would increase the selling price of the goods. That is, they are suitably identified for shipment, and refinement of the identification would produce no improvement in the recognition of associated hazards.

Commodity-class names are those proper shipping names which identify materials by their intended or primary end use rather than their composition. Examples include: COSMETICS, N.O.S.; DISINFECTANT, LIQUID, N.O.S.; MEDICINES, N.O.S.; and MOTOR FUEL, N.O.S. Such names are generic in nature but offer some insights into the hazards presented in handling during loading and spill cleanup. They are generic in the sense that there is not a distinctive hazard class associated with the material. COSMETICS, N.O.S. may be a combustible liquid, a flammable liquid, a flammable solid, an oxidizer, or a corrosive material. Recognition of the associated hazard depends on seeing packaging labels or shipping papers. The shipping name might be refined to reflect the hazard class, but would be of no consequence unless other avenues of communication are strengthened as well.

Hazard-class names are those proper shipping names which are derived from the names of the hazard classes. There is an extensive group of these in the Table, and many of these, such as Flammable Corrosive Solid, N.O.S., reflect multiple hazards. Presence of such names in the Table represents a commendably suitable regulatory mechanism for authorized compliant entry of new materials into commerce.

These classes of proper shipping names are not intended to be absolute, but serve to illustrate the proposed process. There are instances where it is desirable to intentionally violate this name classification scheme.

An hierarchical search of proper shipping name lists can then be required, as shown in Figure III-2. This approach serves to simplify and greatly enhance success in selection of the most appropriate

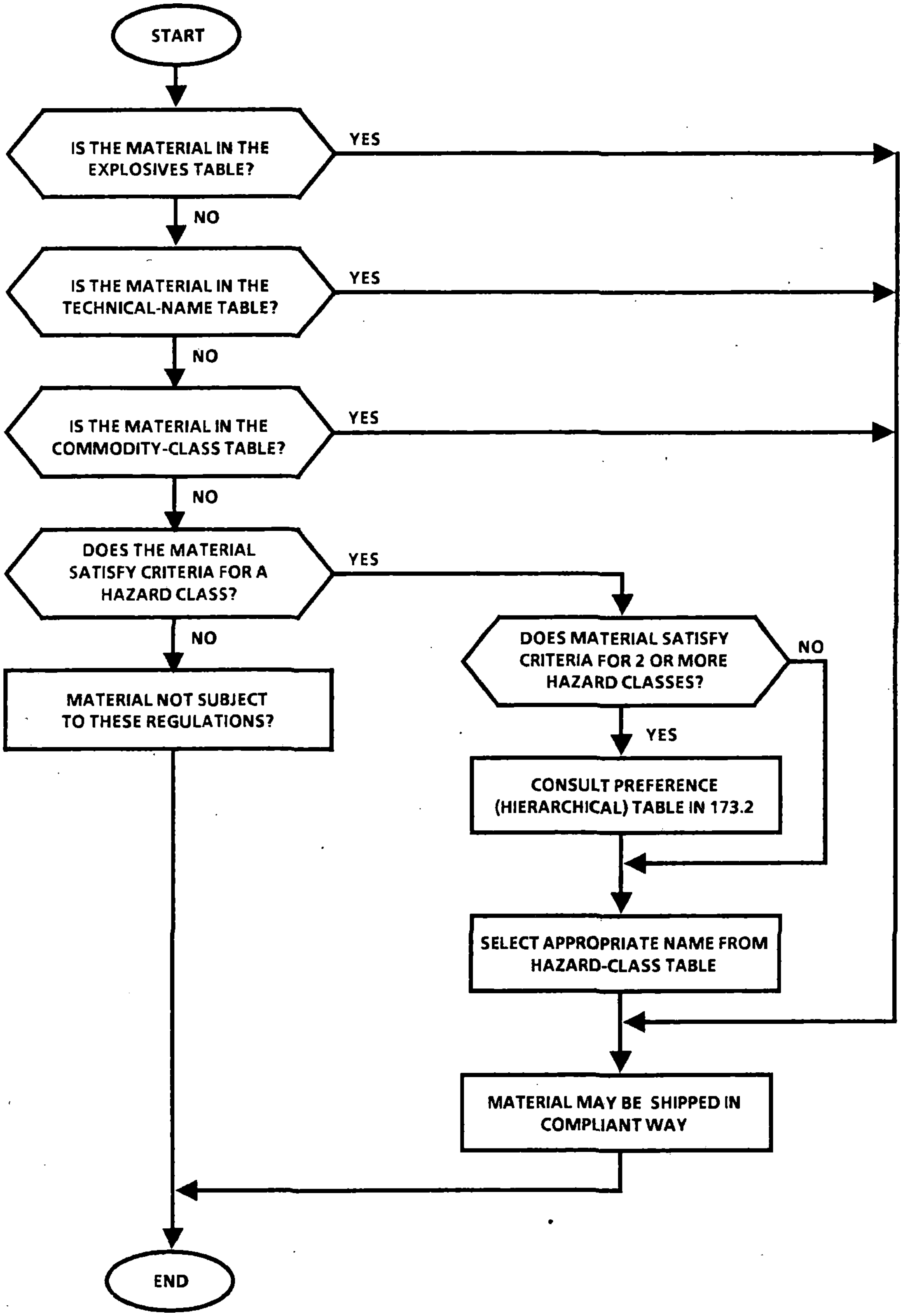

Figure III-2. Proposed Alternative Scheme for Selection of a Proper Shipping Name Using Subtables proper shipping name. Where specific problems arise (usually between commodity-class names and hazard-class names), inter-table cross referencing relieves ambiguity.

While the proper shipping name for a hazardous material is not displayed on a rail car, it does appear in the shipping papers. The most descriptive, informative name should appear there for greatest value at the time of an accident. Application of the name directly to the rail car would be even more useful at an accident scene, especially immediately after an accident.

d. Hazard Recognition from Shipping Papers

All of the regulatory information about hazardous materials is contained in the shipping papers so that defects in information available directly mirrors the shortfalls in the regulations discussed elsewhere and thus are not subject to further criticism. The shipping papers are the heart of the regulatory process and communication of hazard information.

There is some concern, however, about making the shipping papers the central repository for all the hazard information in a railroad environment. The typical modern long-haul freight train is a mile or more long. In the event of a derailment, the duty of the crew is to notify the dispatcher and to move the locomotive and any movable rolling stock a safe distance (say one mile) up the track. The shipping papers, in the hands of the conductor, are traditionally in the caboose which is even further from the locomotive than the derailed cars. On those roads and divisions where the caboose is no longer attached to the train the conductor and shipping papers are aboard the locomotive. In either instance they are some distance from any wreckage that may have to be dealt with by early responders, and therefore there may be some delay in getting shipping paper information into the hands of early responders in a timely fashion. The severity of this drawback in rail transportation is not clear and should warrant consideration. It is support for improved on-container hazard recognition information, and is support for current on-container information practices.

E. OPERATING STANDARDS

There are additional requirements pertaining to hazardous materials of a general operational nature and not necessarily associated with preparing a particular commodity or class of hazardous materials for shipment. These derivative regulations are summarized below.

1. Rail Car Inspection

There are four principal passages pertaining to the inspection of railcars: tank cars; rail cars for explosives; rail cars for radioactive materials; and general requirements.

2. Loading and Unloading Provisions

Loading of fluids into tank cars must comply with ullage requirements; such provisions are found among the general or specific packaging requirements (49 CFR 173) for the materials. Compressed gas loading standards are stated in terms of filling densities; these are fractions or percentages of the water weight capacity (49 CFR 173.314(c)). Filling requirements for butadiene and liquified petroleum gas must follow seasonal requirements (49 CFR 173.315(b)). Liquids must have adequate vapor space for expansion.

3. Consist and Movement Standards

There are a number of regulations pertaining to the assembly of rail cars into trains and the handling of trains and loaded rail cars. These are summarized below in terms of switching and consist standards.

a. Switching Standards

Figure III-3 summarizes the required and forbidden switching operations (49 CFR 174.83, .84, and .85) for various car operation combinations. Placarded cars involved in switching operations that require the use of the handbrakes must be subjected to a handbrake check beforehand. Switching oeprations involving placarded tank cars and the use of handbrakes on ladder tracks (e.g. team tracks and small yards) have additional requirements. There are very few forbidden car-operation combinations. Movements of hazardous materials must be expedited (49 CFR 174.14).

SWITCHING OPERATION	SECTION OF PART 174	CAR: PLACARDED CAR OR DRAFT WITH A PLACARDED CAR	CAR: PLACARDED TANK CAR OR DRAFT WITH A PLACARDED TANK CAR	CAR: CAR PLACARDED EXPLOSIVES A	CAR: CAR PLACARDED POISON GAS	CAR: DOT-113 CLASS TANK CAR PLACARDED FLAMMABLE GAS	CAR: PLACARDED FLAT CAR OR FLAT CAR WITH PLACARDED CARGO
OCCUPYING A LADDER TRACK ALONE*	83		R				
CLEARING A LADDER TRACK BEFORE NEXT CUTOFF*	83		R				
HANDBRAKE CHECK BEFORE OPERATION*	83	R	R				
CAR NEXT TO ENGINE DURING SWITCHING OPERATIONS	83			F			
COUPLING WITH EXCESS FORCE	83,84			F	F	F	F
CUTTING OFF WHILE IN MOTION	83,84			F	F	F	F
PLACED IN DANGER OF FIRE	85			F			
PLACED UNDER BRIDGE OR HIGHWAY CROSSING	85			F			
PLACED IN/NEXT TO PASSENGER SHED OR STATION	85			F			
STRIKING WITH CAR MOVING UNDER ITS OWN MOMENTUM	83,84			F	F	F	F

F = OPERATION FORBIDDEN WITH THAT CAR
R = OPERATION REQUIRED WITH THAT CAR
* = FOR SWITCHING USING HAND BRAKES ONLY

Figure III-3. Switching Standards for Hazardous Material

b. Consist Standards

Figure III-4 broadly summarizes the regulations pertaining to the placement of placarded cars in trains (49 CFR 174.86 to 174.93); the regulations provide more detail. In Figure III-4 "F" means that the placarded car-train location is forbidden; "P" means that the combination is permitted; "PT" signifies a forbidden combination involving tank cars but permitted for other cars; "R" indicates a required combination; and "T" forbids combinations involving placarded tank cars. Placarded cars in Figure III-4 means loaded placarded cars except for the two "empty" columns. The regulations are unclear on this matter and inclusion of empty cars among the loaded placarded cars would lead to inconsistencies in the regulations. Placarded cars are forbidden in passenger trains but may be included in mixed (passenger and freight combined) trains to destinations where there is no freight service (49 CFR 174.87). Occupied revenue cars in Figure III-4 include passenger-carrying cars and attended-cargo freight cars. Ignition sources in that figure include operating heating or refrigeration equipment, operating internal combustion engines and various comfort and safety equipment such as stoves, heaters and lanterns.

4. Other Requirements

There are a number of additional operating standards and these are summarized here.

At each terminal where trains are assembled by yard crews, the carrier must (49 CFR 174.26(a)) prepare consecutively-numbered notices showing the location in each train of cars carrying EXPLOSIVES A or POISON GAS placards. A copy of each notice must be delivered to the train crew, and a copy showing delivery must be kept on file by the carrier at each point where the notice is issued. The notice must be transferred at crew-change points.

For all other cars carrying placards, the crew must (49 CFR 174.26(b)) have a consist or other document showing the train location of each placarded car when the train is accepted by the crew. Location changes, including additions, made by the crew need not appear in the document.

LOCATION OF CAR IN TRAIN	SECTION OF PART 174 (49 CFR)	CAR WITH PLACARD READING								
		EXPLOSIVES A	POISON GAS	RADIOACTIVE	FLAMMABLE	COMBUSTIBLE	COMBUSTIBLE (TANK CAR)	ALL OTHER LOADED AND PLACARDED RAIL CARS	EMPTY (TANK CAR-LAST CONTAINED A COMBUSTIBLE)	EMPTY (ALL OTHER TANK CARS)
NEXT TO ENGINE, CABOOSE, OR OCCUPIED REVENUE CAR	87,92	F	F	F	F	F	P	F	P	F
NEXT TO CAR PLACARDED EXPLOSIVES A	90,92	P	F	F	F	P	P	F		
NEXT TO CAR PLACARDED POISON GAS	90,92	F	P	F	F	P	P	F		
NEXT TO CAR PLACARDED RADIOACTIVE	89,92	F	F	P	F	P	P	F		
LESS THAN SIXTH CAR FROM ENGINE, CABOOSE, OR PASSENGER CAR	88,91	F	T	T	T	T	P	T		
NEXT TO CAR WITH OPERATING IGNITION SOURCE	90	F	F	T	T	T	T	T		
NEXT TO OPEN-TOP CAR WHERE LOAD PROTUDES, OR MAY SHIFT, BEYOND END OF CAR	90	F	F							
NEXT TO AND AHEAD OF CAR WITH GUARDS OR ESCORTS	86	R	R							
FOURTH CAR AHEAD OF CAR WITH GUARDS OR ESCORTS AND EQUIPPED WITH A LIGHTED HEATER OR STOVE	86	R	R							
NEXT TO A LOADED FLAT CAR	90	F	F							
NEXT TO A LOADED FLAT CAR IN COFC/TOFC SERVICE	92	T	T	T	T	T	P	T		

F = FORBIDDEN LOCATION FOR PLACARDED CAR
P = PERMITTED LOCATION FOR PLACARDED CAR
R = REQUIRED LOCATION FOR PLACARDED CAR
T = FORBIDDEN LOCATION FOR PLACARDED TANK CAR ONLY

Figure III-4. Consist Standards for Hazardous Materials

A copy of the properly-completed shipping papers for shipments of hazardous materials in the train (described above) must (49 CFR 174.26(c)) be in the possession of the crew.

F. PENDING REGULATORY CHANGES

The recent massive release of methyl isocyanate in India has prompted the Office of Hazardous Materials Transportation to publish a Notice of Proposed Rulemaking (NPRM)[3]. The proposed changes pertain to volatile liquids with toxic vapors. Specifically, for liquids with a vapor concentration at 68°F that is at least ten times the inhalation LC_{50} toxicity value, and that vapor concentration value is 1000 parts per million (ppm) or less, the following will be required:

- The shipping paper shall bear the words "Poison-Inhalation Hazard" in association with the proper shipping name.
- Rail cars and other freight containers must carry POISON placards on both sides and both ends.

The LC_{50} inhalation toxicity value is determined using the methodology described above for Poison B materials. Note that this standard does not change the hazard classification of the material (methyl isocyanate is classified as a flammable liquid, for example) but it does require the container to be double-placarded.

G. SUMMARY OF REGULATORY REQUIREMENTS

Underlying the scheme for the classification of hazardous materials are the definitions of the hazards. Several of these definitions could be improved, most notably those for toxic, noxious, and irritating materials. The sources of difficulty in defining these hazards are several-fold. First, the nonlethal, incapacitating aspects of toxicity in materials has been neglected, no doubt because these are poorly defined and quantified in the concentration ranges of importance at an accident scene. Second, the regulations are ambiguous about whether minimum lethal dose or route of entry into the body is the important criterion, and this results in ambiguities in the definitions. Both of these factors are important and their roles in the regulatory process need to be examined and clarified.

The classification of a hazardous material is determined by the hazard definition satisfied. When two or more hazard criteria are satisfied, reference is made to a hierarchical preference table to obtain the classification. The classification then determines authorized containers, required placard, etc. Since the vast majority of these hazardous materials are shipped with placards appropriate for only one hazard class, that class effectively becomes the 'designated primary hazard.'

As a practical matter materials that can be specifically identified by their proper shipping name in the Hazardous Materials Table have been classified by the regulations and little is left to chance -- except nonprimary hazards. Where the proper shipping name for a material is determined by the end use or hazards presented, knowledge of the hazards presented and hierarchy of hazards must guide the selection of a proper shipping name. The selection of a best proper shipping name must also recognize the notion that some proper shipping names are more descriptive than others. This hierarchy of descriptiveness in the proper shipping name is a valuable one, is not well prescribed in the regulations, and could be enforced by building the hierarchy into the Hazardous Materials Table.

The recognition of the hazards of regulated materials may be obtained from on-container information or from shipping papers. The shipping papers identify all the aspects of a hazardous cargo that are developed by the regulation. For most cargoes the on-container information includes a four-digit identifying number (one of several thousand) and a placard. Adequate identification of the cargo requires a table indexing proper shipping names to the numbers. Further information is required to determine whether there are any hazards in addition to the 'designated primary hazards.' Timely availability of information from shipping papers to early responders at an accident scene may be a problem, that could be alleviated by stronger on-container information regulations.

CHAPTER IV
TECHNICAL ANALYSIS

In this chapter use will be made of the technical information available about hazardous materials, together with hazardous materials accident experience, to determine the adequacy of the regulations in identifying the dangers associated with hazardous materials in rail transportation.

A. ANALYTICAL TOOLS, OBJECTIVES AND PROCEDURES

The tools used to assess the adequacy, applicability and utility of the DOT Regulations include an automated set of accident data from the USDOT Office of Hazardous Materials Transportation (OHMT) and a set of Commodity Sheets (and supporting data), one for each of the materials identified in Chapter II.

1. Accident Data

The automated data set of accident information obtained from OHMT contained reports of rail accidents involving hazardous materials between mid-1973 and late 1984. In addition to accident date and location, consignor, consignee and carrier information, each record contains information about the container, commodity involved, accident results, injuries and deaths, losses (dollars) and coded information described below. Of the 1488 records in the file, 89 pertained to small containers and were not included in the analyses. Eighty-eight of the remaining records pertained to "HOPPER R" containers, presumably hopper cars and bulk COFC containers suitable for dry materials. The remaining 1311 records pertained to tank cars of one sort or another.

While it may be desirable to compare accident data on a commodity basis for each of the 100 materials identified in Chapter II, there are several reasons why this will not be done. Not all the 100 commodities identified in Chapter II are found among those from the accident data, so that a perfect matching for analysis is not possible. Also the accident experience is not uniform for all commodities due, in part, to differences in shipping rates as well as to numbers of years the material has been shipped. That is, some materials (e.g., hydrochloric, nitric and sulfuric acids) have been shipped in large quantities for many years, while others, such as toluene diisocynate, have been shipped by rail for only a few years. Further, restricting these technical analyses to only the 100 materials from Chapter II means that a lot of data are discarded needlessly.

Because insufficient accident experience can color analyses based on an historical perspective, all the data will be retained and pooled into hazard classes to retain as much analytical robustness as possible. Even with this strategy, however, several hazard classes -ORM's and, to a lesser extent, the Poisons - are poorly represented in the historical data.

2. Commodity Sheets

These documents, one for each of the materials identified in Chapter II, are described and presented in Appendix B. These Commodity Sheets present, in capsule form, a cross-section of physical, chemical, and hazard information intended to provide the reader some insight into the dangers associated with handling these materials, and to support the analyses reported below. While they resemble, and are partially based on, material safety data sheets and emergency response guidelines, they are not intended to substitute for either of them. Rather, the Commodity Sheets are intended to provide the support for a technical analysis and development of hazard profiles for the commodities to be developed below.

While it is not possible in the present format and medium to present the full range of information about a material, the carefully chosen data elements present a useful cross-section of information. Carefully interpreted, virtually all the information required to confirm the hazard assessments may be found there. Much of the rest comes from accident histories.

3. Analytical Objectives

Three broad issues drive the analyses, including the identification, classification and recognition of the material and its associated hazards.

a. Identification of Hazards

Hazard identification consists of testing with two questions:

- are all the hazards identified?
- are the attributes sufficiently well characterized to permit classification?

The first issue is self descriptive, but it and its answers are subject to differences of opinion. The sufficiency of hazard information was discussed, in part, in Chapter III. Because two issues of identification and sufficiency are intertwined with the larger matters of classification and recognition, the matter of hazard identification can not be considered settled.

b. Classification of Hazards

The hazard class definitions and the hierarchical classification preference table (49 CFR 173.2) constitute the classification scheme for the Regulations. As such these are major items to be considered in the technical analysis.

c. Recognition of Hazards

Hazard recognition addresses questions surrounding the subject matter to be communicated by regulatory compliance, and the communication mechanism, as required by the classification, marking, labeling, placarding and shipping paper regulations of 49 CFR 173. It is upon this point that all regulatory standards focus. If there are no derailed cars, no ruptured containers, and no spillage of hazardous materials, then all the requirements have been superfluous save those to guide shipping and handling. It is only when there is a derailment, a container rupture, or spillage that there arises the matter of quality and quantity of information to be communicated. What does a first responder or train crewman need to know in dealing with an accident? What should a yard inspector know about a material dripping from a leaking tank car?

While the DOT Regulations do not directly address the questions, clearly-framed answers must be in hand as the philosophical undergirding to direct the scope and thrust of the DOT Regulations. From such considerations the evaluation found in Chapter III inferred answers to these questions; the technical analysis below will further examine the matter of hazard recognition.

4. Analytical Process

Evaluation of accident data and commodity sheets for presented hazards does not lead to a manageable set of hazard categories, but does lead to an intermediate state from which such a set can be derived.

The development of the full range of hazards for a commodity was accomplished in two parts. One part took advantage of the nature of the hierarchical preference table of hazard classes (49 CFR 173.2) to identify other hazard classes deemed to be of lesser importance in the DOT Regulations than the assigned hazard class. These were combined with other hazards identified from the Commodity Sheets in Appendix B to determine the full range of hazards presented graphically below.

A meta-analysis of the outcomes of this process revealed several interesting points:

- the bulk of the tabulated information could be grouped into eight hazard categories,
- it is possible to produce a reasonable, self-consistent four-point hazard assessment scale (none; slight; moderate; and severe or significant);
- the presence or absence of fire at an accident scene can play a dominating role in assessing the explosion and toxicity hazards of an accident scene.

These three points effectively determine the procedure used for development of hazard profiles from an analysis of the range of presented hazards. Also useful in the development of profiles were portions of the hazard definitions from the DOT Regulations.

The resulting eight hazard profile categories do not correspond to the traditional (i.e, Regulatory) hazard classes. They do provide hazard categories for which comparative assessments can be developed for individual commodities, and therefore provide a very useful vantage point from which to evaluate the DOT Regulations. The eight hazard categories are discussed in detail below.

The reduction of the hazard spectra to hazard profiles necessitated the development of a set of rules for the reduction process to minimize the element of subjectivity that can arise in such a process. The rules, in turn, define the hazard profile categories, provide the means for their understanding, and for using them to evaluate the DOT Regulations. The rules are discussed next as parts of the hazard category descriptions.

B. DESCRIPTIONS OF THE HAZARD CATEGORIES

The eight categories of hazards identified from the tabulation of hazards presented by various materials include:

- ignition hazard
- oxidation hazard
- corrosion hazard
- environmental hazard
- water hazard
- safety hazard
- explosion hazard
- toxicity hazard.

The last two, explosion and toxicity hazards, are dichotomized by the presence or absence of fire at the accident scene.

1. Ignition Hazard

This category identifies materials that can act as fuels in fires and similar processes, and includes: all materials that bear any sort of flammable or combustible placard, and flammable and combustible liquids and flammable gases and solids as defined in the DOT Regulations. Flammable liquids and gases are regarded as moderate hazards. Pyrophoric materials are rated as severe hazards because of their spontaneous ignition properties and the grave importance of fire at an accident scene. Ignitable liquids not classified as flammable or combustible in the Regulations (e.g., glacial acetic acid and dinitrotoluene) are generally treated as slight or moderate ignition hazards while ignitable solids are slight ignition hazards.

Ammonia, a non-flammable gas, can be ignited in concentrations sufficiently high as to pose only a slight ignition hazard.

Accident experience reflected in the OHMT data has shown, for many hazard classes, that fires and explosions are associated outcomes of an accident environment. In addition to combinations of no adverse outcome of this sort, the OHMT data file provides information about all possible outcome combinations for spillage, fire, and explosion. It is possible on this basis to segregate the outcomes neglecting joint events. Table IV-1 shows these results for occurrences of fire neglecting other outcomes (i.e., spillage and explosions) that might be associated with the fire. The most adversely affected class is flammable gases, with a rate about twice that of either flammable solids, the second-place class, or flammable liquids, very close behind in third place. Several percentage points behind in fourth position is Poison B with all other hazard classes displaying nearly inconsequential percentages. Most important to be gleaned in addition to the leaders is the relationship betweem flammable and combustible liquids, with rates of 17% and 3% respectively. This differential in percentage of accidents involving fire can be regarded as strong support for the regulatory differentiation between flammable and combustible liquids. It is not necessarily support for retention of combustible liquids as a separate major class among the hazardous materials. It is noted in closing that Poison B materials (liquids and solids) present a comparatively significant risk of fire. This risk is distinctly greater than that of combustible liquids and nearly as great as that of flammable liquids and solids. This fire hazard associated with Poison B materials is a documented example of the multiplicity of hazards associated with the rail shipment of bulk quantities of hazardous materials. The OHMT data do not support determination of cause and effect in the risk of fire with Poison B materials. Analyses presented later in this chapter reveal that some of the Poison B materials in the list of 100 hazardous materials qualify as combustible liquids.

TABLE IV-1. FIRE OCCURRENCE RATES FOR THE HAZARD CLASSES

Hazard Class	Occurrence of Fire - %[1]
Flammable Gases	34.0
Flammable Solids	17.4
Flammable Liquids	17.2
Poison B Materials	14.3
Combustible Liquids	3.3
Oxidizing Materials	2.7
Corrosive Materials	2.5
Non-Flammable Gases	2.0
Explosives "A" Materials	0.0
Blasting Agents	0.0
ORM-A Materials	0.0
ORM-B Materials	0.0
ORM-C Materials	0.0
ORM-E Materials	0.0

[1]Includes joint occurrences with spillage and explosions.

2. Oxidation Hazard

This hazard category identifies all materials which, when mixed with suitable fuels, enhance the ignition hazard at an accident scene. Included are all materials that must be shipped with either an OXIDIZER or PEROXIDE placard, and stimulate fires by their contribution of oxygen. As noted in Chapter III, however, there are a number of other materials which conform to a broader, more modern definition of oxidizers, and these are also described by this category. They are capable of producing processes phenomenologically identical with fire, resulting in: the production of flame and heat; behavior as an ignition source; and the production of vision-obscuring, noxious, or dangerous fume clouds.

The halogens chlorine (among the 100 dangerous materials) and chemically similar fluorine (not in the list of 100 materials) are two gaseous materials that satisfy this broad definition of oxidation hazard but do not meet the regulatory definition of oxidizing materials. The other two halogens, bromine (a liquid) and iodine (a subliming solid) also not classified as oxidizers are chemically similar to fluorine and chlorine but react much less vigorously with most materials. This lack of reaction vigor suggests that these materials are not capable of initiating and sustaining accident scene processes that produce significant amounts of heat or dangerous fumes.

This phenomenological definition of oxidation hazard is consistent with the modern chemical definition of oxidation which is cast in terms of electron transfer reactions. This definition includes as a special case the much older definition of oxygen transfer reaction of oxidizers that is implemented by the DOT Regulations for oxidizing materials.

3. Corrosion Hazard

Corrosion hazards are presented by those materials that are corrosive to structural metals (e.g., steel and aluminum). Those materials bearing a CORROSIVE placard because of their effect on the structural metals are included in this hazard category. Excluded, however, would be any materials classified as corrosive solely on the basis of their effect on tissue; these materials are regarded as worker safety hazards (discussed below). In general, corrosive materials destructive to structural metals are also destructive to tissue as well.

Aluminum and steel make an interesting pair of materials for the evaluation of the corrosion hazard. The reactivity of acidic materials with steel is rapid while the reactivity with aluminum is quite temperature sensitive and sluggish at ambient temperatures. Alkaline or caustic materials, on the other hand, react slowly with steel but vigorously with aluminum.

The reaction of acids with steel and caustics with aluminum result in the production of hydrogen, a flammable gas. Thus, a massive reaction (e.g., a tank car in a large pool) of these materials has the potential for producing a significant accumulation of unignited hydrogen, posing a potential explosion hazard for reasons discussed below under explosion hazards.

The evolution of hydrogen gas in these corrosion reactions implies chemically that the corrosion reactivity depends upon the strength of the acid or base. The strength of the acid or base, for practical purposes, is determined, by innate properties of the material and, by the concentration of its aqueous solution. These two factors determining the strength of an acid can be complementary or one can suppress the consequences of the other, and the effect can be determined by either or both of the factors.

4. Toxicity Hazard

The assessment of toxicity is complex because of the numerous uses for the data which, in turn, spawn the numerous ways of expressing test results. In part this arises from the nebulous nature of the definition of toxicity. Sax[1] defines toxicity as "the ability of a chemical to cause injury once it reaches a susceptible site in or on the body." Very often the toxicity data pertain to a fatal injury (lethality), and therein lies one of the difficulties of dealing with toxicity data. The data come as harmful effects and lethal effects reports, and there is no valid way to convert injury data to lethality data. It should be noted that the word toxicity is interpreted here as not necessarily fatal, while lethal is the ultimate or end toxic effect. Toxic effects are produced by exposure to smaller amounts of a material while lethal effects result from comparatively larger exposures of the material. Thus, the interpretation and analysis of the Commodity Sheets in Appendix B requires scrupulous attention to the effect expressed in the toxicity data section. Toxic doses or concentrations were assumed to represent a harmful but nonfatal exposure and therefore a less severe threat to the species than lethal (fatal) doses or concentrations. The descriptors "toxic" and "poisonous" found in the various references were interpreted as "harmful" and "lethal", respectively. The word "toxic" as used in this report means "harmful, possibly fatal."

A second issue alluded to, but not directly addressed, in the definition pertains to mechanistic considerations - transportation of the toxic material to a susceptible site as discussed in the evaluation of Chapter III. The DOT Regulations require that a material express its toxic effects via a systemic mechanism in order to be considered a poison. This means that a particular material must manifest its effects on only a few particular organs or sites (e.g., intercell neurotransmission areas) to be deemed poisonous. The alternative is for a material to act by general corrosive destruction of whatever tissue it may come in contact with. For example, chlorine respired into the lungs will corrosively destroy cell integrity, resulting in the release of flooding quantities of body fluids (edema) that prevent respiration. The same corrosive destruction of chlorine can occur to the eyes, skin, digestive system, etc., depending only on accessibility to manifest itself. There is no attack by chlorine on any specific part of the biomachinery in the manifestation of toxic effects.

The time of exposure to a toxic material and the time to onset of symptoms or effects are also important considerations in assessing toxicity. The time (duration) of exposure to a toxic material, together with the concentration or amount of material involved, are major factors in determining the dosage of the toxic material. Other factors are test specific. For example, the breathing rate is determining in inhalation toxicity while the ingestion rate for oral toxicity and skin surface area exposed in skin toxicity can also be central factors.

The time to onset of effects is conceptually simpler to understand, but potentially more difficult to assess especially where non-lethal effects occur. For many toxic materials the effects are prompt; inhalation of even very small amounts of chlorine gas will almost immediately produce respiratory irritation and edema. For other materials the time to onset of symptoms may depend on the concentration; ethylene oxide exposure in high concentrations will promptly produce respiratory irritation or edema while very much lower concentrations will produce delayed nausea and vomiting. For still other materials the effect is damage to other organs and may go undetected unless sought in laboratory test animals.

While the concepts of systemic and corrosive mechanisms are very useful in the study of toxicology, they must not be allowed to obscure the fact that chlorine (and other materials acting via a corrosive mechanism) present a very serious potential or real threat of injury or death to workers at an accident scene. Evaluation of toxicity as an accident hazard will neglect mechanistic consideration in these analyses.

Sax[1] has defined hazard as "the likelihood that a chemical will cause injury under circumstances of ordinary use." While this definition may be appropriate for toxicology, several minor changes are appropriate for this study. First, materials should be considered synonymous with chemicals so that it is clear that hazard considerations may be applied to all 100 of the hazardous materials identified in Chapter II. Second, fatalities should be formally recognized as one form of injury as indicated above. Last, one way of quantifying hazard likelihood is to assign different critical dosage limits to various routes of entry and forms of materials, based on the following considerations.

The route of entry into the body of a material is a major consideration of toxicity in a spill. Oral toxic effects by a material when spilled in bulk at a rail accident can be minimized by a combination of appropriate protective garments, training, personal habits, and careful management of the mitigation and cleanup crews. Use of a respirator (either filter or supplied air, as required) together with protective clothing will provide protection against inhalation of toxic materials. Such protective clothing is heavy and unventilated; heat stress is usually experienced requiring the wearer to stop work and at least partially remove the garments. From these considerations, and recognition of the threat arising from the downwind migration of toxic fumes to points remote to the spill scene, inhalation toxicity presents the most significant threat to accident scene workers.

Table IV-2 represents the quantification of LD_{50} and LC_{50} toxicity hazards in developing the hazard profiles based, in part, on values from values from the Hodge-Sterner Scale discussed in Chapter III. Toxicity (non-lethal effects) data and hazards associated with combustion products for which there are no quantitative data were treated subjectivity in a manner consistent with the above and the following rules for combustion products:

TABLE IV-2. LD_{50} and LC_{50} VALUES FOR HAZARD PROFILE TOXICITY HAZARDS

	LD_{50} and LC_{50} Hazard Limits		
Route	Slight	Moderate	Severe
Inhalation	5000 ppm	500 ppm	50 ppm
Oral	50 g/kg	5 g/kg	0.5 mg/kg
Skin	1000 mg/kg	100 mg/kg	10 mg/kg

- poisonous fumes were considered a severe hazard;
- toxic fumes were usually considered a slight or moderate hazard and only rarely a severe hazard.

Fire, or its absence, at an accident scene produces a dichotomizing effect on the evaluation of the toxicity hazard. Some materials, such as butadiene (flammable gas), present a negligible toxicity hazard if spilled but present a more significant hazard from combustion products if ignited and burned. For other materials, fire may also alter the nature of the risk. Phosphorus, for example, is a moderate oral and skin poison which, if ignited, produces an airborne toxic cloud of phosphorus pentoxide. To recognize this important factor, the toxicity of each material has been evaluated in the absence and presence of fire; the latter assessment is often a subjective judgement based chiefly on response guides and other hazard sources in the absence of appropriate quantitative data.

5. <u>Environmental Hazard</u>

The assessment of environmental hazards is an attempt to assess the environmental consequences of commodity spillage in an accident. Ideally, this should include effects on plant and animal life, soil sterilization, and damage to surface and ground water. In practice, there were a number of problems to be dealt with.

There is scanty soil sterilization data available for consideration and the sterilization mechanism may depend on biodegradation or other reactions. The paucity of available information did not support efforts to assemble such data for this report.

Damage to surface and ground water systems is also difficult to assess because of a strong situation dependency. Spillage of a tank carload of a material into a stream has a much more deleterious effect than into a river. The geology and aquifer depth underlying an accident scene strongly affects groundwater damage assessment.

Evaluation of the toxicity data for terrestrial animals and freshwater and saltwater aquatic species proved troublesome for several reasons. Other than the rating system developed by the National Academy of Sciences (NAS), there appears to be no basis for assessing toxicity to wildlife, and the NAS approach specifies norms only for aquatic life. Values for human toxic effects have been used for terrestrial animals, although there is no established basis, other than expendiency, for adoption of such a substitution. The five-point NAS rating system is not compatible with the four-point rating scale adopted for this study.

The assessment of the environmental hazard associated with an hazardous material was based on the values in Table IV-2 and Table IV-3 where possible. Emphasis was placed on inhalation as the most hazardous for terrestrial animals, with oral and contact (skin) toxicity essentially comparable and less hazardous as routes of entry. No attempt was made to assess the route-of-entry aspect for aquatic life.

TABLE IV-3. ENVIRONMENTAL RATING SCALE FOR AQUATIC LIFE

Toxicity (ppm)	Hazard Rating
Less than 10	Severe
10-500	Moderate
500-2000	Slight
Greater than 2000	Negligible

6. Water Hazard

This hazard reflects the significant effects that firefighting water can have on some of the materials evaluated. Materials that must bear the "FLAMMABLE SOLID W" placard react with water to produce a flammable gas, or react with water to produce explosive materials that present especially serious dangers. Other materials may react with water to produce lesser hazards including: the evolution of heat from dilution (exacerbated by spattering), the production of toxic materials, or materials with other dangers. The production of toxic gases is considered to be especially significant.

7. Safety Hazard

Identified here are several potentially hazardous situations pertinent to workers in the immediate vicinity of an accident scene.

While most are not life-threatening, all are hazards that must be recognized and dealt with to minimize worker hazard in accident site management.

Among the hazards recognized here are:

- cryogenic hazard arising from extremely cold materials including those compressed gases which chill to liquid form when the pressure is suddenly released;
- suffocating gases which produce deleterious effects by displacement of respirable air;
- irritating materials that degrade worker performance and may require assisted removal of an incapacitated worker from the site;
- commodities corrosive to materials frequently found in protective clothing and firefighting equipment such as
  - nonferrous, nonaluminum metals and alloys (e.g., brass)
  - rubber, plastics and kindred materials.

The OHMT data provide some insight into safety hazards in the reporting of injuries and deaths. Since there is no associated causal data, toxic effects may also be included in these data. Table IV-4 shows the injury-and-death experience for the various hazard classes. The rates reflect persons per accident for each class. Zeros in the table imply that there are no reported injuries (or deaths) in the data while values greater than 100 percent reflect multiple injuries per accident. There is no time-related information in the OHMT data pertaining to dosage and exposure.

Inspection of Table IV-4 reveals that the compressed gases are the only classes where fatalities have occured as well as being most injurious. The extremely high injury rates are attributed to multiple injuries and are another indicator of the dangers associated with accidents involving large quantities of hazardous materials.

8. Explosion Hazard

Explosion hazards, like toxicity hazards, are dichotomized by the absence or presence of fire at an accident scene. Class A explosives,

TABLE IV-4. INJURY AND DEATH RATES FOR THE HAZARD CLASSES

Hazard Class	Injury Rate -%[1]	Death Rate -%
Flammable Gases	330	11
Non-Flammable Gases	274	19
Flammable Solids	61	0
Poison B Materials	54	0
Corrosive Materials	24	0
Flammable Liquids	20	0
Explosives "A" Materials	0	0
Blasting Agents	0	0
Oxidizing Materials	0	0
Combustible Liquids	0	0
ORM-A Materials	0	0
ORM-B Materials	0	0
ORM-C Materials	0	0
ORM-E Materials	0	0

[1] Rates in excess of 100 percent imply more than 1 person injured per averaged accident. The rate is expressed as persons per accident, expressed as a percentage of all accidents for the class of material.

and to a lesser extent, Class B explosives, present a serious explosion hazard whether or not there is a fire present. Most other materials that present a major explosion hazard require the involvement of fire and an extended period of container heating to develop the hazard.

There are several classes of fire-related explosion hazards. Perhaps the most spectacular and most feared of these is the boiling-liquid-expanding-vapor explosion (BLEVE) in which the contents of an inadequately vented, heated container are volatilized to relentlessly increase the pressure until the container fails violently. The flammable compressed gases are especially high BLEVE risks. The polymerization of plastics monomers can occur once the polymerization inhibitor is destroyed by heat. These polymerization reactions liberate heat that accelerates the polymerization process, resulting in a spectacular rise in internal pressure and temperature followed by a spectacular, catastrophic explosion. Tank car thermal insulation systems significantly reduce this risk.

If the container fails along the side the explosion produces a roughly circular danger zone. If the failure occurs at the tank head (end), there is a potential for container rocketing in which the container behaves like a missile. Such rapid gross movement can propel a rail tank car several hundred feet, greatly expanding the size of the accident scene and perilously increasing the risk to workers. Fragments have been thrown hundreds of yards.

Unconfined vapor cloud explosions (UVCE's) present another hazard when containment of flammable gases and volatile liquids is lost. If the concentration of the flammable cloud is within the flammable limits of the material, ignition can cause a very rapid, violent combustion process to occur, which is like the dust explosions in grain elevators. Military field trials involving the use of small explosives to initiate UVCE's have produced supersonic flame velocities comparable to the flame velocities in high (Class A) explosives. Using ignition sources most likely to be found at a railway accident, sonic flame velocities, comparable to low (Class B) explosives should be expected.

In emergency response guides such UVCE phenomena are not well identified as explosion hazards but rather as flashback hazards using phrases such as "ignition sources may cause flashback along vapor trail to the spill site." The control of ignition sources at an accident site is very important.

The potential for explosion from BLEVES, violent polymerization, and, to a lesser extent, UVCE's or flashbacks present significant hazards, the first two in the presence of fire.

Other indicators of potential explosion hazards include phrases such as:

- flammable gas produced or released
- violent reaction
- explodes in heat or fire
- explodes when confined and heated

An explosives placard, violent polymerizations or other reactions, and explosions in heat or fire are uniformly regarded for this report as very serious hazards; others may be regarded as less serious, depending on the material and specific hazard.

Table IV-5 shows the explosion accident experience for the various hazard classes in the OHMT data. These values neglect the occurrences of joint events; some of these explosions involved fire. The flammable gases show a rate nearly three-fold higher than Poison B materials which is second in the list, and more than three-fold higher than the flammable solids, third on the list. The materials classed as explosives show no history of explosions, though this might be attributed to the paucity of accident history as much as to the deferential care accorded explosive materials.

Explosions of the compressed gases are to be expected, and the outcomes also mirror the fire data in Table IV-1 above. Flammable solids are much less explosive in comparison to the gases than the fire data would predict. Some of these reports may be attributed to the mingling of materials.

Finally, note there are a number of hazard classes for which there is no recognized tendency toward explosiveness but at least indicate some accident experience with explosions.

TABLE IV-5. EXPLOSION RATES FOR THE HAZARD CLASSES

Hazard Class	Explosion Rate -%[1]
Flammable Gases	15.0
Poison B Materials	5.7
Flammable Solids	4.3
Corrosive Materials	1.2
Non-Flammable Gases	1.0
Flammable Liquids	0.9
Oxidizing Materials	0.9
Combustible Liquids	0.8
Explosives "A" Materials	0.0
Blasting Agents	0.0
ORM-A Materials	0.0
ORM-B Materials	0.0
ORM-C Materials	0.0
ORM-E Materials	0.0

[1] Includes joint occurrences with spillage and fire

Table IV-6 displays the occurrence of joint outcomes involving spillage, fire, and explosions. Rounding will keep rows from adding to 100%. There are no reported instances of explosions unaccompanied by fire or spillage.

Flammable gases, while showing the highest containment rate (measured as nonspillage), show the greatest variety of outcomes including the highest rates for fire and explosion as well as spillage, fire, and explosion results. The compressed gases are the only classes for which spillage and explosion was an accident result. Poison B materials show the second highest spillage, fire, and explosion rate in the table; fires and explosions are not implicit hazards in the regulatory definitions of the poisonous materials.

C. RESULTS OF THE ANALYSIS

For convenience the 100 commodities analyzed were grouped into their hazard classes as assigned in the DOT Regulations. For each hazard class the hazard spectra and their reduction to eight hazard profile categories are presented together. This arrangement focuses on the analytical results without obscuring the process.

1. An Historical Overview

The data obtained from OHMT, though intended for other purposes, also provides useful general information for this study. Some of the information is of a specific nature and has been presented in conjunction with hazard category descriptions above. Other results obtained from this data are of a general nature that present an important background against which the detailed analysis can be viewed.

a. Shipping and Accident Rates

The shipping rate data supplied by AAR for each commodity may be compared with accident rates calculated from OHMT data for each hazard class for which data are available. For purposes here, the shipping rate for a hazard class is the percentage of all hazardous material tank cars shipped that fell into the hazard class. Accident rates, in turn, are the corresponding tank car accident information

TABLE IV-6. JOINT EVENTS INVOLVING SPILLAGE, FIRE AND EXPLOSIONS FOR THE HAZARD CLASSES

	Joint Event Rates - %[1]						
Hazard Class	None	S	F	S&F	S&E	F&E	S,F&E
Explosives A		100					
Blasting Agent		100					
Flammable Liquids	3	80	1	15			1
Combustible Liquid	1	96	1	2		1	
Flammable Solids	9	74	4	9			4
Oxidizers	3	94		3			1
Corrosives	2	96		1			1
Flammable Gases	14	52	7	13	1	6	8
Non-Flammable Gases	10	87	1	1	1		
Poison B	11	74		9			6
ORM-A		100					
ORM-B		100					
ORM-C		100					
ORM-E		100					

[1]S: Spillage; F: Fire; E: Explosions

extracted from the OHMT data. Percentages are used to remove discrepancies between annual shipping rates versus all accidents in the period 1971-1984; some of the shipping data are for 1979 but most pertains to 1983. It is to be expected intuitively that the accident rate should mirror the shipping rates. The comparisons, shown in Table IV-7, clearly show that such expectations are not supported for the compressed gases and flammable liquids. To quantitatively assert that the differences in these cases is important or significant requires an underlying quantitative probability relationship that cannot be evaluated. There are two major barriers to such quantification: absence of other shipping data of a more general nature and the very low accident rates (0.01-0.05%) that can be inferred from the OHMT data. The very low accident rates suggest that the probability distribution for accident rates is relatively broad and flat, and this, in turn, suggests that the differences shown in Table IV-7 may not be statistically significant. Data gathering and model development seem mandatory to pursue the discrepancies further.

The OHMT data base does not support analysis of the effects of coupler restraints, head shields, or insulation systems. There are no data fields pertaining to such matters in the data base, and approximately 50 percent of the rail cars in the data base are described simply as "tank car."

b. Losses

The monetary losses of an accident are another important yardstick for assessing the costs and hazards of transporting dangerous goods. Table IV-8 shows the average losses in thousands of dollars for each hazard class. These data must be regarded as suspect, however. For example, an accident on November 8, 1979 at Inwood, Indiana involved nine type 111AW tank cars loaded with hazardous materials. In the accident 30,000 gallons of corrosive materials, 55,000 gallons of flammable liquids, and 10,000 gallons of combustible liquids were released. For one of the cars, the reported loss was $2.3 million, and for the other eight there are no reported losses. The only plausible interpretation is that the losses for the accident were $2.3 million and that losses

TABLE IV-7. HAZARDOUS MATERIALS SHIPPING AND ACCIDENT RATES

Hazard Class	Shipping Rate - %	Accident Rate - %
Corrosive Material	31.2	30.9
Flammable Gas	21.0	11.7
Flammable Liquid	20.4	33.2
Non-Flammable Gas	15.2	7.6
Combustible Liquid	7.8	9.2
Poison B	2.7	2.7
Flammable Solid	0.8	1.6
ORM-A	0.4	0.3
Oxidizing Material	0.3	2.1
Poison A	0.2	0.0
ORM-E	0.1	0.3

TABLE IV-8. LOSSES FOR HAZARD CLASSES

Hazard Class	Losses[1]
Flammable Gas	$184.8
ORM-C	50.0
Poison B	45.1
Combustible Liquid	34.2
Flammable Liquid	20.7
ORM-E	19.0
Corrosive Material	16.5
Non-Flammable Gas	15.5
Oxidizing Material	5.5
Flammable Solid	3.2
ORM-A	0.5
ORM-B	0.5

[1]Average losses expressed in thousands of dollars.

for individual materials and hazard classes is unknown. Since there is no obvious, simple scheme for apportioning the losses, no attempt was made to refine the data.

c. Multi-Car Hazardous Materials Accidents

It is possible to estimate from the OHMT the frequency of accidents involving two or more rail cars bearing hazardous materials. These relative frequencies are shown in Table IV-9. The historical data clearly suggest that the majority of hazardous materials accidents involve only a single rail car of such commodities, and that the likelihood of an accident involving more than five hazardous materials rail cars is of the order 1:500 to 1:1000. In this context the nine-car Inwood, Indiana accident above is highly unusual. The spillage of 95,000 gallons of hazardous materials in such a multicar accident clearly illustrates the magnitude of the problems that can arise, and is one of the distinguishing features of such rail accidents.

d. Spillage

It might be expected that cargo containment in an accident is important in mitigating damages and losses, but Table IV-10 indicates that, for many hazard classes, containment plays no role in mitigation. Only for the compressed gases, Poison B materials, and flammable solids is there some expectation for cargo retention. While spillage in an accident might be reduced to, say, 50% by building stronger, more crashworthy rail cars, the initial cost and increased weight of the loaded car might make rail transportation uneconomical. Other considerations that make such an approach unfeasible are the vigorous competition from highway transportation and the extra stress and wear caused by heavy cars on rails, especially in line-haul operations. These considerations, together with low accident rates, suggest that a reasonable tradeoff has been found for most materials and that negligible retention rates (high spillage rates) must be regarded as a "price of doing business." Other approaches, such as accident prevention, should be more fruitful.

TABLE IV-9. FREQUENCY OF MULTI-CAR HAZARDOUS MATERIALS ACCIDENTS

Number of Hazardous Materials Cars/Accident	Relative Frequency[1]
1	100.00
2	4.40
3	1.08
4	0.72
5	0.36
6	No Data
7	0.18
8	0.09
9	0.18
10 or more	0.09

[1]Normalized to single-car accidents - 100.0.

TABLE IV-10. SPILLAGE RATES FOR HAZARD CLASSES

Hazard Class	Spillage - %[1]
Explosives A	100
Blasting Agents	100
ORM-A	100
ORM-B	100
ORM-C	100
ORM-E	100
Combustible Liquids	98
Corrosive Materials	98
Oxidizing Materials	97
Flammable Liquids	96
Non-Flammable Gases	89
Poison B Materials	89
Flammable Solids	87
Flammable Gases	74

[1] Includes joint occurrences with fire and explosion

e. Evacuation

Removal of accident site workers and the civilian population from areas threatened by the consequencies of an accident is determined by several factors, chiefly, commodity properties and loss of containment at an accident scene. Evacuations typically are initiated by threats of explosion and by the release and transit of clouds of hazardous materials. Explosion hazards arise principally with intact containers while downwind evacuations for hazardous clouds occur with container rupture and spillage.

Table IV-11 shows evacuation rates, expressed as percentages, for various hazard classes. While the data from multi-car accidents suffer from the problems discussed above, they do provide useful insights into this aspect of dangerous materials. While it is not surprising to see compressed gases and flammable liquids near the top of the list, it is interesting to note that Poison B materials (liquids and solids) are second on the list. More surprising is that the evacuation rate for Poison B materials is nearly as high as that for flammable gases, twice that of non-flammable gases, and three-fold higher than for flammable liquids. This suggests that Poison B materials are more dangerous than their secondary status indicates. Accidents involving explosives and blasting agents, on the other hand, have not led to evacuations. Such an observation may be colored by low shipping rates and infrequency of accidents. The evacuation rate for corrosive materials presumably compares with that for flammable liquids chiefly because of noxious and corrosive fumes from these materials.

f. Summary of General Historical Perspective

It is useful to point out that the various general aspects of an accident scene are much more interdependent than this presentation suggests, and much depends upon the particulars of the accident. Specific commodities involved, containment, presence and location of fire, and nature of the area affected by adverse outcomes play a central role in accident site management, especially in precleanup phases.

TABLE IV-11. EVACUATION RATES FOR HAZARD CLASSES

Hazard Class	Evacuation Rate - %
Flammable Gases	19
Poison B Materials	17
Non-Flammable Gases	8
Flammable Liquids	5
Corrosive Materials	5
Flammable Solid	4
Combustible Liquids	3
Oxidizing Materials	2
Explosives A	0
Blasting Materials	0
ORM-A	0
ORM-B	0
ORM-C	0
ORM-E	0

There are other, more particular accident scene data that will be presented below in conjunction with specific hazards.

2. Flammable Liquids

Figure IV-1 shows the hazard spectra for the 36 flammable liquids. These materials are, with the exception of one material satisfying Poison B criteria, either irritating or noxious (ORM-A) materials, and all exhibit a potential flashback hazard. More or less, most materials are polymerizable monomers for plastics and synthetic rubbers while most of the rest are solvents or solutions. The universality of the flashback hazard is not surprising for this hazard class. Many of the materials present a potential for violent polymerization (explosion). A significant minority were identified as poisonous by CHRIS, producers of poisonous combustion products, or required to bear a poison label when shipped in small quantities; only methyl isocyanate is identified as satisfying the Poison B class requirements. The five commodities satisfying the corrosive materials definition all produce injurious skin, eye, or respiratory effects.

The results of consolidating the hazard spectra into hazard profiles is shown in Figure IV-2. In this and all hazard profile charts, the open circles represent slight hazards, dotted open circles indicate a moderate hazard, and filled circles signify a serious hazard.

Inspection of Figure IV-2 indicates a predictable uniform severe ignition hazard for flammable liquids. Also found are generally light to moderate environmental and safety hazards. In the absence of fire there is a moderate explosion risk attributable chiefly to a flashback hazard and, typically, a moderate toxicity hazard. Inspection of the potential for explosion in the presence of fire reveals an interesting pattern.

There is a group of materials for which there is a severe explosion hazard and a second group for which there is either a slight or negligible hazard. Closer inspection reveals the latter group is comprised chiefly of established, staple solvents used for many decades in the chemical and related industries as well as ingredients in consumer goods. The materials showing a severe explosion hazard in the presence of

	FLAMMABLE LIQUID	CORROSIVE LIQUID	POISON B	IRRITATING MATERIAL	ORM-B	ORM-A	VIOLENT POLYMERIZATION	FLASHBACK	POISON LABEL REQUIRED	POISONOUS COMBUSTION PRODUCTS	CHRIS WARNING	RQ MATERIAL	CRYOGENIC HAZARD	DANGEROUS WHEN WET	HIGH REACTIVITY-COMMON MATERIALS
ACETALDEHYDE	●	●		●			●	●				●			
ACETONE	●					●		●							
ACROLEIN	●	●		●			●	●	●	●	●	●			
ACRYLONITRILE	●	●		●			●	●	●	●	●	●			
BENZENE	●					●		●				●			
2-BUTANOL	●					●		●		●					
CARBON DISULFIDE	●			●				●		●		●			
CHLOROPRENE	●					●	●	●		●					
CYCLOHEXANE	●					●		●				●			
DENATURED ALCOHOL	●					●		●							
EPICHLOROHYDRIN	●			●			●	●	●	●	●	●			
ETHYL ACETATE	●					●		●							
ETHYL ACRYLATE	●			●			●	●		●					
ETHYL ALCOHOL	●					●		●							
ETHYL BENZENE	●					●		●				●			
ETHYL CHLORIDE	●					●		●		●			●		
ETHYLENE OXIDE	●	●		●			●	●							
FUEL, AVIATION, TURBINE ENGINE	●					●		●							
GASOLINE, BLENDED	●					●		●							
GASOLINE, CASING HEAD	●					●		●							
HEXANE	●					●		●							
ISOPROPANOL	●					●		●							
METHANOL	●					●		●			●				
METHANOL, CONTAMINATED	●					●		●			●				
METHYL ETHYL KETONE	●					●		●							
METHYL ISOCYANATE	●	●	●	●	●	●	●	●		●				●	●
METHYL METHACRYLATE	●			●			●	●				●			
NAPHTHA	●					●		●							
PETROLEUM NAPTHA	●					●		●							
PETROLEUM, PARTIALLY REFINED	●							●							
PROPYLENE OXIDE	●			●			●	●				●			
ROSIN SOLUTION	●					●		●							
STYRENE	●					●	●	●				●			
TOLUENE	●					●		●		●					
VINYL ACETATE	●					●	●	●				●			
XYLENE	●					●		●		●					

● SATISFIES HAZARD CLASS DEFINITION OR POSSESSES INDICATED ATTRIBUTE

Figure IV-1. Hazards Spectra of the Flammable Liquids

	ALL ACCIDENTS						FIRE		NO FIRE	
	IGNITION	OXIDATION	CORROSION	ENVIRONMENTAL	WATER	SAFETY	EXPLOSION	TOXICITY	EXPLOSION	TOXICITY
ACETALDEHYDE	●			⊙		⊙	○		⊙	○
ACETONE	●			○		○	○		⊙	⊙
ACROLEIN	●			●		●	●		⊙	⊙
ACRYLONITRILE	●			⊙		●	●	⊙	⊙	●
BENZENE	●			⊙		○			⊙	⊙
2-BUTANOL	●			○		○	○		⊙	○
CARBON DISULFIDE	●			⊙		⊙	●	●	⊙	
CHLOROPRENE	●			●		○	●	⊙	⊙	⊙
CYCLOHEXANE	●			⊙			●		⊙	⊙
DENATURED ALCOHOL	●			○		○			⊙	○
EPICHLOROHYDRIN	●			●		⊙	●	⊙		●
ETHYL ACETATE	●			○		○	○		⊙	○
ETHYL ACRYLATE, INHIBITED	●			⊙		⊙	●	⊙	⊙	⊙
ETHYL ALCOHOL, ANHYDROUS,DENATURED	●			○		○			⊙	○
ETHYL BENZENE	●			⊙		⊙			⊙	⊙
ETHYL CHLORIDE	●			○		○	●	●	⊙	○
ETHYLENE OXIDE	●			⊙		⊙	●		●	⊙
FUEL, AVIATION, TURBINE ENGINE	●			○		○			⊙	○
GASOLINE, BLENDED	●			⊙		○		⊙	⊙	⊙
GASOLINE, CASING HEAD	●			⊙		○			⊙	⊙
HEXANE	●			○			●		⊙	○
ISOPROPANOL	●			○		○			⊙	○
METHANOL	●			○		○	●		⊙	⊙
METHANOL, CONTAMINATED	●			○		○	●		⊙	⊙
METHYL ETHYL KETONE	●			○		⊙	○		⊙	⊙
METHYL ISOCYANATE	●			●	●	⊙	●	⊙	⊙	●
METHYL METHACRYLATE, MONOMER	●			⊙		○	●		⊙	⊙
NAPHTHA	●			○		○	○		⊙	⊙
PETROLEUM NAPTHA	●			○		○	○		⊙	⊙
PETROLEUM, PARTIALLY REFINED	●			○		○	○		⊙	⊙
PROPYLENE OXIDE	●			○		⊙	●		⊙	⊙
ROSIN SOLUTION	●					○			⊙	⊙
STYRENE, MONOMER	●			⊙		⊙	●		⊙	⊙
TOLUENE	●			⊙		○		⊙	⊙	⊙
VINYL ACETATE	●			⊙		○	●		⊙	⊙
XYLENE	●			⊙		○		⊙	⊙	⊙

● SEVERE HAZARD

⊙ MODERATE HAZARD

○ SLIGHT HAZARD

Figure IV-2. Hazard Profiles for the Flammable Liquids fire are the comparatively new polymerizable monomeric materials that have probably been introduced into commerce since the general development of the current regulatory structure, and several common and not-so-common solvents and specialty chemicals. Note also that the materials in this last group that present severe environmental hazards and severe no-fire toxicity hazards or safety hazards are the newer monomeric materials.

3. Combustible Liquids

The hazard spectra for the seven combustible liquids, shown in Figure IV-3, are considerably less complex than those for flammable liquids. In addition to the combustibility property, the majority of these materials emit noxious fumes, one can polymerize, several emit poisonous combustion products, and one has reportable quantity (RQ) limits to be dealt with if spilled.

The hazard Profiles, Figure IV-4, show that all the materials present a moderate ignition hazard in consonance with the definition of combustible liquids. Typically they also present a moderate environmental hazard and a light or moderate accident scene worker safety hazard. In the absence of fire there generally is a slight toxicity hazard and an occasional moderate explosion hazard. If the commodity is involved in a wreck and fire there is a distinct increase in both the explosion and toxicity hazards.

The hazard spectra and hazard profiles for combustible liquids clearly reveal an important point. In a regulatory sense these are materials that are capable of producing noxious fumes and sustaining combustion as fuels. Examination of emergency response guides reveals a few other dangerous elements, and consideration of all the properties of a material, together with accident scene hazard factors (including dichotomizing fire effects), reveals a still larger number of hazard elements. This raises a fundamental question: what is, or should be, the relationship between the DOT Regulations and the hazard profiles. The question will be dealt with in Chapter V; Chapter III has indicated that the answer must be couched in a careful consideration of intended audiences for the DOT Regulations.

	COMBUSTIBLE LIQUID	ORM-A	VIOLENT POLYMERIZATION	POISONOUS COMBUSTION PRODUCTS	RQ MATERIAL
BUTYL ACRYLATE	●	●	●	●	
CREOSOTE, COAL TAR	●	●		●	
FORMALDEHYDE	●	●		●	●
FUEL OIL, No.1,2,4, OR 5	●				
NAPHTHA	●	●			
OCTYL ALCOHOL	●				
PETROLEUM DISTILLATE FUEL OIL	●	●			

● SATISFIES HAZARD CLASS DEFINITION OR POSSESSES INDICATED ATTRIBUTE

Figure IV-3. Hazard Spectra for Combustible Liquids

	ALL ACCIDENTS						FIRE		NO FIRE	
	IGNITION	OXIDATION	CORROSION	ENVIRONMENTAL	WATER	SAFETY	EXPLOSION	TOXICITY	EXPLOSION	TOXICITY
BUTYL ACRYLATE	⊙			⊙		○	●	●		○
CREOSOTE, COAL TAR	⊙			○		⊙	○	●		○
FORMALDEHYDE	⊙			●		⊙	○	●		⊙
FUEL OIL, No.1,2,4, OR 5	⊙			⊙		○	○			○
NAPHTHA	⊙			○		○			⊙	○
OCTYL ALCOHOL	⊙			⊙		⊙	⊙			○
PETROLEUM DISTILLATE FUEL OIL	⊙			⊙		○		⊙		○

● SEVERE HAZARD

⊙ MODERATE HAZARD

○ SLIGHT HAZARD

Figure IV-4. Hazard Profiles for Combustible Liquids

4. Flammable Solids

The three flammable solids in the list of 100 dangerous commodities present interesting and important hazard spectra and profiles, Figures IV-5 and IV-6. In addition to satisfying the definitions of several lesser hazard classes, the hazard spectra show that these materials are poisonous and very reactive. The hazard profiles reveal these properties as well as potential explosion hazards. The most dangerous of these is for metallic sodium, a very reactive material capable of violent reaction with many substances found about an accident scene. Water, some alcohols, acids, and other similar materials produce the most violent reactions and produce flammable hydrogen gas as well. Calcium carbide reacts with the same materials to produce acetylene, also a flammable gas; reaction with caustic solutions produces explosive acetylides.

Not shown clearly in the hazard profiles is the very important pyrophoric nature of phosphorus and sodium. Release of these materials will virtually guarantee initiation or aggravation of a fire. Pyrophoric behavior is quite uncommon among commercially important materials but its presence at an accident scene can play a dominating role in the course of mitigation and cleanup activities. The range of hazards to be dealt with includes the corrosion hazard of acids and caustics produced by the reactions of these commodities.

5. Oxidizing Materials

The hazard spectra for these materials are shown in Figure IV-7. In addition to the oxidation hazard, they present significant explosive tendencies and the ability to evolve toxic or poisonous combustion products, as well as a tendency to be corrosive and otherwise damage rail cars (ORM-B).

The hazard profiles, Figure IV-8, show that these materials present a broad range of other hazards, most of them moderate or severe. Most important of these are explosiveness and toxicity in the presence of fire.

	FLAMMABLE SOLID	CORROSIVE SOLID	IRRITATING MATERIAL	ORM-B	ORM-A	PYROPHORIC	POISON LABEL REQUIRED	POISONOUS COMBUSTION PRODUCTS	RQ MATERIAL	DANGEROUS WHEN WET	HIGHLY REACTIVE-COMMON MATERIALS
CALCIUM CARBIDE	●		●	●					●	●	
PHOSPHORUS, WHITE OR YELLOW	●	●	●		●	●	●	●	●		●
SODIUM, METALLIC	●	●		●		●			●	●	●

● SATISFIES HAZARD CLASS DEFINITION OR POSSESSES INDICATED ATTRIBUTE

Figure IV-5. Hazard Spectra for Flammable Solids

	All Accidents						Fire		No Fire	
	IGNITION	OXIDATION	CORROSION	ENVIRONMENTAL	WATER	SAFETY	EXPLOSION	TOXICITY	EXPLOSION	TOXICITY
CALCIUM CARBIDE				○	●	○	⊙	○	○	○
PHOSPHORUS	●			●		●	⊙	⊙		⊙
SODIUM, METALLIC	●			○	●		●	⊙	●	⊙

● SEVERE HAZARD

⊙ MODERATE HAZARD

○ SLIGHT HAZARD

Figure IV-6. Hazard Profiles for Flammable Solids

	OXIDIZING MATERIAL	FLAMMABLE SOLID	CORROSIVE SOLID OR LIQUID	IRRITATING MATERIAL	ORM-B	MAY EXPLODE	POISONOUS COMBUSTION PRODUCTS	RQ MATERIAL	HIGHLY REACTIVE-COMMON MATERIALS
AMMONIUM NITRATE	●	●		●		●	●		
HYDROGEN PEROXIDE	●		●		●	●			●
NITRIC ACID, FUMING	●		●	●	●		●	●	●
POTASSIUM NITRATE	●					●	●		
SODIUM CHLORATE	●		●		●	●	●		
SODIUM NITRATE	●					●	●		

● SATISFIES HAZARD CLASS DEFINITION OR POSSESSES INDICATED ATTRIBUTE

Figure IV-7. Hazard Spectra for Oxidizing Materials

	ALL ACCIDENTS						FIRE		NO FIRE	
	IGNITION	OXIDATION	CORROSION	ENVIRONMENTAL	WATER	SAFETY	EXPLOSION	TOXICITY	EXPLOSION	TOXICITY
AMMONIUM NITRATE	○	●		⊙		○	●	⊙		
HYDROGEN PEROXIDE, OVER 52%	⊙	●	●	⊙		⊙	●		●	
NITRIC ACID, FUMING	⊙	●	●	●		●	○	●	⊙	⊙
POTASSIUM NITRATE		●					●	⊙		○
SODIUM CHLORATE	○	●	●	○		○	●	⊙	○	⊙
SODIUM NITRATE		●					●	⊙		○

● SEVERE HAZARD

⊙ MODERATE HAZARD

○ SLIGHT HAZARD

Figure IV-8. Hazard Profiles for Oxidizing Materials

Sodium and potassium nitrate are ingredients in black powder and other explosives, Ammonium nitrate was responsible for the massively destructive 1947 explosion in the Texas City harbor. Hydrogen peroxide containers may explode in a fire; the material itself reacts vigorously or violently with a wide variety of materials. Catalytic decomposition of hydrogen peroxide produces hydrogen, a flammable gas. Dilute (3% and 6%) solutions are consumer bleaches. Nitrates and other nitrogen-containing materials, as well as halogen-containing (especially fluorine and chlorine) commodities will produce toxic or poisonous combustion products.

In addition to being an oxidizer, the corrosiveness of nitric acid toward metals produces hydrogen gas and the threat of fire and explosion. Corrosiveness to a wide variety of materials and destructiveness to tissue present a significant danger to site workers. Emitted fumes are toxic and corrosive.

Sodium chlorate and other chlorate salts are explosively sensitive to friction. Mixtures of them with organic materials, carbon, sulfur, etc., are explosively sensitive to heat and percussion; mixtures with phosphorus are spontaneously explosive. Chemically similar potassium chlorate (not on the list of 100 dangerous materials) is a common ingredient in pyrotechnic finished goods.

6. Corrosive Materials

The 16 commodities that satisfy the definition of a corrosive material also satisfy the criteria for irritating materials and for ORM-A materials as indicated in Figure IV-9. All can cause significant damage to a rail car during transportation (ORM-B) and many undergo violent reaction with common materials. Most produce poisonous combustion products and behave unfavorably when encountering water. It is not surprising to see that the corresponding hazard profiles, Figure IV-10, reveal a significant range of consolidated hazard categories.

Since the hazard profile corrosion category applies only to the action of the material on steel and aluminum, not all the materials present a severe corrosion hazard. While the three organic materials (acetic acid, acetic anhydride and hexamethylenediamine) are classified by

	CORROSIVE MATERIAL	IRRITATING MATERIAL	COMBUSTIBLE LIQUID	ORM-B	ORM-A	VIOLENT REACTION-COMMON MATERIALS	POISONOUS COMBUSTION PRODUCTS	CHRIS WARNING	CORROSIVE TO GLASS	RQ MATERIAL	DANGEROUS WHEN WET
ACETIC ACID	●	●	●	●	●		●			●	
ACETIC ANHYDRIDE	●	●	●	●	●		●			●	●
CAUSTIC SODA, POTASSIUM, MIXED	●	●		●	●	●	●				●
FERRIC CHLORIDE, SOLUTION	●	●		●	●	●	●			●	
HEXAMETHYLENE DIAMINE	●	●	●	●	●		●	●			
HYDROCHRORIC ACID	●	●		●	●	●	●			●	●
HYDROFLUOSILICIC ACID	●	●		●	●	●	●		●		●
HYDROGEN FLUORIDE, ANHYDROUS	●	●		●	●	●	●	●	●	●	●
OLEUM	●	●		●	●	●	●			●	●
PHOSPHATIC FERTILIZER SOLUTION	●	●		●	●						
POTASSIUM HYDROXIDE, LIQUID	●	●		●	●	●					
SODIUM HYDROSULFIDE, SOLUTION	●	●		●	●		●				
SODIUM HYDROXIDE, LIQUID	●	●		●	●	●	●				●
SODIUM HYDROXIDE, SOLUTION	●	●		●	●	●	●				●
SULFURIC ACID	●	●		●	●	●	●				●
SULFURIC ACID, SPENT	●	●		●	●	●	●				●

● SATISFIES HAZARD CLASS DEFINITION OR POSSESSES INDICATED ATTRIBUTE

Figure IV-9. Hazard Spectra for the Corrosive Materials

	ALL ACCIDENTS						FIRE		NO FIRE	
	IGNITION	OXIDATION	CORROSION	ENVIRONMENTAL	WATER	SAFETY	EXPLOSION	TOXICITY	EXPLOSION	TOXICITY
ACETIC ACID, GLACIAL	⊙		⊙	⊙		⊙	⊙	⊙		⊙
ACETIC ANHYDRIDE	⊙		○	⊙	○	⊙	⊙	⊙		⊙
CAUSTIC SODIUM, POTASSIUM, MIXED	○		●	⊙	⊙	●	○	⊙		⊙
FERRIC CHLORIDE, SOLUTION			●	⊙		○		⊙		⊙
HEXAMETHYLENE DIAMINE	⊙		⊙	⊙		⊙		⊙		⊙
HYDROCHLORIC ACID			●	⊙	○	●	⊙	⊙		⊙
HYDROFLUOSILICIC ACID	⊙		●	⊙	⊙	⊙		●		⊙
HYDROGEN FLUORIDE, ANHYDROUS			●	⊙	⊙	●		●		●
OLEUM	⊙		●	⊙	●	⊙		●	⊙	⊙
PHOSPHORIC ACID			●	⊙		⊙		○	⊙	○
POTASSIUM HYDROXIDE, SOLUTION	○		●	⊙	⊙	●	○	⊙		⊙
SODIUM HYDROSULFIDE, SOLUTION			●	⊙		⊙		●		●
SODIUM HYDROXIDE, LIQUID	○		●	⊙	⊙	●	○	⊙		⊙
SODIUM HYDROXIDE, SOLUTION	○		●	⊙	⊙	●	○	⊙		⊙
SULFURIC ACID	○		●	⊙	⊙	●		●		⊙
SULFURIC ACID, SPENT			●	⊙	○	●		●		⊙

● SEVERE HAZARD

⊙ MODERATE HAZARD.

○ SLIGHT HAZARD

Figure IV-10. Hazard Profiles for the Corrosive Materials the DOT Regulations as corrosive, this is due chiefly to their injurious effect on tissue (skin, eyes, respiratory system), and this is reflected in the safety hazard column. Inspection of this column shows that these materials are not in the most severe rating category. Mineral acids and caustics in the high concentrations of the commodities selected (ca. 50% for caustics and 80-110% for acids) are more destructive of tissue. Hydrogen fluoride is poisonous, including that which evolves slowly from hydrofluosilicic acid; this evolution is accelerated by heat. Sodium hydrosulfide solutions are also poisonous, as is the hydrogen sulfide (flammable gas) evolved from it by the action of heat and acids. Heat increases the toxicity hazard of several other materials. Addition of modest quantities of water to comparatively large quantities of most of these materials results in the production of heat. For many materials the heat production can be quite vigorous, while with oleum it may become violent; there is also a safety hazard associated with this activity, usually in the vicinity of the spill.

7. Flammable Gases

In addition to flammability these gases also present hazards associated with flashback (a free-air explosion), rocketing (explosion and gross motion of an intact heated container) and frostbite from the cold liquid produced during an abrupt pressure release. Most of these flammable gases are suffocants, and the liquid state of several also present an ignition hazard as shown by the open circles in their hazard spectra in Figure IV-11. The extent of this hazard is determined by the very rapid flash evaporation behavior of the particular spilled liquid and this, in turn, depends chiefly on the boiling temperature of the material, the ambient temperature, and the severity of leakage (dribble versus massive rupture).

Explosions are regarded by workers at an accident scene as a very serious event and rocketing is the more serious manifestation of this hazard. The abrupt movement of such a massive object as a tank car can rupture other containers, ignite additional fires and significantly enlarge an accident scene as well as do general serious injury and damage.

	FLAMMABLE GAS	FLAMMABLE LIQUID	CORROSIVE LIQUID	IRRITATING MATERIAL	ORM-B	VIOLENT POLYMERIZATION	FLASHBACK	ROCKETING	POISONOUS COMBUSTION PRODUCTS	CRYOGENIC HAZARD	SUFFOCANT
BUTADIENE	●	○		●		●	●	●	●	●	●
BUTANE	●	○					●	●		●	
BUTENE	●	○					●	●		●	●
ETHYLENE	●						●	●		●	
ISOBUTANE	●	○					●	●		●	●
ISOBUTANE, IMPURE	●	○					●	●		●	●
ISOBUTYLENE	●	○					●	●		●	●
LIQUEFIED PETROLEUM GAS	●						●	●		●	●
METHYL CHLORIDE	●		●		●		●	●	●	●	●
PROPANE	●						●	●		●	●
PROPYLENE	●						●	●		●	●
VINYL CHLORIDE	●	○				●	●	●	●	●	●

● SATISFIES HAZARD CLASS DEFINITION OR POSSESSES INDICATED ATTRIBUTE

○ DISCHARGED LIQUID SUPPORTS COMBUSTION

Figure IV-11. Hazard Spectra for the Flammable Gases

Because the time of the explosion cannot always be predicted, sound practice at a site where a flammable gas container is engulfed in an uncontrollable fire is to abandon the site and withdraw beyond the radius of potential damage. Typical distances of withdrawal are 1500 to 2500 feet, depending on the material and source of emergency response guide information.

Free air unconfined vapor cloud explosions (UVCE's) also present a problem but these are not associated with the extreme motion of a rocketing rail car. The blast and overpressure of a UVCE can injure and kill people as well as rupture and move rail cars sufficiently to create additional problems and hazards, including the ignition and spread of fires.

The hazard profiles for flammable gases, Figure IV-12, show that ignition and explosion are major hazards. Explosions in fire are of the violent, rupture-and-rocket, variety, while flashbacks (UVCE's) are the explosive mechanism in the absence of fire. The safety hazard is essentially the cryogenic hazard derived from chilling of the material upon the abrupt release of pressure. Environmental and toxicity data are sparse for these materials and some assignments have been surmised by intercomparison with materials of established hazard and similar chemical structure.

8. Non-Flammable Gases

The variety of hazards presented by the four non-flammable gases is impressive, extending from suffocant and cryogenic hazards to flammability and explosion hazards. Their hazard spectra are shown in Figure IV-13.

Anhydrous ammonia is a very unusual material from the regulatory point of view. In Chapter III it was indicated that flammable gases are those compressed gases that satisfy either or both of the following conditions (49 CFR 173.300 (b) (1)):

- a mixture of 13 volume percent or less with air forms a flammable mixture, or
- the flammable range with air is wider than 12 percent regardless of the lower limit.

	ALL ACCIDENTS						FIRE		NO FIRE	
	IGNITION	OXIDATION	CORROSION	ENVIRONMENTAL	WATER	SAFETY	EXPLOSION	TOXICITY	EXPLOSION	TOXICITY
BUTADIENE	●			⊙		○	●	⊙	⊙	○
BUTANE	●			○		○	●		⊙	
BUTENE	●			○		○	●		⊙	○
ETHYLENE	●			⊙		○	●		⊙	○
ISOBUTANE	●			⊙		○	●		⊙	
ISOBUTANE, IMPURE	●			⊙		○	●		⊙	
ISOBUTYLENE	●			⊙		○	●		⊙	○
LIQUEFIED PETROLEUM GAS	●			⊙		○	●		⊙	
METHYL CHLORIDE	●		○	⊙		○	●	⊙	⊙	⊙
PROPANE	●			○		○	●		⊙	
PROPYLENE	●			○		○	●		⊙	○
VINYL CHLORIDE	●		○	⊙		○	●	⊙	⊙	⊙

● SEVERE HAZARD

⊙ MODERATE HAZARD

○ SLIGHT HAZARD

Figure IV-12. Hazard Profiles for the Flammable Gases

● SATISFIES HAZARD CLASS DEFINITION OR POSSESSES INDICATED ATTRIBUTE

Figure IV-13. Hazard Spectra for the Non-Flammable Gases

SULFUR DIOXIDE	CHLORINE	CARBON DIOXIDE, LIQUEFIED	AMMONIA, ANHYDROUS	
●	●	●	●	NON-FLAMMABLE GAS
●	●		●	CORROSIVE MATERIAL
●	●		●	IRRITATING MATERIAL
●	●			ORM-B
●	●		●	ORM-A
			●	FLAMMABLE AT HIGH CONCENTRATIONS
●	●		●	HIGH REACTIVITY-COMMON MATERIALS
	●		●	TOXIC COMBUSTION PRODUCTS
●	●	●		CRYOGENIC HAZARD
	●			POISON LABEL REQUIRED
●	●		●	CHRIS WARNING
		●		SUFFOCANT
		●		EXPLODE IN A FIRE

Anhydrous ammonia with flammability limits of 15.5-27.0%, has a lower limit that exceeds the 13 percent limit of the first criterion and a flammability range of 11.5%, insufficient to satisfy the second criterion. Theoretically, these limits could produce a UVCE above an ammonia spill pool although ignition might be difficult. From an historical perspective there are two instances of accidents involving ammonia in the OHMT data including one as an aqueous solution with a concentration greater than 44 percent; the DOT Regulations classify this material as a compressed gas rather than as a compressed gas in solution because ammonium can be liquefied. Lesser concentrations of aqueous ammonia are shipped as ammonium hydroxide with a different identification number. Neither this material nor the anhydrous ammonia in the second instance were involved in fire.

Several of the materials are highly reactive with common materials and most important in this regard is chlorine. Chlorine is capable of reacting vigorously or violently with a broad spectrum of materials in fire-like processes that produce sufficient heat to kindle conventional fires. In such processes chlorine behaves not as a fuel but rather like an oxidizing material. Because it does not contribute oxygen to such processes it is not classified as an oxidizing material; this is a regulatory defect based on a traditional definition of oxidizing materials, as described elsewhere in this report.

Perhaps a more important attribute of chlorine is its toxicity. Even though it is not so poisonous as others of the 100 dangerous materials, it must be shipped with a poison placard on which the POISON GAS lettering has been replaced by "CHLORINE." Oxygen is the only other material shipped with its identification on the placard.

The hazard profiles, Figure IV-14, are nearly as hetrogeneous as the corresponding hazard spectra. The environmental and safety categories are uniformly moderate, the latter due to a combination of cryogenic and irritant properties. Chlorine gas is moderately corrosive to ferrous metals even in very dilute mixtures with air. Ammonia and sulfur dioxide are distinctly less corrosive; moisture makes the effect more pronounced. Fire and kindred phenomena distinctly alter the toxicity of several of

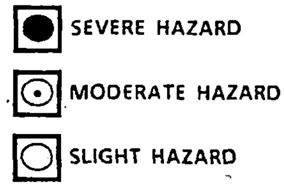

Figure IV-14. Hazard Profiles for the Non-Flammable Gases

SULFUR DIOXIDE	CHLORINE	CARBON DIOXIDE	AMMONIA		
			⊙	IGNITION	ALL ACCIDENTS
	●			OXIDATION	
○	⊙		○	CORROSION	
⊙	⊙	⊙	⊙	ENVIRONMENTAL	
				WATER	
⊙	⊙	⊙	⊙	SAFETY	
○	○	○		EXPLOSION	FIRE
⊙	⊙		⊙	TOXICITY	
				EXPLOSION	NO FIRE
⊙	●		○	TOXICITY	

these materials, and chlorine presents a severe oxidation hazard as discussed. The lack of recognition of the explosiveness of anhydrous ammonia is puzzling and may be based on a lack of experience in the U.S. transportation industry. Instances of explosions in ammonia plant operations have been reported.

9. Poison A Materials

These three gaseous materials all present a severe inhalation toxicity threat. As shown in the hazard spectra, Figure IV-15, all are "RQ Materials" and are destructive to accident scene materials when wet; as liquefied materials they are also cryogenic hazards. Flammability and poisonous combustion product threats are also among the presented hazards. The hazard profiles, shown in Figure IV-16, are dominated by the severe toxicity threat either with or without the presence of fire, and by the severe threat of explosion in a fire. There is a moderate-to-severe environmental danger as well, and for hydrogen cyanide there are ignition and flashback (explosion) hazards for the released material. For such a small group of materials these profiles present a formidable range of dangers.

10. Poison B Materials

At an accident scene where these materials have been released, workers should be in protective clothing to guard against skin toxicity, and, in the event of exposure to heat, all of the Poison B materials in this study produce poisonous fumes. While all will burn, toluene diisocynate (TDI), an ingredient in polyurethane paint, does not meet the flash point criterion for combustible liquids as indicated in the hazard spectra in Figure IV-17. TDI can be ignited with difficulty, however. The corresponding hazard profiles, Figure IV-18, show uniform moderate-to-severe ignition, environmental, and worker hazards as well as toxicity hazards in both fire and non-fire situations. Motor fuel antiknock compounds present either a moderate (combustible liquid) hazard or severe (flammable liquid) hazard depending on formulation, including solvent.

In addition to skin and inhalation toxicity, these materials also present significant oral toxicity threats. Such oral toxicity

	POISON A	FLAMMABLE GAS	NON-FLAMMABLE GAS	FLAMMABLE LIQUID	ORM-B	POISONOUS COMBUSTION PRODUCTS	RQ MATERIAL	CRYOGENIC HAZARD	DANGEROUS WHEN WET
CYANOGEN CHLORIDE	●		●		●	●	●	●	●
HYDROCYANIC ACID	●	●		●		●	●	●	●
PHOSGENE	●		●		●		●	●	●

● SATISFIES HAZARD CLASS DEFINITION OR POSSESSES INDICATED ATTRIBUTE

Figure IV-15. Hazard Spectra for The Poison A Materials

	ALL ACCIDENTS						FIRE		NO FIRE	
	IGNITION	OXIDATION	CORROSION	ENVIRONMENTAL	WATER	SAFETY	EXPLOSION	TOXICITY	EXPLOSION	TOXICITY
CYANOGEN CHLORIDE				●	○	○	●	●		●
HYDROCYANIC ACID	●			●		○	●	●	⊙	●
PHOSGENE				⊙	○	○	●	●		●

● SEVERE HAZARD

⊙ MODERATE HAZARD

○ SLIGHT HAZARD

Figure IV-16. Hazard Profiles for the Poison A Materials

	POISON B	IRRITATING MATERIAL	COMBUSTIBLE	ORM-B	POISON LABEL REQUIRED	POISONOUS COMBUSTION PRODUCTS	CHRIS WARNING	RQ MATERIAL
ANILINE OIL	●	●	●		●	●	●	●
MOTOR FUEL ANTIKNOCK CMPD	●		●		●		●	
PHENOL	●		●	●	●	●	●	●
TOLUENE DIISOCYANATE	●	●			●	●	●	

● SATISFIES HAZARD CLASS DEFINITION OR POSSESSES INDICATED ATTRIBUTE

Figure IV-17. Hazard Spectra for Poison B Materials

	ALL ACCIDENTS						FIRE		NO FIRE	
	IGNITION	OXIDATION	CORROSION	ENVIRONMENTAL	WATER	SAFETY	EXPLOSION	TOXICITY	EXPLOSION	TOXICITY
ANILINE OIL	⊙			⊙		⊙		⊙		●
MOTOR FUEL ANTIKNOCK COMPOUND	●			●		⊙	○	⊙		●
PHENOL	⊙		⊙	⊙		⊙	○	⊙		⊙
TOLUENE DIISOCYANATE	○			●	○	⊙		●		●

● SEVERE HAZARD

⊙ MODERATE HAZARD

○ SLIGHT HAZARD

Figure IV-18. Hazard Profiles for Poison B Materials problems can be minimized by a combination of protective clothing, good personal habits, and careful worker management. Breathing apparatus is the only protection against the toxic combustion products.

11. ORM-A Materials

Figure IV-19 shows the hazard spectra for ORM-A materials. As ORM-A materials they are nuisances or noxious materials that are also environmentally hazardous (RQ) substances. One of them, maleic anhydride, is very reactive toward many of the other 100 hazardous materials. Both of the profiled materials will produce poisonous combustion products; carbon tetrachloride, for example, may form phosgene, one of the Poison A gases. Carbon tetrachloride was also one of the first of the chlorinated solvents to be regulated by industrial workplace safety standards.

The corresponding hazard profiles, Figure IV-20, indicate that while the severity of the hazards is generally less than for some of the other hazard classes, the range of active hazard categories compares with most other hazard classes. That is, reduction in the level or degree of danger is not matched by a corresponding reduction in the range of hazards that must be recognized and dealt with at an accident scene.

12. ORM-E Materials

The sole representative of this class, dinitrotoluene, is used in the manufacture of dyestuffs and explosives. The hazard spectrum, Figure IV-21, reveals that this material is an environmentally hazardous (RQ) material and, like other nitrogen-containing materials, burns to produce dangerous combustion products. The corresponding hazard profile, Figure IV-22, displays a moderate toxicity rating by the material itself as well as by the combustion products; the environmental category also has a moderate rating. The flash point, 404°F, is quite high and indicates that the material is difficult to ignite.

13. Generically - Described Materials

For those materials not specifically provided for in the DOT Regulations, there are a number of generic proper shipping names that may be used, together with their associated hazard classes. The hazard profiles for such materials, Figure IV-23, are quite simple because the

	ORM-A	VIOLENTLY REACTIVE-COMMON MATERIALS	POISONOUS COMBUSTION PRODUCTS	CHRIS WARNING	RQ MATERIAL
CARBON TETRACHLORIDE	●		●	●	●
MALEIC ANHYDRIDE	●	●	●		●

● SATISFIES HAZARD CLASS DEFINITION OR POSSESSES INDICATED ATTRIBUTE

Figure IV-19. Hazard Spectra for the ORM-A Materials

	ALL ACCIDENTS						FIRE		NO FIRE	
	IGNITION	OXIDATION	CORROSION	ENVIRONMENTAL	WATER	SAFETY	EXPLOSION	TOXICITY	EXPLOSION	TOXICITY
CARBON TETRACHLORIDE				⊙		○		●		○
MALEIC ANHYDRYDE	○			○			●	⊙		⊙

● SEVERE HAZARD

⊙ MODERATE HAZARD

○ SLIGHT HAZARD

Figure IV-20. Hazard Profiles for the ORM-A Materials

	ORM-E	POISONOUS COMBUSTION PRODUCTS	CHRIS WARNING	RQ MATERIAL
DINITROTOLUENE	●	●	●	●

● SATISFIES HAZARD CLASS DEFINITION OR POSSESSES INDICATED ATTRIBUTE

Figure IV-21. Hazard Spectrum for an ORM-E Material

Figure IV-22. Hazard Profile for an ORM-E Material

	ALL ACCIDENTS						FIRE		NO FIRE	
	IGNITION	OXIDATION	CORROSION	ENVIRONMENTAL	WATER	SAFETY	EXPLOSION	TOXICITY	EXPLOSION	TOXICITY
DINITROTOLUENE				⊙		○		⊙		⊙

⊙ MODERATE HAZARD

○ SLIGHT HAZARD

	FLAMMABLE LIQUID	CORROSIVE LIQUID	POISON B	IRRITATING MATERIAL	COMBUSTIBLE LIQUID	ORM-B	ORM-A
ALCOHOL, N.O.S.	●						
ALKALINE LIQUID, N.O.S.		●					
COMBUSTIBLE LIQUID, N.O.S.					●		
CORROSIVE LIQUID, N.O.S.		●					
FLAMMABLE LIQUID, N.O.S.	●						
POISONOUS LIQUID, N.O.S.			●				

● SATISFIES HAZARD CLASS DEFINITION

Figure IV-23. Hazard Spectra for Generically-Described Materials generic name communicates essentially no information other than the hazard class. For one material, Alcohol, N.O.S., some additional information is transmitted, but this is less than satisfactory. As indicated elsewhere in this report, Alcohol, N.O.S. covers a variety of spent, contaminated, or diluted alcohols or otherwise unlisted materials with unpredictable properties. This unpredictability in properties implies an unpredictability for the hazard spectra and thus a necessary unpredictability in the hazard profiles. That is, the very simple hazard spectra give rise to equally simple hazard profiles.

It is possible to quantify the hazard profile symbols to a numeric 0-3 scale and obtain an arithmetic average value for each hazard category across all profiles in a hazard class. While it might be argued that this average profile is biased, depending upon the particular commodities, there are two significant counter arguments. First, average profiles obtained from classes of a larger number of commodities will not be significantly disturbed by the odd, unusual material that might have been included in the list. Secondly, because emphasis was placed on the commodities with the highest shipping rates, the derived average profiles can be described as the most appropriate for the hazard classes.

Figures IV-24 through IV-27 compare by hazard class, the hazard profiles obtained from the profiles of the fully-described materials above. Even a casual examination of the comparisons between the generic and average profiles reveals a wealth of additional hazard information associated with fully-described materials that can only be guessed at with the corresponding generically-identified materials. While the generic identifiers may be adequate for situations 'normally incident to operations,' significant improvement is possible for abnormal operating incidents (i.e., accidents). This communications shortfall is comparable to the identification number that may identify ten or more commodities, many of them generic materials. By improving this area, the DOT Regulations could be more robust.

	All Accidents						Fire		No Fire	
	IGNITION	OXIDATION	CORROSION	ENVIRONMENTAL	WATER	SAFETY	EXPLOSION	TOXICITY	EXPLOSION	TOXICITY
ALCOHOL, N.O.S.	●									
FLAMMABLE LIQUID, N.O.S.	●									
AVERAGE FLAMMABLE LIQUID	●			⊙		○	⊙	○	⊙	⊙

● SEVERE HAZARD

⊙ MODERATE HAZARD

○ SLIGHT HAZARD

Figure IV-24. Hazard Profiles for Generic Flammable Liquids and an Average Flammable Liquid

	ALL ACCIDENTS						FIRE		NO FIRE	
	IGNITION	OXIDATION	CORROSION	ENVIRONMENTAL	WATER	SAFETY	EXPLOSION	TOXICITY	EXPLOSION	TOXICITY
COMBUSTIBLE LIQUID, N.O.S.	⊙									
AVERAGE COMBUSTIBLE LIQUID	⊙			⊙		○	○	⊙		○

⊙ MODERATE HAZARD

○ SLIGHT HAZARD

Figure IV-25. Hazard Profiles for a Generic Combustible Liquid and an Average Combustible Liquid

	ALL ACCIDENTS						FIRE		NO FIRE	
	IGNITION	OXIDATION	CORROSION	ENVIRONMENTAL	WATER	SAFETY	EXPLOSION	TOXICITY	EXPLOSION	TOXICITY
ALKALINE CORROSIVE LIQUID, N.O.S.			●							
CORROSIVE LIQUID, N.O.S.			●							
AVERAGE CORROSIVE MATERIAL	○		●	⊙	○	⊙	○	⊙		⊙

● SEVERE HAZARD

⊙ MODERATE HAZARD

○ SLIGHT HAZARD

Figure IV-26. Hazard Profiles for Generic Corrosive Materials and an Average Corrosive Material

	ALL ACCIDENTS						FIRE		NO FIRE	
	IGNITION	OXIDATION	CORROSION	ENVIRONMENTAL	WATER	SAFETY	EXPLOSION	TOXICITY	EXPLOSION	TOXICITY
POISON B LIQUID, N.O.S.										●
AVERAGE POISON B	⊙			●		⊙	○	⊙		●

● SEVERE HAZARD

⊙ MODERATE HAZARD

○ SLIGHT HAZARD

Figure IV-27. Hazard Profiles for a Generic Poison B Material and an Average Poison B Material

CHAPTER V
RECOMMENDATIONS

From the analysis of the DOT Regulations and from technical analyses of the hazards and other properties of 100 hazardous materials, a number of areas where improvements are desirable have been identified and should be addressed. Given the massive quantities of diverse hazardous materials transported by the railroads, and their associated hazards, a rail accident scene can quickly involve large numbers of civilians and their property several miles away from the immediate accident scene. Because the level of danger in such an accident can rise to severe levels almost instantly, it is imperative that immediate communication of the hazards be attained. It is also important to attain a high degree of dependability in the information communicated. The regulations should be structured in such a way as to fully portray the risks and dangers associated with an accident involving hazardous materials by recognizing that these dangers may extend well beyond the accident scene.

It is convenient to describe recommended improvements within the framework of the three broad areas used throughout this report: hazard identification, hazard classification, and hazard recognition.

Hazard identification deals with the delineation of individual hazards; the regulatory definitions of the hazard classes directly address this issue. A well-drawn hazard definition is the foundation of hazard regulation.

Hazard classification provides the regulatory machinery for dealing with those commodities displaying properties corresponding to two or more of the hazard identification definitions above. The assignment of a hazard classification from among the presented hazards is accomplished using a prioritized list of hazards. The order of hazard classes is, in fact, the entire classification system for multi-hazard materials.

The issue of hazard recognition pertains to a number of derivative requirements, such as marking, labeling, placarding, and shipping papers, which serve to communicate the outcomes of the hazard classification process to shippers, carriers, loaders, and others who must deal with a material and its transportation requirements. Hazard recognition issues are the measures of adequacy in hazard identification and classification.

A. HAZARD IDENTIFICATION ISSUES

Analyses have revealed specific questions about the definitions of three hazard classes: oxidizing materials, corrosive materials, and poisons. In addition, the presence in the DOT Regulations of separate hazard classifications for irritating materials, ORM-A (noxious) materials, ORM-C (unfit for transportation unless regulated) materials, and ORM-E (hazardous by designation) materials provide a degree of complexity not warranted by regulatory practice. The ORM-B (damaging to rail cars) materials show a concern for a carrier's equipment more properly dealt with through trade associations than in the regulations.

1. Oxidizing Materials

The definition of oxidizing materials in terms of oxygen transfer is inconsistent with modern chemistry. Oxidizing materials are oxidizing agents -- materials that gain and release electrons in the modern chemical sense -- and materials that react by oxygen transfer are an important subclass of oxidizing materials.

There are a variety of classes of oxidation reactions and the participants in several of these ought to be excluded from this hazard class because they do not represent hazards in transportation. Galvanic and other electrolytic processes such as rusting are important reactions, but proceed at a pace so slow as to not constitute a hazard within the lifetime of an active accident scene. Ferric chloride solutions (among the list of 100) have this potential, but the property may be neglected at an accident scene. They are considerations in container selection.

The DOT Regulations presently define oxidizers in terms of combustion processes. The revised definition should be cast in terms of electron transfer reactions and, to exclude slow processes, should also be cast in terms of combustion and phenomenologically similar processes.

2. Corrosive Materials

The DOT Regulations define corrosive materials in terms of their effects on steel and on human skin. The former is a readily recognized attribute of corrosive materials, and if the latter can also be regarded as an attribute of corrosives, it can also be considered to be a non-lethal toxic effect. A more appealing and useful definition would be to define the behavior of corrosives in terms of their behavior toward steel and aluminum as discussed in Chapter IV. For aqueous solutions an alternative criterion to the National Association of Corrosion Engineers corrosion test is a test of the acidity or alkalinity of the solution. This corresponds to the laboratory measurement of pH, a routine procedure performed in five minutes by any laboratory dealing with such materials. Corrosive materials would be those whose pH lies outside the range 2.0 to 12.0.

3. Poisonous Materials

The DOT Regulations attempt to define poisons in terms of lethality and hazard (mobility). While the qualitative descriptions for poison A and poison B, together with those for irritating and ORM-A materials, provide a more or less satisfying continuum of dangers, the extreme subjectivity of the descriptions make them virtually impossible to implement for new materials.

The quantitative lethal criteria associated with poison B (hazardous to health) materials are so low as to be unreasonable standards for all but the most deadly of poison A (dangerous to life) materials. Thus these quantitative standards should be revised. Hazardous-to-health materials should be less toxic than those that are dangerous to life.

The mobility of released poisonous materials, often expressed in terms of route of entry into the body, is an extremely important aspect of toxicity assessment. The DOT Regulations attempt to incorporate this consideration by requiring class A poisons to include only poisonous gases and vapors of volatile liquids, and relegating liquids and solids to the poison B class. This does not adequately address the problem.

Lastly, the DOT Regulations strongly imply, but fail to explicitly require that only toxic materials acting via a systemic mechanism are regarded as poisons, and that those materials acting via corrosive mechanisms are not poisons. This should be changed for two reasons. First, the rules should be more explicit, one way or the other, to remove the ambiguity and make the implementation of the DOT Regulations less prone to misapplication. Second, if corrosive poisons are excluded, the DOT Regulations fail to properly identify toxic materials that have the same kinds of mobilities and routes of entry as systemic poisons. Far more important, the outcomes of inhalation, oral ingestion, or skin absorption of corrosive poisons are the same as systemic poisons, incapacitation and death. As a practical matter, dealing with corrosive poisons entails the same considerations as systemic poisons, and failure to properly identify potential lethal materials can only increase the dangers of hazardous materials spills.

Addressing these shortfalls in a practical, understandable manner might produce the recommended standards for poisons shown in Table V-1:

TABLE V-1. RECOMMENDED TOXICITY STANDARDS

- Inhalation toxicity criterion has two parts
  - LC_{50} less than 5000 ppm, and
  - for volatile liquids, LD_{50} less than 10 times saturated vapor pressure
- Oral toxicity LD_{50} less than 500 mg/kg
- Skin toxicity LD_{50} less than 1000 mg/kg
- Etiological agents

Consideration might be given to LC_{50} values for the inhalation toxicity of dusts and mists, and to differentiation of LD_{50} values for oral toxicity of liquids and solids.

By implementing different requirements for different routes of entry, issues pertaining to different levels of danger arising from different forms and their mobilities become self-resolving. Inhalable airborne dust and mist standards should mirror the tendency toward sedimentation as a mobility-limiting factor; the respirable fraction of dusts and mists is another issue to be considered. Casting the inhalation toxicity in terms of ppm (parts per million) brings the DOT Regulations into alignment with traditional methods for reporting inhalation toxicity observations; it is equivalent to the present norm -- mg/liter.

By making the criteria so large, the definition of poison will hopefully identify and more carefully regulate a number of materials and situations where incapacitation rather than fatality is the outcome. For airborne risks, it is hoped that standards such as these will decrease the hazards toward any civilian population that might be downwind from an accident scene. Deletion of consideration of systemic <u>versus</u> corrosive mechanisms is directed toward the same results.

4. Consolidation of Hazard Classes

A number of hazard classes and subclasses produce complexity in the DOT Regulations without concomitant benefits. It is recommended that most of these be consolidated and the remainder discarded. Combustible liquids and flammable solids should be grouped with flammable liquids into a superclass. Also, the ORM subclasses should be realigned into three subclasses as follows. A new name must be developed for this class to prevent confusion.

a. New ORM-A Materials

This proposed subclass of materials includes materials presenting an unacceptable danger to, or effect upon humans, the environment, or transportation equipment. Included are irritating materials and ORM subclasses A-C.

b. New ORM-B Materials

This new ORM subclass includes all materials subject to the USEPA hazardous waste manifest system (40 CFR 262) and not described by an non-ORM hazard class. The purposes served here are to clarify the status of hazardous waste; isolation from other criteria should further reduce ambiguity and improve maintenance of the DOT Regulations. There are associated hazard recognition recommendations below.

c. New ORM-C Materials

The proposed new class consists of those materials unsuitable for transportation unless subject to regulation, and not described by any other hazard class. Materials are assigned to this class by USDOT and not by shippers or carriers. It is expected that consideration of generally -- and specifically -- authorized container requirements will be given these materials. Exempted consumer goods (ORM-D) fall into this class.

5. New Hazard Class

It is proposed that the hazards of pyrophoric (spontaneously igniting) materials be formally recognized as a serious hazard. The technical analyses of Chapter IV have revealed the dominating role that fire can play at an accident scene, and prevention of fires should have a significant positive effect on accident spill containment and cleanup. An indication of the presence of such self-igniting materials should be promptly available. A unique placard or other on-container identifier as well as a reference in the shipping paper is appropriate.

6. <u>Proper Shipping Names</u>

The selection of the most appropriate proper shipping name from the Table is not always an easy task. To improve this process significant changes in the DOT Regulations would be required to assure that the proper shipping name selected is the most appropriate, most fully-descriptive one available for the commodity. It is recommended that the Table be split into four parts:

- Explosives - because of their distinctive regulatory treatment
- Other fully specified materials
- Commodity class generic materials (e.g. Alcohol, N.O.S. and Industrial Cleaning Solvent, N.O.S.)
- Hazard class generic materials (e.g., Flammable Liquid, N.O.S)

The DOT Regulations should clearly state that the shipper must examine each of the first three of these tables in turn until an appropriate proper shipping name is found that describes the commodity.

If no entry is found in any of the first three tables, then the shipper should be required, on the basis of knowledge and testing of the material, to select a name appropriate to the material from the fourth table, using the hazard hierarchy (discussed below) to guide selection of the most appropriate name.

If the shipper selects a name from the fourth table, and if either a high annual shipping rate is anticipated or if a large quantity is shipped in one container, the shipper should be required to notify USDOT. In turn, USDOT should monitor these reports and obtain additional information from the shipper. This permits extension and refinement of one of the other three tables to keep the material identification procedures up to date. Alternative proposals, such as monthly, quarterly, or annual reporting may prove to be a more satisfactory process. The objective is to give the Office of Hazardous Materials Transportation a formal, timely means for learning about new hazardous materials being offered for rail transportation.

B. HAZARD CLASSIFICATION ISSUES

The hazard profiles developed in Chapter IV clearly indicate a multiplicity of hazards associated with all nongeneric materials investigated, even though the profile hazard categories did not correspond to regulatory hazard classes. This indicates that the critical aspect of the hazard classification scheme is the hierarchy of hazards and not the individual hazards themselves. Well-drawn hazard definitions, however, give robustness to the classification process, while poorly drafted definitions can only degrade the classification process. In this light, the hierarchy of hazards must be the centerpiece of the classification system.

It is not entirely clear from the regulations themselves that a hierarchical scheme is required for the domestic regulation of rail transportation of hazardous materials. If there are external forces demanding such a scheme, the outcomes of the technical analysis point toward an improved hierarchy. These same results also suggest that non-hierarchical approaches would better protect the public. An alternative hierarchy is presented below, followed by a non-hierarchical regulatory scheme.

The driving considerations in prescribing a possible alternate hierarchy of hazards, as in Table V-2, are the nature of the classification hazard and the magnitude of potential hazards in an accident. Radioactive materials stand at the top because they can be recognized only by external information (marking, placarding, and shipping papers) or special instruments. The manifestation of the hazard is so undetectable as to warrant the highest position. That the effects of exposure to most forms of radioactive materials are delayed increases the hazard and reinforces the placement atop the list.

The devastating effects of an explosion, including container movement and rupture, as well as general spreading of the hazards, is the basis for explosives in the second position. The presence of compressed gases in the next hierarchical position also derives largely from the explosion hazard as revealed in the hazard profiles and accident experience of

TABLE V-2. ALTERNATE PREFERENCE TABLE CLASSES AND SUBCLASSES

1. Radioactive Materials
2. Explosives
   - A. Equivalent to current Explosives A
   - B. Equivalent to current Explosives B
   - C. Equivalent to current Explosives C
   - D. Equivalent to current Blasting Agents
3. Compressed Gases
   - A. Gases that meet the proposed inhalation toxicity criteria
   - B. Equivalent to current Flammable Gases
   - C. Equivalent to current Non-Flammable Gases
4. Flammable Materials
   - A. Pyrophoric Materials
   - B. Equivalent to current Flammable Liquids
   - C. Equivalent to current Combustible Liquids
   - D. Equivalent to current Flammable Solids
5. Poisonous Materials
   - A. Liquids meeting any of the proposed toxicity criteria
   - B. Solids meeting any of the proposed toxicity criteria
   - C. Etiological Agents
6. Oxidizers and Peroxides
7. Corrosive Materials
8. Other Regulated Materials
   - A. Dangerous, irritating, and noxious materials as described
   - B. Hazardous Waste
   - C. Materials unfit for transportation unless regulated

Chapter IV. Within the gases, the poisonous ones are first, reflecting the importance associated with the toxic properties of this very mobile class of materials.

The nongaseous ignitable materials have been consolidated into the Flammable Materials class with four subclasses. Pyrophoric materials are regarded as the most dangerous of these because of the high degree of certainty of their ignition. Positions of the other subclasses is determined by the mobility and flashpoints of the materials. Their collective position before the poisonous liquids and solids is based on mobility and degree-of-hazard judgements.

Oxidizing materials, corrosive materials, and ORM's close out the list in that order. The sequence of ORM subclasses is not regarded as significant as, for example, the compressed gases.

Table V-3 shows that the consequences of the possible alternative hierarchical classification scheme involves the reclassification of less than 10 percent of the 100 hazardous materials. Table V-3 lists the 100 hazardous materials, grouped into their currently assigned hazard classes; part of the current-hazard-class heading is a symbolic indication of the best match to the alternative scheme in Table V-2. In making the assessments in Table V-3 the criteria for volatile liquids presently classified as compressed gases have been changed as follows. Materials with an in-container pressure greater than 40 psi at 70°F are currently classified as compressed gases; simple calculations suggest that these materials have boiling points of about 30°F or less. For the assessment in Table V-3, materials with a boiling point of 80°F or less were considered volatile liquids and treated as compressed gases. Toxicity criteria used were the recommended values in Table V-1 rather than those currently in the DOT Regulations.

Most of the half dozen or so changed classifications represent recognition of poisonous characteristics; there might have been a few more changes with better Commodity Sheet data and a more thorough analysis. Detailed vapor pressure data, for example, were not consulted

TABLE V-3. COMPARISON OF ALTERNATIVES TO CURRENT HIERARCHICAL CLASSIFICATION SCHEME

Commodity[1]	Possible Alternative Hierarchy[2,3]	Currently Required Labels[4]	Hazard Designators[5]
Flammable Liquids - 4B			
Acetaldehyde	4B	FL	CEITL2
Acetone	3A*	FL	EITL2
Acrolein, Inhibited	4B	FL,P	CEITL23
Acrylonitrile	3A*	FL,P	CEITL23
Benzene	4B	FL	ITL
2-Butanol	4B	FL	EIL2
Carbon Bisulfide or Carbon Disulfide	4B	FL	EITL23
Chloroprene, Inhibited	3A*	FL	EITL23
Cyclohexane	4B	FL	EITL2
Denatured Alcohol	4B	FL	ITL
Epichlorohydrin	4B	FL	EITL23
Ethylene Oxide	4B	FL	CEIL
Ethyl Alcohol, Anhydrous, Denatured	4B	FL	ITL
Ethyl Acetate	4B	FL	EITL2
Ethyl Acrylate, Inhibited	4B	FL	EITL23
Ethyl Benzene	4B	FL	ITL
Ethyl Chloride	4B	FL	EITL23
Fuel, Aviation, Turbine Engine	4B	FL	ITL
Gasoline, Blended	4B	FL	ITL3
Gasoline, Casing Head	4B	FL	ITL
Hexane	4B	FL	EITL2
Isopropanol	4B	FL	ITL
Methanol	4B	FL	EITL2
Methanol, Contaminated	4B	FL	EITL2
Methyl Ethyl Ketone	4B	FL	EITL2
Methyl Isocynate	4B	FL,P	CEITL23
Methyl Methacrylate Monomer, Inhibited	4B	FL	EIT2
Naphtha	4B	FL	EITL2
Petroleum Naphtha	4B	FL	EITL2
Petroleum, Partially Refined	4B	FL	EITL2
Propylene Oxide	4B	FL	EITL2
Rosin Solution	4B	FL	ITL
Styrene Monomer, Inhibited	4B	FL	EITL2
Toluene	4B	FL	ITL3
Vinyl Acetate	4B	FL	EITL2
Xylene	4B	FL	EITL3

TABLE V-3. COMPARISON OF ALTERNATIVES TO CURRENT HIERARCHICAL CLASSIFICATION SCHEME (CONTINUED)

Commodity[1]	Possible Alternative Hierarchy[2,3]	Currently Required Labels[4]	Hazard Designators[5]
Combustible Liquids - 4C			
Butyl Acrylate	4C	None	IL23
Creosote, Coal Tar	4C	None	ITL2
Formaldehyde Liquid	4C	None	ITL2
Fuel Oil, No. 1,2, 4, or 5	4C	None	ITL2
Naphtha	4C	None	ITL
Octyl Alcohol, other than perfumery grade	4C	None	ITL2
Petroleum Distillate Fuel Oil, not for illuminating purposes	4C	None	ITL
Flammable Solids - 4D			
Calcium Carbide	4D	FSW	ITS123
Phosphorus, White or Yellow, in water	4A*	FS,P	CIPTS23
Sodium, Metallic	4A*	FSW	CIPTS123
Oxidixing Materials 6			
Ammonium Nitrate Fertilizer, not more than 0.2% carbon	6	OM	IOS23
Hydrogen Peroxide Solution, over 52% peroxide	6	OM, CM	COL2
Nitric Acid, Fuming	5A*	OM, P	COTL23
Potassium Nitrate	6	OM	OTS23
Sodium Chlorate	6	OM	COTS23
Sodium Nitrate	6	OM	OTS23

TABLE V-3. COMPARISON OF ALTERNATIVES TO CURRENT HIERARCHICAL CLASSIFICATION SCHEME (CONTINUED)

Commodity[1]	Possible Alternative Hierarchy[2,3]	Currently Required Labels[4]	Hazard Designators[5]
Corrosive Materials - 7			
Acetic Acid, Glacial	7	CM	CITL23
Acetic Anhydride	7	CM	CITL123
Caustic Soda and Caustic Potassium, mixed, in solution	7	CM	CLT123
Ferric Chloride Solution, Crude, at least 50% water	7	CM	CTL3
Hexamethylenediamine Solution	7	CM	CITL3
Hydrochloric Acid	7	CM	CTL123
Hydrofluosilicic Acid	5A*	CM	CTL13
Hydrogen Fluoride, Anhydrous	5A(3A?)*	CM	CTV13
Oleum	7	CM	CTL13
Phosphatic Fertilizer Solution	7	CM	CTL3
Potassium Hydroxide, Liquid or Solution	7	CM	CTL23
Sodium Hydrosulfide, Solution	5A*	CM	CTL3
Sodium Hydroxide, Liquid	7	CM	CTL123
Sodium Hydroxide, Liquid or Solution, at least 48% water	7	CM	CTL123
Sulfuric Acid	7	CM	CTL13
Sulfuric Acid, Spent	7	CM	CTL13
Flammable Gases - 3B			
Butadiene	3B	FG	ITG23
Butane	3B	FG	IG2
Butene Gas, Liquefied	3B	FG	ITG2
Ethylene	3B	FG	ITG2
Isobutane	3B	FG	IG2
Isobutane, for further refinery processing	3B	FG	IG2
Isobutylene	3B	FG	IGT2
Liquefied Petroleum Gas	3B	FG	IG2
Methyl Chloride	3B	FG	CITG23
Propane	3B	FG	IG2
Propylene	3B	FG	ITG2
Vinyl Chloride	3B(3A?)	FG	CITG23

TABLE V-3. COMPARISON OF ALTERNATIVES TO CURRENT HIERARCHICAL CLASSIFICATION SCHEME (CONTINUED)

Commodity[1]	Possible Alternative Hierarchy[2,3]	Currently Required Labels[4]	Hazard Designators[5]
Non-Flammable Gases - 3C			
Anhydrous Ammonia	3C	NFG	CITG3
Carbon Dioxide, Liquefied	3C	NFG	NG2
Chlorine	3A*	NFG,P	CONTG23
Sulfur Dioxide	3C	NFG	CNTG23
Poison A - 3A			
Cyanogen Chloride, less than 0.9% water	3A	FG,PG	NTV123
Hydrocyanic Acid, Liquefied	3A	FG,PG	ITV123
Phosgene	3A	PG	NTV123
Poison B - 5B/5C			
Aniline Oil, Liquid	5B	P	ITL3
Carbolic Acid or Phenol	5A or 5B	P	CITL23
Motor Fuel Antiknock Compound	5A	P	ITL23
Toluene Diisocynate	5A	P	ITL3
ORM-A - 8A			
Carbon Tetrachloride	8A	None	TL3
Maleic Anyhydride	8A?	None	ITL23
ORM-E - 8C			
Dinitrotoluene	8C	None	TL3

TABLE V-3. COMPARISON OF ALTERNATIVES TO CURRENT HIERARCHICAL CLASSIFICATION SCHEME (CONTINUED)

Commodity[1]	Possible Alternative Hierarchy[2,3]	Currently Required Labels[4]	Hazard Designators[5]
Generics			
Alcohol, NOS (Flammable Liquid)	4B	FL	IL
Alkaline Liquid, NOS	7	CM	CL
Combustible Liquid, NOS	4C	None	IL
Corrosive Liquid, NOS	7	CM	CL
Flammable Liquid, NOS	4B	FL	IL
Poisonous Liquid, NOS	5A	P	TL

1. Materials are listed by their AAR identifiers rather than proper shipping name to minimize the numbers of generic identifiers.
2. An asterisk (*) indicates new hazard class assignment
3. Based on Table V-1 hierarchy
4. Based on the Hazardous Materials Table (49 CFR 172.101). Symbols are as follows for labels:

   CM = Corrosive Material
   P = Poison
   PG = Poison Gas
   OM = Oxidizing Material
   FG = Flammable Gas
   FL = Flammable Liquid
   FS = Flammable Solid
   FSW = Flammable Solid - Dangerous When Wet

5. See Table V-4 for symbols

and some judgement calls were made on the basis of boiling points and prior experience with liquid-vapor phase equilibria. This approach, even with the broader criteria for volatile liquids used for Table V-3, is potentially treacherous - not all liquids behave in typical fashion.

Examination of a single hazardous materials accident reveals the difficulty inherent in hierarchical classification schemes, consideration of situations normally incident to rail transportation, and the problems they create. A recent industrial accident in Bhopal, India resulted in the deaths of several thousand people due to the inhalation of methyl isocyante (MIC) released into the atmosphere as a result of the accident. The methyl isocyanate escaped into the atmosphere because the material, with a boiling point of 102.4°F, allegedly had been heated by chemical processes resulting from the addition of water before failure of a manufacturing container. Several points need to be made here.

First, the extensive reaction of MIC prior to release greatly increased the scope and degree of hazard beyond that which might be expected from an ambient-temperature spill of the liquid.

Second, the Bhopal event clearly illustrates the dependency of hazard presentation upon associated events. There was no fire associated with the Bhopal release so that its flammbility was of no consequence in that event. After October 1, 1986 the Regulations recognize the toxicity of vapors emitted by MIC and certain other volatile liquids because of a change in the regulations prompted by the Bhopal tragedy. Still not recognized in the regulations is the violent reaction of MIC with water (the basis of the Bhopal release) or any of the other hazards that might be associated with the handling and shipping of MIC. Chapter IV was devoted to illustrating that MIC is not an isolated example, suggesting that a more extensive recognition of the hazards of hazardous materials is warranted.

Interestingly enough, such provisions for broader disclosure already exist in the Regulations in the form of labeling standards for small packages. While requirements for multiple labeling are extensive, they are not as complete as they might be. To illustrate the extent to which multiple labeling (or placarding) can be used, a hazard designation scheme has been developed and is presented in Table V-4. Use of the hazard designation scheme is simple and straightforward, requiring only knowledge of which hazard criteria are met by a particular material. With this in mind, consultation of the Hazard Designation Table, Table V-4, produces a hazard designation using the following simple rules:

- Hazard designators are selected from the left column if the material satisfies the hazard criteria,
- A physical state designator is selected from the right column
- As many of the supplemental designators as appropriate are selected for the full description of the material.

TABLE V-4. HAZARD DESIGNATION TABLE

Hazard Designator (Symbol)	Physical State (Symbol)
Corrosive (C)	Compressed Gas (G)
Explosive (E)	Liquid (L)
Ignitable (I)	Solid (S)
Non-Flammable (N)	Volatile Liquid (V)
Oxidizing (O)	
Pyrophoric (P)	
Radioactive (R)	
Toxic (T)	

Supplemental Designators

1. Hazardous When Wet
2. Explosive in a Fire
3. Toxic Combustion Products

Using this scheme vinyl chloride, a corrosive, toxic, flammable gas that may explode in a fire and release toxic combustion products, would be designated CITG23.

The hazard designator scheme has been applied to the 100 hazardous materials using the hazard profiles developed in Chapter IV together with recommended changes in hazard designations and the results are shown in Table V-3 together with current labeling requirements. The outcomes of hazard designation can, of course, be used to augment present labeling and placarding standards, but its relationship to the present hazard classification scheme needs more careful scrutiny.

The present hazard classification scheme, or any hierarchical classification system, implicitly assumes that, for every material, there is a "preferred" hazard to be designated, and that other presented hazards are subsidiary to it. Any hierarchical classification system not requiring multiple placards for a multiple-hazard material does not provide complete information about some of the dangers of hazardous materials. That is, an hierarchical order represents a calculated risk and an assignment of relative value; these activities do not give complete protection of the public.

An alternative to hierarchical classification is required, and may be found by extending the current labeling requirements to placarding. Multiple labeling is extensively required for hazardous materials, and similar standards could be developed for placards. The application of the Hazard Designator Table, Table V-4, to the 100 hazardous materials reveals that the designator system approach is workable for identifying and characterizing hazards. Extensions to address environmental hazards and loader/unloader/spill-cleanup-worker may be desirable. The designator system, because it does not have hazard classes, does not provide a number of features that are embedded in the present hierarchical scheme such as container selection and consist and switching standards. Present regulations can be adapted for operating standards by rephrasing from requirements based on hazard classes to those pertaining to rail cars bearing the associated placard (or labels in the case of cargo tanks and portable tanks with a capacity of less than 1000 gallons being carried in

COFC/TOFC service). Every material has authorized containers and these may be grouped, designated in the DOT Regulations, and referenced from tables such as the Hazardous Materials Table. The recent proposal to change standards for small containers (47 FR 26172; Docket HM-181) clearly reveals that such changes are not impossible.

The hazard designation scheme, Table V-4, or an extension of labeling standards rejects assumptions about the need for hazard hierarchies and replaces hazard classification with hazard designation. Effectively, a "designated primary hazard" is replaced by a full, or perhaps fuller, disclosure of hazards. Given the complexity of modern materials, hazard designation is more appropriate than hierarchical classification.

C. HAZARD RECOGNITION ISSUES

The three hazard recognition issues to be dealt with are marking, placarding, and shipping papers. As a minimum, adjustment of existing requirements for these areas is required to harmonize them with the issues raised in Chapter IV as well as with the identification and classification recommendations above.

1. Marking

It is recommended that the proper shipping name be "stenciled" to the car to replace the identification number; lettering should be four inches high and white on a black field. Given the modern materials available such a requirement is no more difficult to attain than the peel-and-reapply address labels used to mail magazines and Federal income tax forms. Permanent marking (e.g., painting) is not necessarily required; placards are not permanent. Proper shipping name holders, like placard holders, can be fastened to a rail car. Other options exist and details can be worked out with trade associations.

Identification numbers as found in The Hazardous Materials Table are not recommended for two reasons:

- They do not uniquely identify materials in all instances, and
- Their use requires supplemental information (e.g., a book) to "translate" the number.

The use of the diamond placard format is especially onerous because it requires the obscuration of hazard lettering information. This is a reduction in the quantity of information instantly transmitted from a rail car involved in an accident. This is especially important where the placard may be any of several different placards distinguished only by the lettering, such as for oxidizers and peroxides or flammable, combustible, and flammable gas. It is recommended, if the display of identification numbers is to be continued, that use of the diamond placard format be discontinued in favor of the panel format. Identification numbers and placards should be separate.

2. Placarding

A placard should be developed for pyrophoric materials to reflect their danger and importance in the classification scheme. It is also recommended that the corrosive placard not be changed even though there was a recommended change in the associated definition. Changing the definition does not alter the fact that these materials usually produce significant skin injuries, and retention of the current symbol is consonant with the principle of maximum transmission of information.

There is a more troublesome matter to be dealt with and that is the recognition of multiple hazards. The DOT Regulations require, in most instances, display of a single placard. In certain instances where the second hazard is toxicity, display of a poison placard also may be required. Given the near universality of hazard multiplicity, there is a need for additional hazard communication.

As described elsewhere in this report, labeling standards frequently require a second label on small containers to more fully describe the nature of the material. It is puzzling that similar standards have not been extended to placarding activities. Double placarding requirements, consonant with labeling norms, seem to be an appropriate, minimal, but relatively neglected regulatory option. Adoption of the hazard designation scheme and the abandonment of hazard classification is to be preferred.

There are several reasons to consider alternatives to double placarding. The hazard profiles developed in Chapter IV are a portrayal of hazards associated with particular materials, and some of the consolidated information did not fit into categories corresponding to regulatory hazard classes. Further, the toxicity and explosion hazards were found in Chapter IV to be dependent on fire at the scene. This all suggests that double placarding may not be an adequate solution. A number of alternatives are considered below as extensions to current placarding requirements.

3. Shipping Papers

To complement the other requirements for recognition of multiple hazards, additional information should be displayed on the shipping papers. The precise form and nature of this shipping paper information depends on the on-container identification of multiple hazards. For example, if a second placard is affixed to the container, there should be a second placard notation on the shipping paper as is required for the first. If an endorsement is required for the first placard, then an endorsement of the second placard, if different from the first, should also be entered on the shipping paper. If the hazard designation is employed, an appropriate plain-English entry should be made on the papers.

One other requirement, pertaining to the transportation of hazardous waste subject to USEPA manifest requirements (40 CFR 262), should be developed. The basic recommended requirement is to identify those constituents of hazardous waste shipment which are listed in the Hazardous Materials Table, the CERCLA table, the CWA table, or the CAA table of 49 CFR 172.101. A number of materials (e.g., hexachlorobenzene, tetrachlorobenzene, malonitrile, and thallium metal) are in the latter tables, but not the Hazardous Materials Table. The shipping paper should identify all USEPA hazardous constituents of a hazardous waste shipment even if not in the Hazardous Materials Table. It might be proper to set a lower shipment weight limit, such as 100 pounds, below which the requirement would be waived if there is no reportable quantity (RQ). Such a requirement would be in addition to any USEPA manifest requirement.

D. EXTENSIONS TO THE REGULATIONS

There are a number of ways that on-container hazard identifiers might be implemented. A few of these, such as identification numbers, proper shipping names, placards, and multiple placarding have been discussed above. There are several similar systems in use elsewhere, and their review is useful.

1. British Hazard Information System (UKHIS)

The heart of this system is a 16 by 28 inch multipart panel such as the one illustrated in Figure V-1, and a wallet card, Figure V-2, used to decode the emergency action information. The five part panel for acetic acid, redrawn to illustrate U.S. use, would contain: a placard, the previously-mentioned emergency action information, the UN or NA identification number, a source of specialist information, and the name of the shipper. The emergency action information consists of a digit and a letter. The former provides firefighting materials information decoded by the wallet card while the latter, also decoded by the wallet card, provides information about the potential for violent behavior, requirements for breathing apparatus versus full protective clothing, and whether spillage may be flushed or must be contained. A third character, E, if present, indicates the need to consider evacuation. Copies of the wallet card information may be printed on adhesive labels for application to clipboards, communications devices, emergency vehicles, and other useful locations.

The emergency action information sketches appropriate responses for early responders, but does not provide any direct insights into the hazards presented in an accident beyond those of the current classification system.

2. The ADR/RID System

The continental European system uses a two-part 12 by 16 inch panel such as Figure V-3. The lower part is the UN identification number, and the remarks about this identifier elsewhere are appropriate here.

The three-digit hazard indicator provides both primary and secondary hazard information. Table V-5 shows the hazards associated with

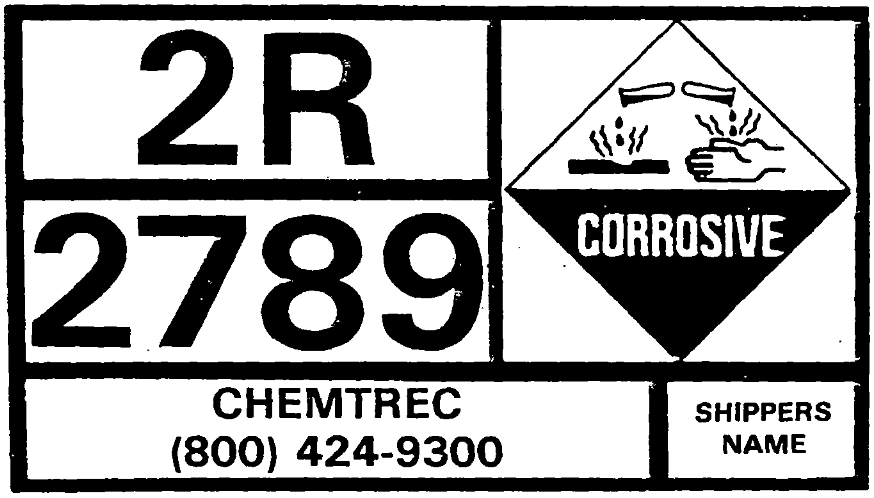

Figure V-1. The UKHIS Panel

Emergency Action
Code Scale
FOR FIRE OR SPILLAGE

1 JETS

2 FOG

3 FOAM

4 DRY AGENT

P	V	FULL	DILUTE
R			
S	V	BA	
S		BA for FIRE only	
T		BA	
T		BA for FIRE only	
W	V	FULL	CONTAIN
X			
Y	V	BA	
Y		BA for FIRE only	
Z		BA	
Z		BA for FIRE only	
E	CONSIDER EVACUATION		

Notes for Guidance

FOG
In the absence of fog equipment a fine spray may be used.

DRY AGENT
Water **must not** be allowed to come into contact with the substance at risk.

V
Can be violently or even explosively reactive.

FULL
Full body protective clothing with BA.

BA
Breathing apparatus plus protective gloves.

DILUTE
May be washed to drain with large quantities of water.

CONTAIN
Prevent, by any means available, spillage for entering drains or water course.

Figure V-2. The UKHIS Wallet Card

*5PW5068-31

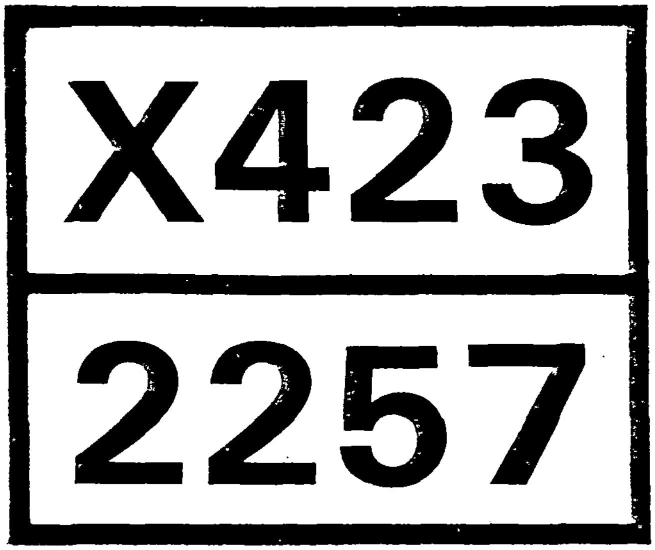

Figure V-3. The ADR/RID Hazard Panel

*5PW5068-32

TABLE V-5. ADR/RID PRIMARY HAZARDS

Digit	Interpretation
2	Gas
3	Flammable Liquid
4	Flammable Solid
5	Oxidizing Substance or Organic Peroxides
6	Toxic Substance
8	Corrosive

the first digit; these appear to correspond to the most frequently used hazard classes. The second and third digits display secondary hazards, as shown in Table V-6. An interesting feature of the system is that repetition of the first digit signifies an intensification of the primary hazard. Thus an 88 identifies a very corrosive material and a 22 indicates a refrigerated liquid. The other digits provide additional hazard information based on Table V-6. If the three-digit number is preceded by the letter X, as in the example in Figure V-3, the application of water is strictly forbidden. The panel in Figure V-3 represents metallic potassium, a very flammable solid that should not contact water and may evolve a gas (flammable hydrogen gas) if wetted. The system identifies hazards, but provides no early-responder guides.

TABLE V-6. ADR/RID SECONDARY HAZARDS

Digit	Interpretation
0	No Meaning
1	Explosion Risk
2	Possibility of Gas Being Given Off
3	Flammable Risk
5	Oxidizing Risk
6	Toxic Risk
8	Corrosive Risk
9	Risk of Violent Reaction from Spontaneous Decomposition or Self-Polymerization

REFERENCES

1. Perry's Chemical Engineers Handbook, 50th edition, McGraw Hill, D. W. Green, editor; page 3-73 has Henry's Law (partial pressure) data for methanol-water mixtures at 102°F and, page 4-67, graphs of activity coefficients for ethanol-water mixtures which should behave much like methanol-water mixtures.

2. A complete list of the 49-series STCC names and numbers can be found in the back of "Tarrif No. BOE-6000-D," May 1, 1984 edition issued by BOE/AAR.

3. Notice of Proposed Rulemaking (NPRM), 50 FR 5270-5279 (Docket Number HM-196). A telephone conversation with Mr. Darrel Raines on March 28, 1985 revealed that the deadline for comments had been extended to April 16, 1985. At the time of the call only one comment had been received.

APPENDIX A
DEFINITIONS

A number of terms used in this report are defined here. Those defined in Title 49 of the Code of Federal Regulations are identified by the regulatory part in parenthesis at the end of the definition.

"AAR" means Association of American Railroads.

"ASTM" means American Society for Testing and Materials. Information enclosed in parenthesis with "ASTM" refers to an ASTM specification or test standard.

"BOE" means the former Bureau of Explosives now called Hazardous Materials Systems; an agency of the Association of American Railroads.

"Cargo tank" means 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. Any packaging fabricated under specifications for cylinders is not a cargo tank. Examples are gasoline trucks and tractor-trailer tank trucks. (171.8)

"Carrier" means a person engaged in the transportation of passengers or property by rail. (171.8; modified).

"CFR" means Code of Federal Regulations.

"COFC" means container-on-flat-car. (171.8)

"Cylinder" means a pressure vessel designed for pressure 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. (171.8)

"Dedicated service" means the sole use of a rail car by a single consignor, consignee, and commodity for which all loading and unloading are carried out with the direct supervision of the consignee or consignor.

"DOD" or "USDOD" means the US Department of Defense.

"DOT" or "USDOT" means the US Department of Transportation

"EPA" or "USEPA" means the US Environmental Protection Agency.

"Exclusive use" (also referred to in other regulations as "sole use" or "full load") means the sole use of a conveyance by a single consignor and for which all initial, intermediate, and final loading and unloading are carried out in accordance with the direction of the consignor or consignee. Specific instructions for maintenance of exclusive use shipment controls must be issued in writing and included with the shipping paper information provided to the carrier by the consignor. (173.403(i))

"Flash point" means the minimum temperature at which a substance gives off flammable vapors which in contact with spark or flame will ignite. (171.8)

"FR" means the Federal Register.

"FRA" means the Federal Railroad Administration.

"Hazardous material" means substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. (171.8)

"Hazardous substance" means a material, and its mixtures or solutions, that is identified by the letter "E" in Column 1 of the Table to 172.101 when offered for transportation in one package, or in one transport vehicle if not packaged, and when the quantity of the material therein equals or exceeds the reportable quantity (RQ). This definition does not apply to petroleum products that are lubricants or fuels; or to a mixture or solution containing a material identified by the letter "E" in Column 1 of the Table to 172.101 if it is in a concentration less than that shown in the following table based on the reportable quantity (RQ) specified for the materials in Column 2 of the Table to 172.101:

RQ pounds	RQ kilograms	Concentration by weight	
		Percent	PPM
5000	2270	10	100,000
1000	454	2	20,000
100	45.4	0.2	2,000
10	4.54	0.02	200
1	0.45	0.002	20

"Hazardous waste" means any material that is subject to the hazardous waste manifest requirements of the EPA specified in 40 CFR Part 262 or would be subject to these requirements absent an interim authorization to a state under 40 CFR Part 123. Subpart F. (171.8)

"Labeling" means applying the required panel or diamond (square-on-point) numeric hazard identification symbols to small containers as prescribed in the Hazardous Materials Table, Column 4 of 49 CFR 172.101. It is the small container counterpart of placarding.

"Large container" means those containers subject to placarding requirements rather than labeling requirements and includes rail cars, portable tanks and freight containers in COFC service, containers and cargo tanks in TOFC service.

"LC_{50}" means the calculated concentration of a substance in air or water exposure to which, for a specified period of time, is expected to cause the death of 50% of an entire defined experimental animal population. LC_{50} is determined from the exposure to the substance of a significant number from that population.

"LD_{50}" means the calculated dose of a substance which is expected to cause the death of 50% of an entire defined animal population. The LD_{50} is determined from the exposure to the substance by any route of entry except respiration of a significant number from that population.

"Marking" means applying the descriptive name, instructions, cautions, weight, or specification marks or combination thereof required by this subchapter to be placed upon rail cars outside containers of hazardous materials. (171.8)

"NACE" means the National Association of Corrosion Engineers. Information enclosed in parenthesis with "NACE" refers to a NACE specification or test standard.

"OHMT" means Office of Hazardous Materials Transportation, the agency of the Department of Transportation responsible for the regulation of hazardous materials transportation.

"Outage" or "ullage" means the amount by which a packaging falls short of being liquid full, usually expressed in percent by volume. (171.8)

"Package" or "Outside Package" means a packaging plus its contents. (171.8)

"Packaging" means the assembly of one or more containers and any other components necessary to assure compliance with minimum packaging requirements and includes containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, and multi-unit tank car tanks. This word is frequently used in this report as a synonym for rail freight cars and COFC/TOFC containers used for transporting hazardous commodities.

"Poisonous" for this report is synonymous with "toxic" (qv).

"Placarding" means applying the diamond (square-on-point) hazard identification symbol to large containers as prescribed in 49 CFR 172.504.

"Placarded car" means a rail car which is placarded in accordance with the requirements of Part 172 of the DOT Regulations except those cars displaying only the FUMIGATION placards as required by 172.510. (171.8)

"Portable tank" means 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 rail car and equipped with skids, mounting, or accessories to facilitate handling of the tank by mechanical means. It does not include any cargo tank, tank car tank, or tank of the DOT-106A or 110A type. (171.8)

"Rail freight car" means a car designed to carry freight or non-passenger personnel by rail, and includes a box car, flat car, gondola car, hopper car, tank car, and occupied caboose. (171.8)

"Receiver" means the last person to whom a shipment is delivered; synonymous with "consignee".

"The DOT Regulations" or "These DOT Regulations" means Title 49 of the Code of Federal Regulations, Parts 171-174 and 178-179.

"Reportable quantity (RQ)" for the purposes of this subchapter means the quantity specified in Column 2 of the Hazardous Materials Table for any material identified by the letter "E" in Column 1. (171.8)

"Shipper" means the person who initially offers hazardous materials for transportation.

"Shipping paper" means a shipping order, bill of lading, manifest or other shipping document serving a similar purpose and containing the information required by 49 CFR 172.202, 172.203 and 172.204. A shipping paper, as defined here, does not necessarily comply with the USEPA hazardous waste manifest regulations (40 CFR 263, Subpart B). (171.8)

"Small container" means those containers subject to labeling requirements rather than placarding requirements, and includes cylinders bags, barrels, bottles, boxes, carboys, jugs and numerous other containers. Some portable tanks and freight containers also are subject to labeling standards.

"TOFC" means trailer-on-flat-car.

"Toxicity" for purposes of this report means the ability of a material to cause incapacitation, injury or death upon ingestion, inhalation, or contact with the skin, and acts by either a corrosive or systemic mechanism. Note that this definition does not correspond to the regulations of the Office of Hazardous Materials Transportation and that toxic materials do not necessarily produce lethal effects.

APPENDIX B
COMMODITY SHEETS

This appendix contains, in summary form, a variety of information for the 100 hazardous commodities identified in Chapter II of this report. The information presented here represents the commodity hazard contributions to the Hazard Profiles presented in Chapter IV. The pieces of information, individually and in combination, provide a broad general guide to the hazards that might be encountered at an accident scene involving these materials.

There are five sections to each Commodity Sheet: Identification Section; Hazard Summary; Shipping Physical and Chemical Data; Spill and Cleanup Hazards; and Toxicity Data. For some Commodity Sheets a sixth section, Other Information, has been added to record a variety of information including: an occasional regulatory anomaly; multiple-hazard information; or other information that may explain information found elsewhere on the Commodity Sheet.

A. <u>IDENTIFICATION SECTION</u>

This section provides both text and numerical identifiers for each material, in both USDOT and AAR notation. The USDOT proper shipping name and six-character identifier and the AAR's Standard Transportation Commodity Code (STCC) number and descriptor are supplied to fully identify each material. Also included is: the required placards; shipping rate (tank cars per year) when available; the hazardous materials incident reportable quantities (RQ's); and synonyms for the material.

Several of these materials have no unique names that are universally accepted. For example, hyrofluosilicic acid is the AAR's STCC descriptor of the same substance labelled by the USDOT proper shipping name hydrofluorosilicic acid. CHRIS refers to this material as fluosilicic acid, while DPIM, a standard reference text, lists the material under the heading hexafluorosilicate (2-) dihydrogen. An attempt was made to include under the synonym category the most commonly used names for each commodity.

Where the marking requirements or regulatory passages requires the "stenciling" of the commodity name on the tank car, this is noted by the phrase 'tank marking required' in association with the placard specification.

Where appropriate, the environmentally hazardous reportable quantity (RQ) is also shown.

B. HAZARD SUMMARY

This section provides, when available, an independent assessment of the hazards associated with the commodity. There are two classification schemes for rating the hazards, both using a five point numeric rating scale ranging from 0 (no hazard) to 4 (extreme hazard). Because they are more detailed, the ratings from the National Academy of Sciences (NAS) are preferred. A summary of the NAS rating system follows.

		Health		
Rating	Fire	Vapor Irritant	Liquid or Solid Irritant	Poisons
0/4	No hazard	No effect	No effect	No effect
1/4	Flash point (C.C.) above 140°F	Slight effect	Causes skin smarting	Slightly toxic
2/4	Flash point (C.C.) 100 to 140°F	Moderate irritation; temporary effect	First-degree burns, short exposure	Intermediate toxicity

3/4	Flash point (C.C.) below $100^{o}F$; boiling point above $100^{o}F$	Irritating; cannot be tolerated	Second-degree burns, few minutes' exposure	Moderately toxic
3/4	Flash point (C.C.) below $100^{o}F$; boiling point below $100^{o}F$	Severe effect; may do permanent injury	Second-degree and third-degree burns	Severely toxic

Water Pollution

Rating	Human Toxicity	Aquatic Toxicity	Aesthetic Effect
0/4	Nontoxic; LD_{50} 15 g/kg	Acute threshold limits above 10,000 ppm	No significant pollution; gases and odorless liquids
1/4	Practically nontoxic; LD_{50} 5 to 15 g/kg	Threshold limits 1,000 to 10,000 ppm	Mild-odored, light oils and soluble chemicals
2/4	Slightly toxic; LD_{50} 0.5 to 5 g/kg	Threshold limits 100 to 1,000 ppm	Mid-odored, colorless, water-insoluble oils; boiling point 150-$450^{o}F$
3/4	Moderately toxic; LD_{50} 50 to 500 mg/kg	Threshold limits 1 to 100 ppm	Light-colored high-boiling oils; odorous water-soluble compounds
4/4	Toxic; LD_{50} LT 50 mg/kg	Threshold limits below 1 ppm	Heavy oils, colored or bad odors

Reactivity

Rating	Other Chemicals	Water	Self-Reaction
0/4	Inactive; may be attacked by materials rated 4	No reaction	No reaction
1/4	React only with materials rated 4	Mild reaction unlikely to be hazardous	Mild-self-reaction under some conditions
2/4	React with materials rated 3 or 4	Moderate reaction	Will undergo self-reaction if contaminated; do not require stabilizer
3/4	React with each other and with materials rated 2 or 4	More vigorous reaction; may be hazardous	Vigorous self-reaction; require stabilizer
4/4	React with each other and materials rated 0-3	Vigorous reation; likely to be hazardous	Self-oxidizing chemical; capable of explosion or detonation

If there is no NAS rating available, the less-detailed ratings developed by the National Fire Prevention Association will be presented, if available. The NFPA classification ratings follow.

Classification

Health Hazard	Definition
4/4	Materials which on very short exposure could cause death or major residual injury even though prompt medical treatment were given.
3/4	Materials which on short exposure could cause serious temporary or residual injury even though prompt medical treatment were given.
2/4	Materials which intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given.

1/4 Materials which on exposure could cause irritation but only minor residual injury even if no treatment is given.

0/4 Materials which on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material.

Flammabilty

4/4 Materials which will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature, or which are readily dispersed in air and which will burn readily.

3/4 Liquids and solids that can be ignited under almost all ambient temperature conditions.

2/4 Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.

1/4 Materials that must be preheated before ignition can occur.

0/4 Materials that will not burn.

Reactivity

4/4 Materials which in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressures.

3/4 Materials which in themselves are capable of detonation or explosive reaction but require a strong initiating source or which must be heated under confinement before initiation or which react explosively with water.

2/4 Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Also materials which may react violently with water or which may form potentially explosive mixtures with water.

1/4 Materials which in themselves are normally stable, but which can become unstable at elevated temperatures and pressures or which may react with water with some release of energy but not violently.

0/4 Materials which in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water.

C. SHIPPING PHYSICAL AND CHEMICAL DATA

This section presents a selection of information about the shipped commodity and its hazards.

The Flammability Limits, expressed as percentages, are the composition limits of a mixture of a material (or its vapor) with air which will support combustion; the combustible range lies between the limits. Outside these limits the mixture is not flammable. Typical flammability limits are about 3% to 12%, although there are exceptions. Ethylene, for example, has an upper flammability limit of 100%, indicating that it will burn in the absence of air. Flammability limits are pertinent to the definition of flammability of compressed gases (49 CFR 173.300(b)).

The Flash Point of a material is the minimum temperature at which a material gives off flammable vapors which will ignite when contacted by a spark or flame. Vapors over their liquids that are below the flash point will not ignite. A rule of thumb is that the flash point is lower for more volatile materials.

There are two ways of measuring flash point--in open-cup (OC) and closed-cup (CC) testers. The closed-cup flash point is a rough measure of the behavior of the material in an intact tank car and therefore represents the normal hazard of a commodity in transit as well as in accidents where the container is intact. The open-cup value is more representative of the hazard presented by a spilled commodity. The closed-cup flash point is the criterion for distinguishing between flammable and combustible liquids (49 CFR 173.115(a),(b)).

Diffusivity is the rate at which vapors migrate along a concentration gradient in the absence of any external (e.g., meteorological) forces. Diffusivity thus is a measure of the speed with which a hazard can spread to affect larger and larger areas. To the extent that there is no replenishment of diffusing vapors at the source, (e.g., small spills) diffusivity is an indirect measure of the dilution of the vapor.

Physical state as shipped indicates the physical form of the material in transit. Gases which are chilled or sufficiently compressed to liquefy them in the intact container are regarded as being shipped as liquids; the presence of vapor in the ullage space above the liquid is a very small percentage of the material and is neglected. Solids and liquids under ambient conditions are normally shipped in that condition. Some solids, such as metallic sodium may be melted for purposes of loading and unloading but transported as a solid.

Physical state as released indicates the physical form of the material as it emerges from a ruptured container. Principal factors are size and location of the rupture, orientation of the container, and the material itself. Ruptures above the liquid level of a tank car preclude direct release of liquid under any circumstances. Because rapid pressure reduction will lead to a temperature drop causing some gases to liquefy, the liquid phase may be found on the exterior of the tank; this is usually accompanied by frost formation from the condensation of atmospheric moisture. Rapid venting of carbon dioxide, by contrast, will produce solid carbon dioxide (dry ice) which sublimes (varpoizes directly from the solid state without melting or production of a liquid phase). Ruptures below the liquid level will produce any of the above phenomena and, typically, also produce a pool; the relative contributions of vapor and pool to the total discharge depend on the particular material and the release rate. Solids generally will discharge only if the rupture is below the fill level and the solid is free to flow. On the other hand metallic sodium, transported as a single piece of material, is not free to flow and will remain in place - at least briefly - if there is no external source of heat. Because it is pyrophoric (self-igniting), metallic sodium will start to burn when it comes in contact with the atmosphere. The heat produced by this combustion, if not suppressed, will liquefy the material to produce a discharge.

D. SPILL AND CLEANUP HAZARDS

Presented here is selected information about the hazards and considerations frequently encountered in both the containment and cleanup phases of a hazardous materials accident.

1. Reactivity With Water

Any adverse behavior resulting from mingling of the commodity with the large quantities of water found at a fiery accident scene will be described here.

2. Reactivity With Other Materials

Identified here are materials that are expected to produce some adverse effect when mingled with the commodity. Little coverage is given to materials unlikely to be encountered at a hazardous material spill site. Emphasis is placed on hazard classes and the materials in this appendix; no attempt is made to describe the adverse effects.

3. Corrosiveness

For each commodity, any irritating characteristics toward the skin, eyes, or respiratory system are noted under this category. Corrosiveness toward other common materials, especially those found in containers, protective garments, and other accident scene gear, is also noted here.

4. Behavior in Fire

The behavior of each commodity under fire conditions is noted under this category. The hazardous behavior of each of these materials generally falls under one or more of the following categories:

- Upon heating, the vapor pressure of the material confined in an enclosed place increases to such an extent that it may violently rupture (explode) the container.
- The material is pressurized to such an extent that containers of it may be propelled considerable distances upon explosion, a phenomenon commonly referred to as "rocketing".
- High temperatures encourage the material to polymerize, a process that may proceed with explosive speed, liberating large amounts of additional heat and vapor.

- Toxic or poisonous fumes are emitted when the material is heated to high temperature and/or decomposition.
- Combustible fumes are emitted when the material is heated.
- The vapor of the commodity is both combustible and heavier than air, thereby constituting a flashback hazard from the point of ignition to the source of the vapor.
- Hydrogen or other flammable gases are emitted when the material comes into contact with certain metals or other materials. This occurrence may greatly increase the hazard of dealing with the material under fire conditions.

The potential for one or more of these events at the scene of a railway accident presents a grave hazard requiring very skillful evaluation and handling.

5. <u>Evacuation Guidelines</u>

Evacuation guidelines depend on the following factors:

- Materials in the containers
- Structural integrity of the containers
- Involvement of the containers in fire
- Degree of control over the fire.

Hazards that may arise include: container rupture (explosion); container rocketing (gross movement); initiation or exacerbation of fire; and the atmospheric dispersion of harmful vapors.

Hazards from explosions and rocketing arise from fiery accident scenes. If the fire cannot be controlled and the containers kept cool, then a circular area should be evacuated if there is a commodity involved that could cause an explosion or rocketing situation. Depending on the particular set of guidelines consulted, the recommended radius of this evacuation circle is generally 0.3 miles to 0.5 miles.

If there is no fire at the accident scene then the principal hazards requiring consideration of evacuation arise from the downwind atmospheric transport of ignitable or toxic vapors. Ignitable vapors may drift a considerable distance from the spill to an ignition source; the ignited cloud will flash back (burn) explosively along the vapor trail to the accident scene where spectacular, catastrophic outcomes may arise. Depending on meteorological conditions and toxicity of the commodity, hazards may extend some miles downwind. Downwind toxicity hazards may also arise from fire; several of the commodities described here burn to produce highly toxic products.

There are several response guides with evacuation information available. The Chemical Hazard Response Information System (CHRIS) has used models with worst case meteorological inputs, together with appropriate commodity data, to develop worst case evacuation guidelines for about 15 commodities in this appendix. The information available are the crosswind and downwind dimensions of evacuation areas based on "harmfulness" and ignitability of the cloud.

The AAR publication, "Emergency Handling of Hazardous Materials," is one such publication which provides response guides for each STCC commodity, including evacuation guidelines where they deem appropriate. These evacuation guidelines are much less conservative than those recommended in the USDOT publication "1984 Emergency Response Guidebook" which are identified as initial evacuation guidelines for materials not involved in fire. Evacuation to 0.5 miles where there is a possibility of rupturing or rocketing (involved in fire) is the norm for USDOT guidelines, while the AAR values range from 0.25 miles to 0.5 miles. Evacuation to a distance of 1 mile is not unknown. The AAR guidelines recommend evacuation for significantly fewer of the 100 hazardous commodities than does the USDOT manual.

Evacuation guidelines for the Commodity Sheets are taken from either USDOT or AAR recommendations, whichever is more conservative; CHRIS guidelines are, in most cases, unnecessarily conservative for this study. The FIRE guidelines assume that the tank car is involved in an uncontrollable pool- or jet-fire condition that may explode or rocket and assume a circular hazard area. The NO FIRE guidelines are the dimensions (crosswind x downwind) of an area that may be initially affected by an ignitable or toxic cloud. The crosswind dimension is the total width of the area; the accident scene is centered on the upwind edge of the area and requirements for upwind evacuation have been neglected.

6. Conditions to Avoid

This entry will be used to present additional hazard information not provided for elsewhere in the Spill and Cleanup Hazards Section, or to highlight the most serious aspects of the information provided in this section.

E. TOXICITY DATA

The information in this block is intended primarily to provide information about hazards to the environment and, for some commodities, support for hazard class assignment or justification for multiple-hazard assessment.

Available toxicity data are presented for humans, terrestrial, freshwater and saltwater species, and for avian species. Dose, exposure time, particular species tested, toxicity effect, and route of entry are provided in a frequently used linear format in which the individual data items are separated by slashmarks. Unless indicated otherwise, the dosage is expressed in milligrams of material per kilogram of animal weight (mg/kg) for solids and liquids or milligrams of material per liter (mg/l) for gases, the units of measure in POISON B definitions. Exposure times for each species are listed in hours unless otherwise specified.

F. GENERAL INFORMATION ABOUT THE COMMODITY SHEETS

Most of the commodities are essentially pure materials such that the available physical and toxicity data available for the pure main constituent can be applied to the commercial material. For these materials, estimates for some data may be obtained from other properties of material, or from the data for chemically similar compounds. Application of such techniques may also lead to suspicions about reported data for a material.

Other materials are complex mixtures of indefinite composition, such as blended gasoline, partially refined petroleum, rosin solution, or isobutane for further refining. Other materials, composed of a mixtures of compounds with the same molecular formula but different molecular structures (isomers), present similar problems; butadiene and xylene are examples. For such materials, the component isomers are well known and often these are reasonably well characterized. Variability in the relative isomeric composition of such mixtures will produce variability in the physical, chemical and toxicological properties.

Materials with known contaminants present in unknown variable amounts, such as denatured alcohol (gasoline denaturant), can have values for physical properties that are very sensitive to the composition of the commercial material. Contaminated methanol and crude ferric chloride solution are commodity names suggesting the presence of constituents that may significantly alter in an unpredictable way the properties of the commercial material from those of a laboratory-grade chemical. Dissolution of solids or gases in solvents, like the mixing of two liquid materials, will have significant, variable effects different from the separate components.

G. ARRANGEMENT OF THE INFORMATION

Each commodity is described on its own separate Commodity Sheet. The Commodity Sheets are arranged alphabetically by STCC commodity name within the hazard class assigned in Table B-1. The order of hazard classes is that of 49CFR with generic commodities grouped at the end; data sources follow the Commodity Sheets in Appendix B-13.

A number of abbreviations and notations have been used in assembling the data for each commodity sheet. These are listed in Table B-2 along with their associated explanations.

TABLE B-1. 100 HAZARDOUS RAIL-SHIPPED COMMODITIES

Tank Cars	Commodity (STCC Name in parentheses)
	Flammable Liquids
3713	Acetaldehyde
2347	Acetone
ND	Acrolein, Inhibited
5303	Acrylonitrile
2204	Alcohol, N.O.S. (Methanol, Contaminated)
2311	Benzene
745	Butyl Alcohol (2-Butanol)
1345	Carbon Bisulfide or Carbon Disulfide
925	Chloroprene, Inhibited
2405	Cyclohexane
3677	Denatured Alcohol
ND	Epichlorohydrin
875	Ethyl Acetate
1194	Ethyl Acrylate, Inhibited
5513	Ethyl Alcohol
1335	Ethyl Benzene
1166	Ethyl Chloride
5000	Ethylene Oxide
638	Flammable Liquid, N.O.S. (Rosin Solution)
4801	Fuel, Aviation, Turbine Engine
745	Gasoline (Gasoline, Blended)
1461	Gasoline (Gasoline, Casing Head)
1250	Hexane
1844	Isopropanol
19907	Methyl/Alcohol (Methanol)
1394	Methyl Ethyl Ketone
ND	Methyl Isocynate
2714	Methyl Methacrylate Monomer, Inhibited
1206*	Naphtha
3273	Petroleum Naphtha
7865	Petroleum Oil, N.O.S. (Petroleum, Partially Refined)
5011	Propylene Oxide
5585	Styrene Monomer, Inhibited
1597	Toluene
3866	Vinyl Acetate
2578	Xylene

TABLE B-1. 100 HAZARDOUS RAIL-SHIPPED COMMODITIES (CONTINUED)

Flammable Gases

7412	Butadiene
5520	Butene Gas, Liquefied
1006*	Ethylene
31775	Liquefied Petroleum Gas
10536	Liquefied Petroleum Gas (Butane)
5354	Liquefied Petroleum Gas (Isobutane)
3166	Liquefied Petroleum Gas (Isobutane, for further refinery processing)
1254	Liquefied Petroleum Gas (Isobutylene)
26882	Liquefied Petroleum Gas (Propane)
2844	Liquefied Petroleum Gas (Propylene)
1448	Methyl Chloride
18773	Vinyl Chloride

Non-Flammable Gases

37097	Anhydrous Ammonia
6175	Carbon Dioxide, Liquefied
37870	Chlorine
2910	Sulfur Dioxide

Poison A

ND	Cyanogen Chloride, less than 0.9% water
866	Hydrocyanic Acid, Liquefied
ND	Phosgene

Poison B

928	Aniline Oil, Liquid
3458	Motor Fuel Antiknock Compound
6916	Phenol
2515	Toluene Diisocynate

ORM-A

1100	Carbon Tetrachloride
976	Maleic Anyhydride

ORM-E

790	Dinitrotoluene

TABLE B-1. 100 HAZARDOUS RAIL-SHIPPED COMMODITIES (CONTINUED)

Combustible Liquids

1384	Alcohol, N.O.S. (Octyl Alcohol, other than perfumery grade)
1548	Combustible Liquid, N.O.S. (Butyl Acrylate)
1114	Combustible Liquid, N.O.S. (Creosote, Coal Tar)
2259	Formaldehyde Solution (Formaldehyde, Liquid)
24878	Fuel Oil, No. 1,2, 4, or 5
2693*	Naphtha
6445	Petroleum Distillate (Petroleum Distillate Fuel Oil, not for illuminating purposes)

Flammable Solids

ND	Calcium Carbide
3233	Phosphorus, White or Yellow, in water
877	Sodium, Metallic

Oxidixing Materials

ND	Ammonium Nitrate Fertilizer, not more than 0.2% carbon
1571	Hydrogen Peroxide Solution, over 52% peroxide
ND	Nitric Acid, Fuming
ND	Potassium Nitrate
ND	Sodium Chlorate
ND	Sodium Nitrate

Corrosive Materials

3399	Acetic Acid, Glacial
2022	Acetic Anhydride
782*	Corrosive Liquid, N.O.S. (Caustic Soda and Caustic Potassium, mixed, in solution)
1728	Ferric Chloride Solution, Crude, at least 50% water
5683	Hexamethylene Diamine Solution
11165	Hydrochloric Acid
961	Hydrofluosilicic Acid
2008	Hydrogen Fluoride, Anhydrous
2549	Oleum
23947	Phosphoric Acid (Phosphatic Fertilizer Solution)
2458	Potassium Hydroxide, Liquid or Solution
1268	Sodium Hydrosulfide, Solution
27735	Sodium Hydroxide, Liquid
37158	Sodium Hydroxide, Liquid or Solution, at least 48% water
42640	Sulfuric Acid
3233	Sulfuric Acid, Spent

TABLE B-1. 100 HAZARDOUS RAIL-SHIPPED COMMODITIES (CONTINUED)

Generics

1060*	Alcohol, NOS (Flammable Liquid)
1411	Alkaline Liquid, NOS
2343	Combustible Liquid, NOS
1653	Corrosive Liquid, NOS
1785	Flammable Liquid, NOS
846*	Poisonous Liquid, NOS

* 1979 Data

TABLE B-2. LIST OF ABBREVIATIONS USED IN THE HAZARDOUS COMMODITY SHEETS

GT	Greater than
HMN	Adult human
IHL	Inhalation
IRR	Irritant effects - any irritant effect on the skin, eyes, or mucous membrane
K	Kill
LC50(100)	A calculated concentration of a substance in air or water exposure to which, for a specified period of time, is expected to cause the death of 50% (100%) of an entire defined experimental animal population. It is determined from the exposure to the substance of a significant number from that population.
LCLO	The lowest concentration of a substance in air which has been reported to have caused death in humans or animals.
LD50(100)	A calculated dose of a substance which is expected to cause the death of 50% (100%) of an entire defined animal population. It is determined from the exposure to the substance by any route other than inhalation of a significant number from that population.
LDLO	The lowest dose (other than LD50) at a substance introduced by any route, other than inhalation, over any given period of time in one or more divided portions and reported to have caused death in humans or animals.
LT	Less than
ND	No data
NP	Not pertinent
ORL	Oral
PPM	Part per million

TABLE B-2. LIST OF ABBREVIATIONS USED IN THE HAZARDOUS COMMODITY SHEETS (CONTINUED)

TCLO	The lowest concentration of a substance in air to which humans or animals have been exposed for any given period of time that has produced any toxic effect in humans or produced a carcinogenic effect in animals or humans.
TDLO	The lowest dose of a substance introduced by any route, other than inhalation, over any given period of time and reported to produce any toxic effect in humans or to produce carcinogenic effects in animals or humans.
TFX	Toxic effects
TLM	Specified concentration will kill 50% of the exposed organisms within the specified time period.
TLV	American Conference of Governmental Industrial Hygienists (ACGIH)-recommended time-weighted average concentration of a substance to which most workers can be exposed without adverse effect.

APPENDIX B-1

FLAMMABLE LIQUIDS

A flammable liquid is defined (49 CFR 173.115(a)) as any liquid having a flash point below 100°F (37.8°C), with the following exceptions:

(a) Any liquid meeting one of the definitions specified in 49 CFR 173.300 (a regulation dealing with compressed gases)

(b) Any mixture having one component or more with a flash point of 100°F (37.8°C) or higher that makes up at least 99 percent of the total volume of the mixture

For definition purposes, a distilled spirit of 140 proof or lower is considered to have a flash point no lower than 73°F (22.8°C).

This appendix lists 36 commodities which are classified as flammable liquids. These are:

(a) ACETALDEHYDE
(b) ACETONE
(c) ACROLEIN, INHIBITED
(d) ACRYLONITRILE
(e) ALCOHOL N.O.S. (METHANOL, CONTAMINATED)
(f) BENZENE
(g) BUTYL ALCOHOL (2-BUTANOL)
(h) CARBON BISULFIDE or CARBON DISULFIDE
(i) CHLOROPRENE, INHIBITED
(j) CYCLOHEXANE
(k) DENATURED ALCOHOL
(l) EPICHLOROHYDRIN
(m) ETHYL ACETATE
(n) ETHYL ACRYLATE, INHIBITED
(o) ETHYL ALCOHOL
(p) ETHYL BENZENE
(q) ETHYL CHLORIDE
(r) ETHYLENE OXIDE
(s) FLAMMABLE LIQUID, N.O.S. (ROSIN SOLUTION)

(t) FUEL, AVIATION, TURBINE ENGINE

(u) GASOLINE (GASOLINE, BLENDED)

(v) GASOLINE (GASOLINE, CASING HEAD)

(w) HEXANE

(x) ISOPROPANOL

(y) METHYL ALCOHOL (METHANOL)

(z) METHYL ETHYL KETONE

(aa) METHYL ISOCYANATE

(bb) METHYL METHACRYLATE MONOMER, INHIBITED

(cc) NAPHTHA

(dd) PETROLEUM NAPHTHA

(ee) PETROLEUM OIL, N.O.S. (PETROLEUM, PARTIALLY REFINED)

(ff) PROPYLENE OXIDE

(gg) STYRENE MONOMER, INHIBITED

(hh) TOLUENE

(ii) VINYL ACETATE

(jj) XYLENE

Proper Shipping Name: **ACETALDEHYDE**
Commodity: **ACETALDEHYDE**
STCC: **4907210** DOT ID Number: **UN1089**
Synonyms: **ETHYL ALDEHYDE**
DOT Placard: **FLAMMABLE**
Shipping Rate: 3713 Tank Cars/Year **(1983)** RQ 1000 lb

-- HAZARD SUMMARY --

NAS Hazard Rating:
  Fire - **4/4**
  Health -
    Vapor Irritant: **3/4**; Liquid/Solid Irritant: **1/4**; Poison: **2/4**
  Water Pollution -
    Human Toxicity: **2/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **2/4**
  Reactivity -
    Other Chemicals: **2/4**; Water: **0/4**; Self Reaction: **1/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **4% - 60%**
Flash Point: -36°F(cc); -58 °F(oc); Diffusivity: **27.45 FT^2/MIN @ 68°F**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **ACID ANHYDRIDES; AIR; ANHYDROUS AMMONIA; HALOGENS; HYDROGEN CYANIDE; HYDROGEN SULFIDE; KETONES; PHENOLS.**
Corrosiveness: **SKIN AND RESPIRATORY IRRITANT; RUBBER PRODUCTS DECOMPOSED; NON-CORROSIVE TO METALS UNLESS OXIDIZED TO ACETIC ACID**
Behavior in Fire: **MAY FLASH BACK ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **HEAT, ACIDS; ALKALIES; AIR; OXYGEN; CONTAMINATION WITH OTHER ALDOL OR POLYMERIZATION CATALYSTS**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**200ppm/0.25/HMN/IRR/IHL**
Animals	**20,000ppm/ND/RAT/LD50/IHL**
Freshwater	**53ppm/96/BLUEGILL/LC50/ND**
Saltwater	**100+ppm/48/SHRIMP/LC50/ND**
Avian	**ND**

-- OTHER INFORMATION --

MAY POLYMERIZE

Proper Shipping Name: **ACETONE**
Commodity: **ACETONE**
STCC: **4908105** DOT ID Number: **UN1090**
DOT Placard: **FLAMMABLE**
Shipping Rate: **2347** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating:
- Fire - **3/4**
- Health -
  - Vapor Irritant: **1/4**; Liquid/Solid Irritant: **0/4**; Poison: **0/4**
- Water Pollution -
  - Human Toxicity: **1/4**; Aquatic Toxicity: **1/4**; Aesthetic Effect: **1/4**
- Reactivity -
  - Other Chemicals: **2/4**; Water: **0/4**; Self Reaction: **1/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **2.6% - 12.8%**
Flash Point: 0^{o}F(cc); 4^{o}F(oc); Diffusivity: **0.109CM^2/SEC @ 0^{o}(AIR)**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **ACIDS; OXIDIZERS; NITROSYL CHLORIDE**
Corrosiveness: **VAPOR IS EYE AND RESPIRATORY IRRITANT**
Behavior in Fire: **VERY VOLATILE; EXTREMELY FLAMMABLE; FLASHBACK ALONG VAPOR TRAIL MAY OCCUR**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **SPARKS AND OPEN FLAME; PLASTICS; RAYON; EXPLOSIVES; TOXICANTS; OXIDIZERS; OXIDIZABLE MATERIALS**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**500ppm/ND/HMN/TCLO/IHL**
Animals	**SAT VAPOR/0.5/RAT/LETHAL/IHL**
Freshwater	**8300ppm/96/BLUEGILL/TLM/ND**
Saltwater	**5000ppm/ND/WATER SHRIMP/TLM/ND**
Avian	**ND**

Proper Shipping Name: **ACROLEIN, INHIBITED**
Commodity: **ACROLEIN, INHIBITED**
STCC: **4906410** DOT ID Number: **UN1092**
DOT Placard: **FLAMMABLE; TANK MARKING REQUIRED**
Shipping Rate: **ND** RQ 1 lb

-- HAZARD SUMMARY --

NAS Hazard Rating:
Fire - **3/4**
Health -
Vapor Irritant: **4/4**; Liquid/Solid Irritant: **3/4**; Poison: **4/4**
Water Pollution -
Human Toxicity: **4/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **3/4**
Reactivity -
Other Chemicals: **3/4**; Water: **0/4**; Self Reaction: **3/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **2.8% - 31%**
Flash Point: **-13°F(cc)**; LT 0°F(oc); Diffusivity: **0.108CM^2/SEC @ 20°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **ACIDS; CAUSTICS: AMINES; SULFUR DIOXIDE; THIOUREA; METAL SALTS; OXIDANTS**
Corrosiveness: **VAPOR IS STRONG SKIN, EYE, RESPIRATORY IRRITANT; TOXIC**
Behavior in Fire: **FLASHBACK ALONG VAPOR TRAIL MAY OCCUR; MAY POLYMERIZE AND CONTAINERS MAY EXPLODE IN FIRE. EMITS HIGHLY TOXIC FUMES WHEN HEATED TO DECOMPOSITION.**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **1.5x2.4 MILES**
Conditions to Avoid: **CONTACT WITH HEAT AND LIGHT**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**1ppm/ND/HMN/TCLO/IHL**
Animals	**8ppm/4/RAT/LCLO/IHL**
Freshwater	**LT1ppm/96/AQUATIC LIFE/TLM/ND**
Saltwater	**LT1ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

Proper Shipping Name: **ACRYLONITRILE**
Commodity: **ACRYLONITRILE**
STCC: **4906420** DOT ID Number: **UN1093**
DOT Placard: **FLAMMABLE**
Shipping Rate: **5303** Tank Cars/Year **(1983)** RQ **100** lb

-- HAZARD SUMMARY --

NAS Hazard Rating:
- Fire - **3/4**
- Health -
  - Vapor Irritant: **3/4**; Liquid/Solid Irritant: **1/4**; Poison: **3/4**
- Water Pollution -
  - Human Toxicity: **4/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **2/4**
- Reactivity -
  - Other Chemicals: **3/4**; Water: **0/4**; Self Reaction: **3/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **3.05% - 17.0%**
Flash Point: 30°F(cc); 31 °F(oc); Diffusivity: **0.108CM²/SEC @20°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **STRONG ACIDS; STRONG CAUSTICS; COPPER AND ITS ALLOYS; ALUMINUM; LEATHER**
Corrosiveness: **SEVERE SKIN AND EYE IRRITANT; POISON; EXPOSURE REQUIRES SKILLED MEDICAL TREATMENT**
Behavior in Fire: **FLASHBACK ALONG VAPOR TRAIL MAY OCCUR; MAY POLYMERIZE AND EXPLODE**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **0.4x0.6 MILES**
Conditions to Avoid: **TANK HEATING MAY INITIATE POLYMERIZATION AND EXPLOSION; IGNITION SOURCES; COMBUSTION PRODUCTS ARE TOXIC.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**45/ND/HMN/TLV/ND**
Animals	**500ppm/ND/RAT/LCLO/IHL**
Freshwater	**100ppm/24/ALLFISH/LETHAL/ND**
Saltwater	**0.05-1ppm/24/BLUEGILL/LETHAL/ND**
Avian	**ND**

Proper Shipping Name: **BENZENE**
Commodity: **BENZENE**
STCC: **4908110** DOT ID Number: **UN1114**
Synonyms: **BENZOL**
DOT Placard: **FLAMMABLE**
Shipping Rate: **2311** Tank Cars/Year **(1983)** RQ 1000 lb

-- HAZARD SUMMARY --

NAS Hazard Rating:
  Fire - **3/4**
  Health -
    Vapor Irritant: **1/4**; Liquid/Solid Irritant: **1/4**; Poison: **3/4**
  Water Pollution -
    Human Toxicity: **1/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **2/4**
  Reactivity -
    Other Chemicals: **1/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.3% - 7.9%**
Flash Point: 12°F(cc); ND°F(oc); Diffusivity: **0.084CM^2/SEC @15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **CHLORINE; OXYGEN; PERMANGANATES AND SULFURIC ACID; PEROXIDES**
Corrosiveness: **EYE, SKIN AND RESPIRATORY IRRITANT**
Behavior in Fire: **FLASHBACK ALONG VAPOR TRAIL MAY OCCUR**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **IF LEAKING, DOWNWIND EVACUATION MUST BE CONSIDERED**
Conditions to Avoid: **LEUKEMIA HAS BEEN REPORTED FOLLOWING REPEATED OR PROLONGED EXPOSURE; KEEP FROM STRONG OXIDIXERS**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	50ppm/ND/HMN/TLCO/IHL
Animals	16000ppm/4/RAT/LD50/IHL
Freshwater	20ppm/24-48/BLUEGILL SUNFISH/LD50/ND
Saltwater	50ppm/24-96/YNG COHO SALMON/60%K/ND
Avian	ND

Proper Shipping Name: **BUTYL ALCOHOL**
Commodity: **2-BUTANOL**
STCC: **4909129** DOT ID Number: **NA1120**
Synonyms: **sec-BUTYL ALCOHOL**
DOT Placard: **FLAMMABLE**
Shipping Rate: **745** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating:
- Fire - **3/4**
- Health -
  - Vapor Irritant: **1/4**; Liquid/Solid Irritant: **0/4**; Poison: **1/4**
- Water Pollution -
  - Human Toxicity: **1/4**; Aquatic Toxicity: **1/4**; Aesthetic Effect: **2/4**
- Reactivity -
  - Other Chemicals: **2/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.7% - 9.0%**
Flash Point: 75°F(cc); Diffusivity: **0.082CM^2/SEC @15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **OXIDIZERS**
Corrosiveness: **ALUMINUM**
Behavior in Fire: **FLASHBACK ALONG VAPOR TRAIL MAY OCCUR; EXPLOSION HAZARD OUTDOORS AND IN CONFINED AREAS**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **ALUMINUM; OXIDIZERS; IGNITION SOURCES; CONTACT; INHALATION**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	25ppm/ND/HMN/TCLO-IRR/IHL
Animals	16000ppm/4/RAT/LCLO/IHL
Freshwater	4300ppm/24/GOLDFISH/LD50/ND
Saltwater	1000+ppm/96/AQUATIC LIFE/TLM/ND
Avian	ND

Proper Shipping Name: **CARBON BISULFIDE or CARBON DISULFIDE**
Commodity: **CARBON BISULFIDE OR CARBON DISULFIDE**
STCC: **4908125** DOT ID Number: **UN1131**
DOT Placard: **FLAMMABLE**
Shipping Rate: **1345** Tank Cars/Year **(1983)** RQ **5000** lb

-- HAZARD SUMMARY --

NAS Hazard Rating:
Fire - **4/4**
Health -
Vapor Irritant: **2/4**; Liquid/Solid Irritant: **2/4**; Poison: **3/4**
Water Pollution -
Human Toxicity: **1/4**; Aquatic Toxicity: **2/4**; Aesthetic Effect: **3/4**
Reactivity -
Other Chemicals: **2/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.3% - 50%**
Flash Point: -22°F(cc); Diffusivity: **0.097CM^2/SEC@15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **ACIDS; ALKALIES; CHLORINE; PERMANGANATES; AZIDES; OXIDIZERS**
Corrosiveness: **IRRITATING TO SKIN, EYES, RESPIRATORY SYSTEM**
Behavior in Fire: **HIGHLY FLAMMABLE; MAY FLASH BACK ALONG VAPOR TRAIL; SEVERE EXPLOSION HAZARD. EMITS HIGHLY TOXIC FUMES IF HEATED TO DECOMPOSITION**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **0.2x0.3 MILES**
Conditions to Avoid: **IGNITION AND HEAT SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**4000ppm/0.5/HMN/LCLO/IHL**
Animals	**2000ppm/0.1/MAMMAL/LCLO/IHL**
Freshwater	**162ppm/24/MOSQUITO FISH/TLM/ND**
Saltwater	**100-1000+ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

-- OTHER INFORMATION --

NOTE WIDE FLAMMABLE LIMITS

Proper Shipping Name: **CHLOROPRENE, INHIBITED**
Commodity: **CHLOROPRENE, INHIBITED**
STCC: **4907223** DOT ID Number: **UN1991**
Synonyms: **NEOPRENE**
DOT Placard: **FLAMMABLE**
Shipping Rate: 925 Tank Cars/Year (1983)

-- HAZARD SUMMARY --

NFPA HAZARD CLASSIFICATION
Health Hazard: **2/4**; Flammability: **3/4**; Reactivity: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **4% - 20%**
Flash Point: **-20°F(cc)**; **-22°F(oc)**; Diffusivity: **0.080CM^2/SEC@15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **POLYMERIZES IN THE PRESENCE OF OXIDIZERS**
Corrosiveness: **ND**
Behavior in Fire: **VERY FLAMMABLE; HEAT MAY CAUSE POLYMERIZATION AND TANK RUPTURE; EMITS TOXIC FUMES WHEN HEATED TO DECOMPOSITION**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**80ppm/ND/HMN/TOXIC SYMPTOMS/IHL**
Animals	**605ppm/8/RAT/LC100/IHL**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

Proper Shipping Name: **CYCLOHEXANE**
Commodity: **CYCLOHEXANE**
STCC: **4908132** DOT ID Number: **UN1145**
DOT Placard: **FLAMMABLE**
Shipping Rate: **2405** Tank Cars/Year **(1983)** RQ **1000** lb

-- HAZARD SUMMARY --

NAS Hazard Rating:
  Fire - **3/4**
  Health -
    Vapor Irritant: **1/4**; Liquid/Solid Irritant: **1/4**; Poison: **2/4**
  Water Pollution -
    Human Toxicity: **1/4**; Aquatic Toxicity: **2/4**; Aesthetic Effect: **2/4**
  Reactivity -
    Other Chemicals: **0/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.33% - 8.35%**
Flash Point: **-4**°F(cc); **ND** °F(oc); Diffusivity: **0.086CM^2/SEC@15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **OXIDIZERS**
Corrosiveness: **NONE**
Behavior in Fire: **MAY FLASH BACK ALONG VAPOR TRAIL; MAY EXPLODE IF IGNITED IN AN ENCLOSED AREA**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **HEAT; OXIDIZERS; IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**300ppm/8/HMN/TLV/IHL**
Animals	**18000ppm/1/MOUSE/LC50/IHL**
Freshwater	**42ppm/24/BLUEGILL/TLM/ND**
Saltwater	**10-100ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

Proper Shipping Name: **DENATURED ALCOHOL**
Commodity: **DENATURED ALCOHOL**
STCC: **4909141** DOT ID Number: **UN1986**
Synonyms: **ETHYL ALCOHOL, GRAIN ALCOHOL, COLOGNE SPIRIT**
DOT Placard: **FLAMMABLE**
Shipping Rate: 3677 Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating:
- Fire - **3/4**
- Health -
  - Vapor Irritant: **1/4**; Liquid/Solid Irritant: **0/4**; Poison: **1/4**
- Water Pollution -
  - Human Toxicity: **1/4**; Aquatic Toxicity: **1/4**; Aesthetic Effect: **1/4**
- Reactivity -
  - Other Chemicals: **2/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **3.3% - 19%**
Flash Point: 55°F(cc); 64°F(oc); Diffusivity: **0.097CM^2/SEC@15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NITRIC ACID; SULFURIC ACID AND PEROXIDE; OXIDIZERS; POTASSIUM; PLATINUM; SILVER NITRATE**
Corrosiveness: **ND**
Behavior in Fire: **MAY FLASH BACK ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **SOURCES OF IGNITION**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**1000ppm/ND/HMN/TLV/IHL**
Animals	**20,000ppm/10/RAT/LC50/IHL**
Freshwater	**250ppm/6/GOLDFISH/LETHAL/ND**
Saltwater	**1000ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

-- OTHER INFORMATION --

DENATURANT DEPENDS ON END USE

Proper Shipping Name: **EPICHLOROHYDRIN**
Commodity: **EPICHLOROHYDRIN**
STCC: **4907420** DOT ID Number: **UN2023**
DOT Placard: **FLAMMABLE**
Shipping Rate: **ND** RQ **1000** lb

-- HAZARD SUMMARY --

NAS Hazard Rating:
- Fire - **3/4**
- Health -
  - Vapor Irritant: **3/4**; Liquid/Solid Irritant: **3/4**; Poison: **4/4**
- Water Pollution -
  - Human Toxicity: **3/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **2/4**
- Reactivity -
  - Other Chemicals: **3/4**; Water: **1/4**; Self Reaction: **2/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **3.8% - 21.0%**
Flash Point: 100^{o}F(cc); 92^{o}F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **MILD REACTION**
Reactivity with Other Materials: **ACIDS; CAUSTICS AND INORGANIC PEROXIDES; MATERIALS WITH ACTIVE HYDROGEN; VIGOROUSLY WITH OXIDIZERS**
Corrosiveness: **IRRITATING TO SKIN, EYES, AND RESPIRATORY SYSTEM**
Behavior in Fire: **MAY POLYMERIZE AND RUPTURE CONTAINER**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **0.2x0.3 MILE**
Conditions to Avoid: **HEAT, IGNITION SOURCES, INHALATION**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	20ppm/ND/HMN/TCLO/IHL
Animals	100ppm/6/RAT/TCLO/IHL
Freshwater	36ppm/48/RASBORA FISH/TLM/ND
Saltwater	10-100ppm/96/AQUATIC LIFE/TLM/ND
Avian	ND

Proper Shipping Name: **ETHYLENE OXIDE**
Commodity: **ETHYLENE OXIDE**
STCC: **4906610** DOT ID Number: UN1040
Synonyms: **OXIRANE**
DOT Placard: **FLAMMABLE; TANK MARKING REQUIRED**
Shipping Rate: 5000 Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating:
Fire - **4/4**
Health -
Vapor Irritant: **3/4**; Liquid/Solid Irritant: **3/4**; Poison: **2/4**
Water Pollution -
Human Toxicity: **3/4**; Aquatic Toxicity: **2/4**; Aesthetic Effect: **1/4**
Reactivity -
Other Chemicals: **3/4**; Water: **1/4**; Self Reaction: **4/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **3% - 100%**
Flash Point: **-4°F(cc)**; ND°F(oc); Diffusivity: **$0.112 cm^2/sec$ @ 15°C**
Physical State: as Shipped: **LIQUID;** as Released: **GAS, LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **SLOW REACTION, NOT HAZARDOUS**
Reactivity with Other Materials: **ACIDS; CAUSTICS; ALCOHOLS; AMMONIA; SOME IRON-CONTAINING COMPOUNDS; MERCAPTANS; COPPER; TIN**
Corrosiveness: **IRRITATING; ATTACKS COPPER AND TIN**
Behavior in Fire: **MAY FLASH BACK ALONG VAPOR TRAIL; MAY POLYMERIZE AND EXPLODE WHEN HEATED**
Evacuation Guidelines: FIRE: **1 MILE**; NO FIRE: **0.4 x 0.5 MILES**
Conditions to Avoid: **HEAT AND IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	250ppm/1/HMN/SEV/TFX/IHL
Animals	4000ppm/ND/RAT/LC50/IHL
Freshwater	90ppm/24/GOLDFISH/LD50/ND
Saltwater	10-100ppm/96/AQUATIC LIFE/TLM/ND
Avian	ND

Proper Shipping Name: **ALCOHOL, N.O.S.**
Commodity: **ETHYL ALCOHOL, ANHYDROUS, DENATURED**
STCC: **4909110** DOT ID Number: **UN1987**
Synonyms: **GRAIN ALCOHOL, COLOGNE, SPIRIT**
DOT Placard: **FLAMMABLE**
Shipping Rate: **5513** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating:
Fire - **3/4**
Health -
Vapor Irritant: **1/4**; Liquid/Solid Irritant: **0/4**; Poison: **1/4**
Water Pollution -
Human Toxicity: **1/4**; Aquatic Toxicity: **1/4**; Aesthetic Effect: **1/4**
Reactivity -
Other Chemicals: **2/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **3.3% - 19%**
Flash Point: 55°F(cc); 64°F(oc) Diffusivity: **0.102CM^2/SEC @0°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NITRIC ACID; SULFURIC ACID PLUS PEROXIDE; OXIDANTS; POTASSIUM; PLATINUM; SILVER NITRATE**
Corrosiveness: **NP**
Behavior in Fire: **MAY FLASHBACK ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **SOURCES OF IGNITION**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**1000ppm/ND/HMN/TLV/IHL**
Animals	**20000ppm/10/RAT/LC50/IHL**
Freshwater	**250ppm/6/GOLDFISH/LETHAL/ND**
Saltwater	**1000+ppm/96/AQUATIC LIFE/TLM**
Avian	**ND**

-- OTHER INFORMATION --

DENATURANT IS GASOLINE (LT 5%); FOR GASOHOL

Proper Shipping Name: **ETHYL ACETATE**
Commodity: **ETHYL ACETATE**
STCC: **4909160** DOT ID Number: **UN1173**
DOT Placard: **FLAMMABLE**
Shipping Rate: 875 Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating:
- Fire - **3/4**
- Health -
  - Vapor Irritant: **1/4**; Liquid/Solid Irritant: **1/4**; Poison: **2/4**
- Water Pollution -
  - Human Toxicity: **1/4**; Aquatic Toxicity: **2/4**; Aesthetic Effect: **2/4**
- Reactivity -
  - Other Chemicals: **1/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **2.2% - 9.0%**
Flash Point: 24°F(cc); 55°F(oc); Diffusivity: **$0.078CM^2$/SEC@15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **CAUSTICS; STRONG OXIDIZERS; OLEUM**
Corrosiveness: **MILD CORROSIVE IN MOIST ENVIRONMENTS; IRRITATES EYES AND RESPIRATORY SYSTEM**
Behavior in Fire: **MAY FLASH BACK ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **HEAT; IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**400ppm/ND/HMN/IRR/EYE**
Animals	**1600ppm/8/RAT/LC50/IHL**
Freshwater	**1540ppm/24/SHRIMP/TLM/ND**
Saltwater	**1540ppm/24/BRINE SHRIMP/TLM/ND**
Avian	**ND**

Proper Shipping Name: **ETHYL ACRYLATE, INHIBITED**
Commodity: **ETHYL ACRYLATE, INHIBITED**
STCC: **4907215** DOT ID Number: **UN1917**
DOT Placard: **FLAMMABLE**
Shipping Rate: 1194 Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating:
Fire - **3/4**
Health -
Vapor Irritant: **3/4**; Liquid/Solid Irritant: **2/4**; Poison: **3/4**
Water Pollution -
Human Toxicity: **2/4**; Aquatic Toxicity: **2/4**; Aesthetic Effect: **2/4**
Reactivity -
Other Chemicals: **2/4**; Water: **0/4**; Self Reaction: **3/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.8% - 9.5% (CALC)**
Flash Point: ND°F(cc); 44°F(oc); Diffusivity: **0.073CM^2/SEC@15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **OXIDES; PEROXIDES; ACIDS; CAUSTICS**
Corrosiveness: **IRRITATES SKIN AND EYES**
Behavior in Fire: **MAY FLASH BACK ALONG VAPOR TRAIL; HEAT MAY CAUSE POLYMERIZATION AND CONTAINER RUPTURE. EMITS SMOKE AND ACRID FUMES**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **HEAT; OXIDIZERS; IGNITION SOURCES; STRONG ACIDS**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**50ppm/ND/HMN/TCLO/IHL**
Animals	**2000ppm/4/RAT/LCLO/IHL**
Freshwater	**100-1000ppm/96/AQUATIC LIFE/TLM/ND**
Saltwater	**12ppm/24/BRINE SHRIMP/TLM/ND**
Avian	**ND**

Proper Shipping Name: **ETHYL BENZENE**
Commodity: **ETHYL BENZENE**
STCC: **4909163** DOT ID Number: **UN1175**
DOT Placard: **FLAMMABLE**
Shipping Rate: 1335 Tank Cars/Year **(1983)** RQ **1000** lb

-- HAZARD SUMMARY --

NAS Hazard Rating:
- Fire - **3/4**
- Health -
  - Vapor Irritant: **2/4**; Liquid/Solid Irritant: **2/4**; Poison: **2/4**
- Water Pollution -
  - Human Toxicity: **1/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **2/4**
- Reactivity -
  - Other Chemicals: **1/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.0% - 6.7%**
Flash Point: 59°F(cc); 80°F(oc); Diffusivity: ND
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **VAPORS IRRITATING TO EYES, RESPIRATORY SYSTEM; LIQUID IRRITATES SKIN**
Behavior in Fire: **POSSIBLE FLASH BACK ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **HEAT; IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**100ppm/8/HMN/TCLO/IHL**
Animals	**4000ppm/4/RAT/LCLO/IHL**
Freshwater	**29ppm/96/BLUEGILL/TLM/ND**
Saltwater	**10-100ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

Proper Shipping Name: **ETHYL CHLORIDE**
Commodity: **ETHYL CHLORIDE**
STCC: **4908162** DOT ID Number: **UN1037**
DOT Placard: **FLAMMABLE**
Shipping Rate: **1164** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating:
- Fire - **4/4**
- Health -
  - Vapor Irritant: **1/4**; Liquid/Solid Irritant: **1/4**; Poison: **1/4**
- Water Pollution -
  - Human Toxicity: **0/4**; Aquatic Toxicity: **1/4**; Aesthetic Effect: **1/4**
- Reactivity -
  - Other Chemicals: **1/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **3.6% - 12%**
Flash Point: **-58^{o}F(cc); -45^{o}F(oc)**; Diffusivity: **0.04CM^2/SEC@15^{o}C**
Physical State: as Shipped: **LIQUID**; as Released: **GAS, LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **REACTS WITH VERY HOT WATER**
Reactivity with Other Materials: **METALLIC SODIUM; VIGOROUSLY WITH OXIDIZERS**
Corrosiveness: **MILDLY IRRITATING; CONTACT WITH LIQUID MAY CAUSE FROSTBITE**
Behavior in Fire: **PHOSGENE (POISON GAS) AND HYDROGEN CHLORIDE (POISON GAS; CORROSIVE GAS) PRODUCED; CONTAINER MAY EXPLODE; FLASH BACK MAY OCCUR**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **HEAT; IGNITION SOURCES; INHALATION; CONTACT WITH OXIDIZERS**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**13000ppm/ND/HMN/TCLO/IHL**
Animals	**4000ppm/0.75/GPG/LCLO/IHL**
Freshwater	**1000+ppm/96/AQUATIC LIFE/TLM/ND**
Saltwater	**1000+ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

Proper Shipping Name: **FUEL, AVIATION, TURBINE ENGINE**
Commodity: **FUEL, AVIATION, TURBINE ENGINE**
STCC: **4909215** DOT ID Number: **UN1863**
DOT Placard: **FLAMMABLE**
Shipping Rate: **4801** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating:
Fire - **3/4**
Health -
Vapor Irritant: **1/4**; Liquid/Solid Irritant: **1/4**; Poison: **1/4**
Water Pollution -
Human Toxicity: **1/4**; Aquatic Toxicity: **1/3**; Aesthetic Effect: **3/4**
Reactivity -
Other Chemicals: **0/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.3% - 8.0%**
Flash Point: **(-10)-(+30)**°F(cc); **ND**°F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **ND**
Corrosiveness: **ND**
Behavior in Fire: **EXTREMELY FLAMMABLE; FLASH BACK MAY OCCUR ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **HEAT; IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**200ppm/ND/HMN/TLV/IHL**
Animals	**500-5000/ND/ANIMAL/LD50/ORAL**
Freshwater	**500ppm/ND/SALMON FINGERLING/LETHAL/ND**
Saltwater	**ND**
Avian	**ND**

Proper Shipping Name: **GASOLINE**
Commodity: **GASOLINE, BLENDED**
STCC: **4908177** DOT ID Number: **UN1203**
DOT Placard: **FLAMMABLE**
Shipping Rate: **745** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating:
Fire - **3/4**
Health -
Vapor Irritant: **1/4**; Liquid/Solid Irritant: **1/4**; Poison: **2/4**
Water Pollution -
Human Toxicity: **1/4**; Aquatic Toxicity: **2/4**; Aesthetic Effect: **2/4**
Reactivity -
Other Chemicals: **0/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.4% - 7.4%**
Flash Point: **-36°F(cc)**; Diffusity: **ND**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **NP**
Behavior in Fire: **MAY FLASH BACK ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	ND
Animals	500-5000/ND/ANIMAL/LD50/ORAL
Freshwater	90ppm/24/JUVENILE AMERICAN SHAD/TLM/ND
Saltwater	90ppm/24/JUVENILE AMERICAN SHAD/TLM/ND
Avian	ND

Proper Shipping Name: **GASOLINE**
Commodity: **GASOLINE. CASING HEAD**
STCC: **4908176** DOT ID Number: **UN1203**
DOT Placard: **FLAMMABLE**
Shipping Rate: 1461 Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating:
  Fire - **4/4**
  Health -
    Vapor Irritant: **1/4**; Liquid/Solid Irritant: **0/4**; Poison: **1/4**
  Water Pollution -
    Human Toxicity: **1/4**; Aquatic Toxicity: **2/4**; Aesthetic Effect: **1/4**
  Reactivity -
    Other Chemicals: **0/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.3% - 7.1%**
Flash Point: **ND**^{o}F(cc); LT 0^{o}F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **ND**
Behavior in Fire: **MAY FLASH BACK ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **IF LEAKING,CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	ND
Animals	500-5000/ND/ANIMAL/LD50/ORAL
Freshwater	90ppm/24/JUVENILE AMERICAN SHAD/TLM/ND
Saltwater	90ppm/24/JUVENILE AMERICAN SHAD/TLM/ND
Avian	ND

Proper Shipping Name: **HEXANE**
Commodity: **HEXANE**
STCC: **4908183** DOT ID Number: **UN1208**
DOT Placard: **FLAMMABLE**
Shipping Rate: **1250** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating:
Fire - **3/4**
Health -
Vapor Irritant: **0/4**; Liquid/Solid Irritant: **0/4**; Poison: **1/4**
Water Pollution -
Human Toxicity: **1/4**; Aquatic Toxicity: **1/4**; Aesthetic Effect: **1/4**
Reactivity -
Other Chemicals: **0/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.2% - 7.7%**
Flash Point: -7°F(cc); ND°F(oc); Diffusivity: **0.066CM^2/SEC@15°C**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **OXIDIZING MATERIALS**
Corrosiveness: **NP**
Behavior in Fire: **VAPORS MAY EXPLODE. MAY FLASHBACK ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **HEAT; IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**5000ppm/0.2/HMN/TCLO/IHL**
Animals	**1000ppm/6/RAT/TCLO/IHL**
Freshwater	**1000+ppm/96/AQUATIC LIFE/TLM/ND**
Saltwater	**1000+ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

Proper Shipping Name: **ISOPROPANOL**
Commodity: **ISOPROPANOL**
STCC: **4909205** DOT ID Number: **UN1219**
Synonyms: **ISOPROPYL ALCOHOL; 2-PROPANOL; RUBBING ALCOHOL**
DOT Placard: **FLAMMABLE**
Shipping Rate: **1844** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating:
- Fire - **3/4**
- Health -
  - Vapor Irritant: **1/4**; Liquid/Solid Irritant: **0/4**; Poison: **2/4**
- Water Pollution -
  - Human Toxicity: **2/4**; Aquatic Toxicity: **2/4**; Aesthetic Effect: **1/4**
- Reactivity -
  - Other Chemicals: **2/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **2.3% - 12.7%**
Flash Point: **53°F(cc); 65°F(oc);** Diffusivity: **$0.093 CM^2$/Sec @ 15°C**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **REACTS WITH OXIDIZERS**
Corrosiveness: **NA**
Behavior in Fire: **MATERIAL CAN BE IGNITED AT ALMOST ALL TEMPERATURES. FLASH BACK ALONG VAPOR TRAIL POSSIBLE**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **HEAT; IGNITION SOURCES; OXIDIZING MATERIALS**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	400ppm/ND/HMN/TCLO-IRR/IHL
Animals	16000ppm/8/RAT/LC67/IHL
Freshwater	900-1100ppm/24/CHUB/CRITICAL RANGE/ND
Saltwater	1400ppm/48/BROWN SHRIMP/LC50/ND
Avian	ND

Proper Shipping Name: **METHYL ALCOHOL**
Commodity: **METHANOL**
STCC: **4909230** DOT ID Number: **UN1230**
Synonyms: **METHANOL ALCOHOL; WOOD ALCOHOL; COLUMBIAN SPIRITS**
DOT Placard: **FLAMMABLE**
Shipping Rate: **19907** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating:
- Fire - **3/4**
- Health -
  - Vapor Irritant: **1/4**; Liquid/Solid Irritant: **1/4**; Poison: **2/4**
- Water Pollution -
  - Human Toxicity: **1/4**; Aquatic Toxicity: **1/4**; Aesthetic Effect: **1/4**
- Reactivity -
  - Other Chemicals: **2/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **6.0% - 36.5%**
Flash Point: 54^{o}F(cc); 61^{o}F(oc); Diffusivity: **0.14CM^{2}/Sec @ 15^{o}C**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **PERCHLORIC ACID; POTASSIUM HYDROXIDE AND CHLOROFORM; SOME METALS**
Corrosiveness: **CORROSIVE TO LEAD AND ALUMINUM**
Behavior in Fire: **QUITE FLAMMABLE; CONTAINER MAY EXPLODE; FLASH BACK MAY OCCUR ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **SOURCES OF IGNITION; HEAT; OXIDIZING MATERIALS**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**300ppm/ND/HMN/TCLO/IHL**
Animals	**1000ppm/ND/MONKEY/LCLO/IHL**
Freshwater	**13680ppm/96/RAINBOW TROUT FINGERLINGS/LC50/ND**
Saltwater	**1700ppm/96/BROWN SHRIMP/LC50/ND**
Avian	**ND**

Proper Shipping Name: **ALCOHOL, N.O.S.**
Commodity: **METHANOL, CONTAMINATED, VALUE ONLY FOR REFINING**
STCC: **4909237** DOT ID Number: **UN1987**
DOT Placard: **FLAMMABLE**
Shipping Rate: **2204** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating:
Fire - **3/4**
Health -
Vapor Irritant: **1/4**; Liquid/Solid Irritant: **1/4**; Poison: **2/4**
Water Pollution -
Human Toxicity: **1/4**; Aquatic Toxicity: **1/4**; Aesthetic Effect: **1/4**
Reactivity -
Other Chemicals: **2/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **6.0% - 36.5%**
Flash Point: **54°F(cc)**; **61°F(oc)**; Diffusivity: **0.14CM^2/Sec @ 15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **PERCHLORIC ACID; POTASSIUM HYDROXIDE AND CHLOROFORM; SODIUM HYDROXIDE AND CHLOROFORM; SOME METALS**
Corrosiveness: **CORROSIVE TO LEAD AND ALUMINUM**
Behavior in Fire: **QUITE FLAMMABLE; CONTAINER MAY EXPLODE; FLASH BACK MAY OCCUR ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **SOURCES OF IGNITION; HEAT; OXIDIZING MATERIALS**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**300ppm/ND/HMN/TCLO/IRR/IHL**
Animals	**1000ppm/ND/MONKEY/LCLO/IHL**
Freshwater	**13680ppm/96/RAINBOW TROUT FINGERLINGS/LC50/ND**
Saltwater	**1700ppm/96/BROWN SHRIMP/LC50/ND**
Avian	**ND**

-- OTHER INFORMATION --

NATURE AND EFFECT OF CONTAMINANT UNKNOWN, VARIABLE

Proper Shipping Name: **METHYL ETHYL KETONE**
Commodity: **METHYL ETHYL KETONE or ETHYL METHYL KETONE**
STCC: **4909243** DOT ID Number: **UN1193**
Synonyms: **MEK**
DOT Placard: **FLAMMABLE**
Shipping Rate: **1394** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating:
  Fire - **3/4**
  Health -
    Vapor Irritant: **1/4**; Liquid/Solid Irritant: **1/4**; Poison: **2/4**
  Water Pollution -
    Human Toxicity: **2/4**; Aquatic Toxicity: **1/4**; Aesthetic Effect: **1/4**
  Reactivity -
    Other Chemicals: **2/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.8% - 11.5%**
Flash Point: 20°F(cc); 22°F(oc); Diffusivity: **0.095CM^2/Sec @ 15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID OR VAPOR**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **REACTS WITH OXIDIZERS**
Corrosiveness: **SOFTENS AND DISSOLVES PLASTICS**
Behavior in Fire: **QUITE FLAMMABLE; FLASH BACK MAY OCCUR ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **FIRE; OXIDIZING MATERIALS; ORGANIC PEROXIDES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**100ppm/0.1/HMN/TCLO-IRR/IHL**
Animals	**2000ppm/ND/RAT/TCLO/IHL**
Freshwater	**5000ppm/24/GOLDFISH/LD50/ND**
Saltwater	**1950ppm/24/BRINE SHRIMP/TLM/ND**
Avian	**ND**

Proper Shipping Name: **METHYL ISOCYANATE**
Commodity: **METHYL ISOCYANATE**
STCC: **4907448** DOT ID Number: **UN2480**
DOT Placard: **FLAMMABLE**
Shipping Rate: **ND**

-- HAZARD SUMMARY --

NOT RATED

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **ND**
Flash Point: **LT 5°F(cc);** **ND°F(oc);** Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID, VAPOR**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **LIBERATES HEAT; IF HEAT IS NOT REMOVED, REACTION RATE WILL RAPIDLY INCREASE**
Reactivity with Other Materials: **IRON, COPPER, TIN AND ZINC CATALYZE EXPLOSIVE POLYMERIZATION**
Corrosiveness: **CORROSIVE TO NUMEROUS MATERIALS**
Behavior in Fire: **FLAMMABLE WHEN EXPOSED TO HEAT, FLAME, OR OXIDIZING MATERIALS. MAY EMIT TOXIC VAPORS**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **CONTACT WITH IGNITION SOURCES, HEAT, OXIDIZING MATERIALS. INHALATION OF VAPORS**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**2ppm/ND/HMN/TCLO/IHL**
Animals	**5ppm/4/RAT/LC50/IHL**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

-- OTHER INFORMATION --

A PROPOSED REGULATION (50 FR 5270; DOCKET HM-196) WOULD REQUIRE A POISON PLACARD (AND SHIPPING PAPER ANNOTATION) IN ADDITION TO THE FLAMMABLE PLACARD.

Proper Shipping Name: **METHYL METHACRYLATE MONOMER, INHIBITED**
Commodity: **METHYL METHACRYLATE MONOMER, INHIBITED**
STCC: **4907250** DOT ID Number: **UN1247**
DOT Placard: **FLAMMABLE**
Shipping Rate: **2714** Tank Cars/Year **(1983)** RQ **5000** lb

-- HAZARD SUMMARY --

NAS Hazard Rating:
Fire - **3/4**
Health -
Vapor Irritant: **3/4**; Liquid/Solid Irritant: **2/4**; Poison: **3/4**
Water Pollution -
Human Toxicity: **2/4**; Aquatic Toxicity: **2/4**; Aesthetic Effect: **2/4**
Reactivity -
Other Chemicals: **2/4**; Water: **0/4**; Self Reaction: **3/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **2.1% - 12.5%**
Flash Point: **ND**^{o}F(cc); **50** ^{o}F(oc); Diffusivity: **0.074 FT^{2}/MIN @ 68^{o}F**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **OXIDIZERS MAY IGNITE; PEROXIDES MAY INITIATE POLYLMERIZATION, CAUSING EXPLOSION.**
Corrosiveness: **NP**
Behavior in Fire: **POSSIBLE FLASH BACK ALONG VAPOR TRAIL: POLYMERIZATION MAY CAUSE CONTAINERS TO EXPLODE.**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **HEAT AND IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**125ppm/ND/HMN/TCLO-IRR/IHL**
Animals	**3750ppm/8/RAT/LC50/IHL**
Freshwater	**250ppm/96/BLUEGILL/TLM/ND**
Saltwater	**100-1000ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

Proper Shipping Name: **NAPHTHA**
Commodity: **NAPHTHA**
STCC: **4910239** DOT ID Number: **UN2553**
DOT Placard: **FLAMMABLE**
Shipping Rate: **1206** Tank Cars/Year **(1979)**

-- HAZARD SUMMARY --

NFPA HAZARD CLASSIFICATION
Health Hazard: **1/4;** Flammability: **4/4;** Reactivity: **2/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **0.9% - 6.7%**
Flash Point: **20-55**°F(cc); **ND**°F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **NP**
Behavior in Fire: **MAY FLASH BACK ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **NONE**
Conditions to Avoid: **IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**300ppm/ND/HMN/TLV/IHL**
Animals	**1600ppm/6/RAT/LCLO/IHL**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

-- OTHER INFORMATION --

SOLVENT OF VARIABLE COMPOSITION CHARACTERIZED COMMERCIALLY BY ITS BOILING-POINT RANGE

Proper Shipping Name: **PETROLEUM NAPHTHA**
Commodity: **PETROLEUM NAPHTHA**
STCC: **4910259** DOT ID Number: **UN1255**
DOT Placard: **FLAMMABLE**
Shipping Rate: **3273** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NOT RATED

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **0.9% - 6.0%**
Flash Point: **LT 100°F(cc);** **ND°F(oc);** Diffusivity: **$0.014 CM^2$/SEC @ 15°C**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **MAY REACT WITH STRONG OXIDIZERS**
Corrosiveness: **NP**
Behavior in Fire: **MAY FLASH BACK ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **NONE**
Conditions to Avoid: **CONTACT WITH OXIDIZERS, HEAT, AND OTHER SOURCES OF IGNITION**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	600MGper M^3/8/HMN/TCLO/IHL
Animals	3400ppm/4/RAT/LC50/IHL
Freshwater	100ppm/96/FISH/TLM/ND
Saltwater	ND
Avian	ND

-- OTHER INFORMATION --

SOLVENT OF VARIABLE COMPOSITION CHARACTERIZED COMMERCIALLY BY ITS BOILING-POINT RANGE

Proper Shipping Name: **PETROLEUM OIL, N.O.S. and others**
Commodity: **PETROLEUM, PARTIALLY REFINED, FOR FURTHER PROCESSING**
STCC: **4910243** DOT ID Number: **NA1270**
DOT Placard: **FLAMMABLE**
Shipping Rate: **7865** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NOT RATED

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **ND**
Flash Point: **LT 100°F(cc); ND°F(oc);** Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NONE**
Reactivity with Other Materials: **ND**
Corrosiveness: **NP**
Behavior in Fire: **FLAMMABLE; POSSIBLE FLASHBACK HAZARD**
Evacuation Guidelines: FIRE: **ND;**NO FIRE: **ND**
Conditions to Avoid: **IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**8000/ND/RAT/LD50/ORAL**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

-- OTHER INFORMATION --

COMPLEX MIXTURE WITH VARIABLE COMPOSITION AND PROPERTIES.

Proper Shipping Name: **PROPYLENE OXIDE**
Commodity: **PROPYLENE OXIDE**
STCC: **4906620** DOT ID Number: **UN1280**
Synonyms: **EPOXYPROPENE**
DOT Placard: **FLAMMABLE**
Shipping Rate: **5011** Tank Cars/Year **(1983)** RQ **5000** lb

-- HAZARD SUMMARY --

NAS Hazard Rating:
- Fire - **4/4**
- Health -
  - Vapor Irritant: **3/4**; Liquid/Solid Irritant: **2/4**; Poison: **2/4**
- Water Pollution -
  - Human Toxicity: **2/4**; Aquatic Toxicity: **1/4**; Aesthetic Effect: **1/4**
- Reactivity -
  - Other Chemicals: **3/4**; Water: **1/4**; Self Reaction: **3/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **2.1% - 38.5%**
Flash Point: **-35°F(cc); -20 °F(oc);** Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID OR VAPOR**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **IRRITATING TO EYES, SKIN, RESPIRATORY SYSTEM**
Behavior in Fire: **CONTAINERS MAY EXPLODE. POSSIBLE FLASH BACK ALONG VAPOR TRAIL: HEAT MAY CAUSE POLYMERIZATION AND EXPLOSION**
Evacuation Guidelines: FIRE: **1 MILE;** NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **SOURCES OF IGNITION**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**20ppm/ND/HMN/TLV/IHL**
Animals	**4000ppm/4/RAT/LCLO/IHL**
Freshwater	**1000+ppm/96/AQUATIC LIFE/TLM/ND**
Saltwater	**1000+ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

Proper Shipping Name: **FLAMMABLE LIQUID, N.O.S.**
Commodity: **ROSIN SOLUTION**
STCC: **4910444** DOT ID Number: **UN1993**
DOT Placard: **FLAMMABLE**
Shipping Rate: **638** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating:
Fire - **2/4**
Health -
Vapor Irritant: **2/4**; Liquid/Solid Irritant: **2/4**; Poison: **2/4**
Water Pollution -
Human Toxicity: **1/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **2/4**
Reactivity -
Other Chemicals: **2/4**; Water: **0/4**; Self Reaction: **3/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **VARIES**
Flash Point: **LT 100°F(cc); ND** °F(oc); Diffusivity: **VARIES**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID OR VAPOR**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **CAN REACT WITH STRONG OXIDIZERS**
Corrosiveness: **NONE**
Behavior in Fire: **POSSIBLE FLASH BACK ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **HEAT, SPARKS, OPEN FLAME, STRONG OXIDIZERS**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**ND**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

-- OTHER INFORMATION --

ROSIN SOLUTIONS MAY ALSO BE SHIPPED AS COMBUSTIBLE LIQUID, N.O.S. IF FLASH POINT PERMITS

Proper Shipping Name: **STYRENE MONOMER, INHIBITED**
Commodity: **STYRENE MONOMER, INHIBITED**
STCC: **4907265** DOT ID Number: **UN2055**
DOT Placard: **FLAMMABLE**
Shipping Rate: **5585** Tank Cars/Year **(1983)** RQ **1000** lb

-- HAZARD SUMMARY --

NAS Hazard Rating:
- Fire - **3/4**
- Health -
  - Vapor Irritant: **2/4**; Liquid/Solid Irritant: **2/4**; Poison: **2/4**
- Water Pollution -
  - Human Toxicity: **1/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **2/4**
- Reactivity -
  - Other Chemicals: **2/4**; Water: **0/4**; Self Reaction: **3/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.1% - 6.1% (CALC)**
Flash Point: 88°F(cc); 93°F(oc); Diffusivity: **0.071CM^2/SEC@15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **ACIDS; CAUSTICS; HALOGENS; HYDROGEN HALIDES; GLYCOLS**
Corrosiveness: **CORROSIVE TO COPPER AND ITS ALLOYS**
Behavior in Fire: **MAY FLASH BACK ALONG VAPOR TRAIL; HEAT MAY CAUSE EXPLOSIVE POLYMERIZATION**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **HEAT; SPARKS, OPEN FLAME**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**200ppm/1/HMN/TFX/IHL**
Animals	**5000ppm/8/RAT/LCLO/IHL**
Freshwater	**22ppm/96/BLUEGILL/TLM/ND**
Saltwater	**52ppm/48/BRINE SHRIMP/TLM/ND**
Avian	**ND**

Proper Shipping Name: **TOLUENE**
Commodity: **TOLUENE**
STCC: **4909305** DOT ID Number: **UN1294**
Synonyms: **METHYL BENZENE; TOLUOL; METHYL BENZOL**
DOT Placard: **FLAMMABLE**
Shipping Rate: **1597** Tank Cars/Year **(1983)** RQ **1000** lb

-- HAZARD SUMMARY --

NAS Hazard Rating:
- Fire - **3/4**
- Health -
  - Vapor Irritant: **1/4**; Liquid/Solid Irritant: **1/4**; Poison: **2/4**
- Water Pollution -
  - Human Toxicity: **1/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **2/4**
- Reactivity -
  - Other Chemicals: **1/4**; Water: **0/4**; Self Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.27% - 7%**
Flash Point: **40°F(cc)**; **55°F(oc)**; Diffusivity: **0.088CM^2/Sec @ 15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **OXIDIZERS, LIQUID CHLORINE, OXYGEN-RICH ATMOSPHERE**
Corrosiveness: **NP**
Behavior in Fire: **QUITE FLAMMABLE; COMBUSTION PROBABLE; FLASH BACK MAY OCCUR ALONG VAPOR TRAIL; EMITS IRRITATING FUMES**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **HEAT, SPARKS, OPEN FLAME**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**500ppm/ND/HMN/TCLO/IHL**
Animals	**8000ppm/ND/RAT/LC50/IHL**
Freshwater	**58ppm/24/GOLDFISH/LD50/ND**
Saltwater	**50ppm/24/YOUNG COHO SALMON/90% FATAL/ND**
Avian	**ND**

Proper Shipping Name: **VINYL ACETATE**
Commodity: **VINYL ACETATE**
STCC: **4907270** DOT ID Number: **UN1301**
DOT Placard: **FLAMMABLE**
Shipping Rate: **3866** Tank Cars/Year **(1983)** RQ **1000** lb

-- HAZARD SUMMARY --

NAS Hazard Rating:
Fire - **3/4**
Health -
Vapor Irritant: **1/4**; Liquid/Solid Irritant: **1/4**; Poison: **2/4**
Water Pollution -
Human Toxicity: **2/4**; Aquatic Toxicity: **1/4**; Aesthetic Effect: **2/4**
Reactivity -
Other Chemicals: **2/4**; Water: **0/4**; Self Reaction: **3/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **2.6% - 13.4%**
Flash Point: 18°F(cc); 23°F(oc); Diffusivity: **0.075CM^2/SEC@15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **PEROXIDES**
Corrosiveness: **MILD IRRITANT**
Behavior in Fire: **EXTREMELY FLAMMABLE; MAY FLASH BACK ALONG VAPOR TRAIL; HEAT CAN CAUSE EXPLOSIVE POLYMERIZATION**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **HIGH TEMPERATURES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**22ppm/ND/HMN/IRR/EYE**
Animals	**4000ppm/4/RAT/LC50/IHL**
Freshwater	**18.5ppm/24/BLUEGILL/TLM/ND**
Saltwater	**10-100ppm/48/SHRIMP/LC50/ND**
Avian	**ND**

Proper Shipping Name: **XYLENE**
Commodity: **XYLENE**
STCC: **4909350** DOT ID Number: **UN1307**
Synonyms: **XYLOL**
DOT Placard: **FLAMMABLE**
Shipping Rate: **2578** Tank Cars/Year **(1983)** RQ **1000 lb.**

-- HAZARD SUMMARY --

NAS Hazard Rating
Fire - **3/4**
Health -
Vapor Irritant: **1/4**; Liquid/Solid Irritant: **1/4**; Poison: **2/4**
Water Pollution -
Human Toxicity: **1/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **2/4**
Reactivity -
Other Chemicals: **1/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.1%-7%**
Flash Point: **63°F(cc); 90°F(oc)**; Diffusivity: **0.069CM^2/Sec @15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID OR VAPOR**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **REACTS WITH STRONG OXIDIZERS, CHLORINE, OXYGEN-RICH ATMOSPHERE**
Corrosiveness: **MILD IRRITANT**
Behavior in Fire: **VAPORS CAN IGNITE AT AMBIENT TEMPERATURES; MAY FLASH BACK ALONG VAPOR TRAIL; EMITS ACRID SMOKE AND FUMES**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **ND**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**100ppm/8/HMN/TLV/IHL**
Animals	**8000ppm/4/RAT/CLCO/IHL**
Freshwater	**22ppm/96/BLUEGILL/TLM//ND**
Saltwater	**10-100ppm/96/AQUATIC LIFE/TLM//ND**
Avian	**ND**

-- OTHER INFORMATION --

COMMERCIAL XYLENE IS A MIXTURE, OF VARIABLE PROPORTIONS, OF THE ortho, meta, AND para ISOMERS

APPENDIX B-2
COMBUSTIBLE LIQUIDS

A combustible liquid is defined (49 CFR 173.115(b)) as any liquid that does not meet the definition of any other classification under the regulations and has a flash point at or above 100°F (37.8°C) and below 200°F (93.3°C), except any mixture having one component or more with a flash point at 200°F (93.3°C) or higher, that makes up at least 99 percent of the total volume of the mixture. For the purposes of definition:

(a) An aqueous solution containing 24 percent or less alcohol by volume is considered to have a flash point no less than 100°F (37.8°C) if the remainder of the solution is not subject to this classification.

(b) An aqueous solution containing 24 percent or less alcohol by volume is not subject to this classification if it contains no less than 50 percent water and no material (other than the alcohol) which is subject to this classification.

This appendix lists seven commodities which are classified as combustible liquids. These are:

(a) ALCOHOL, N.O.S. (OCTYL ALCOHOL, OTHER THAN PERFUMERY GRADE)
(b) COMBUSTIBLE LIQUID, N.O.S. (BUTYL ACRYLATE)
(c) COMBUSTIBLE LIQUID, N.O.S. (CREOSOTE, COAL TAR)
(d) FORMALDEHYDE SOLUTION (FORMALDEHYDE, LIQUID)
(e) FUEL OIL, NO. 1,2,4, or 5
(f) NAPHTHA
(g) PETROLEUM DISTILLATE (PETROLEUM DISTILLATE FUEL OIL, NOT FOR ILLUMINATING PURPOSES)

Proper Shipping Name: **COMBUSTIBLE LIQUID, NOS**
Commodity: **BUTYL ACRYLATE**
STCC: **4912215** DOT ID Number: **NA1993**
DOT Placard: **COMBUSTIBLE**
Shipping Rate: **1548** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **2/4**
- Health -
  - Vapor Irritant: **1/4**; Liquid/Solid Irritant: **1/4**; Poison: **1/4**
- Water Pollution -
- Human Toxicity: **1/4**; Aquatic Toxicity: **2/4**; Aesthetic Effect: **2/4**
- Reactivity -
  - Other Chemicals: **2/4**; Water: **0/4**; Self-Reaction: **3/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.4% - 9.4%**
Flash Point: **ND** ^{o}F(cc); **118** ^{o}F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **IRRITATING VAPORS AT HIGH CONCENTRATION; LIQUID IRRITATING TO SKIN AND EYES**
Behavior in Fire: **MAY POLYMERIZE WITH VIOLENT RUPTURE AND ROCKETING OF CONTAINER. EMITS ACRID SMOKE WHEN HEATED TO DECOMPOSITION.**
Evacuation Guidelines: **FIRE: 0.5 MILE;** NO FIRE: **NONE**
Conditions to Avoid: **FIRE, HEATING OF CONTAINER; OXIDIZERS.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	10ppm/ND/HMN/TLV/IHL
Animals	1000ppm/4/RAT/LCLO/IHL
Freshwater	100-1000ppm/96/AQUATIC LIFE/TLM/ND
Saltwater	100-1000ppm/96/AQUATIC LIFE/TLM/ND
Avian	ND

Proper Shipping Name: **COMBUSTIBLE LIQUID, N.O.S.**
Commodity: **CREOSOTE, COAL TAR**
STCC: **4915363** DOT ID Number: **NA1993**
DOT Placard: **COMBUSTIBLE**
Shipping Rate: **1114** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating
Fire - **1/4**
Health -
Vapor Irritant: **2/4**; Liquid/Solid Irritant: **3/4**; Poison: **2/4**
Water Pollution -
Human Toxicity: **2/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **4/4**
Reactivity -
Other Chemicals: **1/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **ND**
Flash Point: **GT 160** $^{\circ}$F(cc); **185** $^{\circ}$F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION WITH MOST COMMON MATERIALS**
Corrosiveness: **MODERATE TO SEVERE IRRITATION TO SKIN, EYES, AND RESPIRATORY SYSTEM; NOT CORROSIVE TO METALS.**
Behavior in Fire: **HEATED LIQUID CAN PRODUCE FLAMMABLE VAPORS, HEAVY, IRRITATING BLACK SMOKE.**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **VAPOR INHALATION; OXIDIZERS; IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**7G/SINGLE DOSE/HMN/LETHAL IN 24-36HR/ORL**
Animals	**725/ND/RAT/LD50/ORL**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

Proper Shipping Name: **FORMALDEHYDE SOLUTION**
Commodity: **FORMALDEHYDE, LIQUID**
STCC: **4913144** DOT ID Number: **UN1198**
DOT Placard: **COMBUSTIBLE**
Shipping Rate: **2259** Tank Cars/Year **(1983)** RQ **1000** lb.

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **2/4**
- Health -
  - Vapor Irritant: **3/4**; Liquid/Solid Irritant: **2/4**; Poison: **3/4**
- Water Pollution -
  - Human Toxicity: **3/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **2/4**
- Reactivity -
  - Other Chemicals: **2/4**; Water: **0/4**; Self-Reaction: **1/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **7.0% - 73%**
Flash Point: **122 - 182** ^{o}F(cc); **ND** ^{o}F(oc); Diffusivity: **0.154 CM^2/SEC @ 15^{o}C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **PERCHLORIC ACID; ANILINE**
Corrosiveness: **CORROSIVE TO STEEL, COPPER, COPPER ALLOYS.**
Behavior in Fire: **DIFFICULT TO IGNITE; IRRITATING VAPOR EMITTED.**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **AMMONIA; CAUSTICS; IRON, COPPER, SILVER SALTS; STRONG OXIDIZERS; SOURCES OF IGNITION.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**0.25ppm/ND/HMN/IRR/EYE**
Animals	**250ppm/ND/RAT/LC50/IHL**
Freshwater	**15ppm/24/STRIPED BASS LARVAE/LC50/ND**
Saltwater	**18ppm/96/STRIPED BASS FINGERLING/LC50/ND**
Avian	**ND**

-- OTHER INFORMATION --

FLASH POINTS ARE FOR 37% CONCENTRATION AND DEPEND ON SOLVENT COMPOSITION. A 15% METHANOL (FLAMMABLE LIQUID) COSOLVENT PRODUCES THE LOWER FLASHPOINT CITED FOR A SATURATED (37%) SOLUTION.

Proper Shipping Name: **FUEL OIL, No. 1, 2, 4, or 5**
Commodity: **FUEL OIL, No. 1**
STCC: **4915112** DOT ID Number: **NA1993**
DOT Placard: **COMBUSTIBLE**
Shipping Rate: **24878** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating
Fire - 2/4
Health -
Vapor Irritant: **1/4**; Liquid/Solid Irritant: **1/4**; Poison: **1/4**
Water Pollution -
Human Toxicity: **1/4**; Aquatic Toxicity: **1/4**; Aesthetic Effect: **3/4**
Reactivity -
Other Chemicals: **0/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **0.7% - 5%**
Flash Point: GT100°F(cc); **ND** °F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **NP**
Behavior in Fire: **VARIABLE IGNITABILITY**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **SOURCES OF IGNITION**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**200ppm/ND/HMN/TLV/IHL**
Animals	**28,500/ND/RABBIT/LD50/ORAL**
Freshwater	**2990ppm/24/BLUEGILL/TLM/ND**
Saltwater	**0.1ppm/ND/PREDATORY SNAILS/AVOIDANCE/ND**
Avian	**ND**

-- OTHER INFORMATION --

SHIPPING RATE IS FOR ALL GRADES

Proper Shipping Name: **FUEL OIL, No. 1, 2, 4, or 5**
Commodity: **FUEL OIL, No. 2**
STCC: **4915112** DOT ID Number: **NA1993**
DOT Placard: **COMBUSTIBLE**
Shipping Rate: **24878** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NFPA HAZARD CLASSIFICATION
Health Hazard: 0/4; Flammability: 2/4; Reactivity: 0/4

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **ND**
Flash Point: **136°F(cc)**; **ND** °F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **NP**
Behavior in Fire: **NO SPECIAL HAZARD**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **NONE**
Conditions to Avoid: **SOURCES OF IGNITION**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**28350/ND/RABBIT/LD50/ORAL**
Freshwater	**95ppm/96/BLUEGILL/LC50/ND**
Saltwater	**700ppm/96/GULF MENHADEN/LIFE/LC50/ND**
Avian	**ND**

-- OTHER INFORMATION --

SHIPPING RATE IS FOR ALL GRADES

Proper Shipping Name: **FUEL OIL, No. 1, 2, 4, or 5**
Commodity: **FUEL OIL, No. 4**
STCC: **4915112** DOT ID Number: **NA1993**
DOT Placard: **COMBUSTIBLE**
Shipping Rate: **24878** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NFPA HAZARD CLASSIFICATION
Health Hazard: 0/4; Flammability: 2/4; Reactivity: 0/4

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.0%-5%**
Flash Point: **GT 130**°F(cc); **ND** °F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **NP**
Behavior in Fire: **NO SPECIAL HAZARD**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **SOURCES OF IGNITION**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**5000-15000/ND/ANIMAL/LD50/ORAL**
Freshwater	**22.5ppm/24/BANDED KILLIFISH/LC50/ND**
Saltwater	**ND**
Avian	**ND**

-- OTHER INFORMATION --

SHIPPING RATE IS FOR ALL GRADES

Proper Shipping Name: **FUEL OIL, No. 1, 2, 4, or 5**
Commodity: **FUEL OIL, No. 5**
STCC: **4915112** DOT ID Number: **NA1993**
DOT Placard: **COMBUSTIBLE**
Shipping Rate: **24878** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NFPA HAZARD CLASSIFICATION
Health Hazard: 0/4; Flammability: 2/4; Reactivity: 0/4

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1%-5%**
Flash Point: **GT 130°F(cc);** **ND** °F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **NP**
Behavior in Fire: **NO SPECIAL HAZARD**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **SOURCES OF IGNITION**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**5000-15000/ND/ANIMAL/LD50/ND**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

-- OTHER INFORMATION --

SHIPPING RATE IS FOR ALL GRADES

Proper Shipping Name: **NAPHTHA**
Commodity: **NAPHTHA**
STCC: **4915239** DOT ID Number: **UN2553**
DOT Placard: **COMBUSTIBLE**
Shipping Rate: **2693** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NFPA HAZARD CLASSIFICATION
Health Hazard: **1/4**; Flammability: **4/4**; Reactivity: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **0.8%-5%**
Flash Point: 107°F(cc); ND°F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **NP**
Behavior in Fire: **MAY FLASH BACK ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**300ppm/ND/HMN/TLV/IHL**
Animals	**1600ppm/6/RAT/LCLO/IHL**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

-- OTHER INFORMATION --

PETROLEUM SOLVENT OF VARIABLE COMPOSITION CHARACTERIZED COMMERCIALLY BY ITS BOILING-POINT RANGE

Proper Shipping Name: **ALCOHOL, N.O.S.**
Commodity: **OCTYL ALCOHOL, OTHER THAN PERFUMERY GRADE**
STCC: **4913158** DOT ID Number: **UN1987**
DOT Placard: **COMBUSTIBLE**
Shipping Rate: **1384** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NOT RATED

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **ND**
Flash Point: 178 ^{o}F(cc); **ND** ^{o}F(oc); Diffusivity: **0.0592 CM^2/SEC @ 15^{o}C**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **CAN REACT WITH STRONG OXIDIZERS**
Corrosiveness: **NP**
Behavior in Fire: **AT AMBIENT TEMPERATURES NOT VERY VOLATILE. POSSIBLE FLASH BACK ALONG VAPOR TRAIL IF EXPOSED TO HEAT.**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **NONE**
Conditions to Avoid: **HEAT, SPARKS, OPEN FLAME.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**500 MG/ND/RABBIT/IRR/SKIN**
Freshwater	**67-200ppm/4/CYPRINS DORES/PARALYSIS/ND**
Saltwater	**10-100ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

Proper Shipping Name: **PETROLEUM DISTILLATE**
Commodity: **PETROLEUM DISTILLATE FUEL OIL, NOT FOR ILLUMINATING PURPOSES**
STCC: **4915257** DOT ID Number: **UN1268**
DOT Placard: **COMBUSTIBLE**
Shipping Rate: **6445** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NOT RATED

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **ND**
Flash Point: **100-199**°F(cc); **ND**°F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **MAY REACT WITH STRONG OXIDIZERS**
Corrosiveness: **FUMES MAY BE NOXIOUS OR IRRITATING**
Behavior in Fire: **WHEN HEATED TO DECOMPOSITION, EMITS ACRID SMOKE AND FUMES.**
Evacuation Guidelines: FIRE: **NONE;** NO FIRE: **NONE**
Conditions to Avoid: **EXCESSIVE HEAT; STRONG OXIDIZERS; SMOKE; FUMES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**ND**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

APPENDIX B-3
FLAMMABLE SOLIDS

A flammable solid is defined (49 CFR 173.150) as any solid material, other than one classified as an explosive, which, under conditions normally incident to transportation is liable to cause fires through friction, retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious transportation hazard. Included in this class are spontaneously combustible and water-reactive materials.

This appendix lists three commodities which are classified as flammable solids. These are:

(a) CALCIUM CARBIDE

(b) PHOSPHORUS, WHITE OR YELLOW

(c) SODIUM, METALLIC

Proper Shipping Name: **CALCIUM CARBIDE**
Commodity: **CALCIUM CARBIDE**
STCC: **4916408**
DOT Placard: **FLAMMABLE SOLID W**
Shipping Rate: **ND**

DOT ID Number: **UN1402**

RQ **5000** lb.

-- HAZARD SUMMARY --

NFPA Hazard Classification
Health Hazard: **1/4;** Flammability: **4/4;** Reactivity: **2/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** ^{o}F(cc); **NP** ^{o}F(oc); Diffusivity: **NP**
Physical State: as Shipped: **SOLID;** as Released: **SOLID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **VIGOROUSLY WITH WATER TO FORM ACETYLENE GAS (FLAMMABLE GAS)**
Reactivity with Other Materials: **ACIDS PRODUCE ACETYLENE (FLAMMABLE GAS); CAUSTICS PRODUCE ACETYLIDES (EXPLOSIVE SOLIDS); SALTS MAY PRODUCE ACETYLIDES (EXPLOSIVE SOLIDS).**
Corrosiveness: **IRRITATING TO SKIN AND EYES**
Behavior in Fire: **WATER PRODUCES EXPLOSIVE ACETYLENE.**
Evacuation Guidelines: FIRE: **NONE** NO FIRE: **NONE**
Conditions to Avoid: **CONTACT WITH: WATER, ACIDS, CAUSTICS, LEAD (II) FLUORIDE, MAGNESIUM, SILVER NITRATE, SULFUR.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**1000/CHRONIC/LIVESTOCK/TFX/ND**
Freshwater	**ND**
Saltwater	**ND**
Avian	**500ppm/CHRONIC/WATERFOWL/TFX/ND**

Proper Shipping Name: **PHOSPHORUS, WHITE or YELLOW, IN WATER**
Commodity: **PHOSPHORUS, WHITE or YELLOW, IN WATER**
STCC: **4916141** DOT ID Number: **UN1381**
DOT Placard: **FLAMMABLE SOLID AND POISON**
Shipping Rate: **3233** Tank Cars/Year **(1983)** RQ **1** lb.

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **3/4**
- Health -
  - Vapor Irritant: **ND**; Liquid/Solid Irritant: **4/4**; Poison: **4/4**
- Water Pollution -
  - Human Toxicity: **3/4**; Aquatic Toxicity: **4/4**; Aesthetic Effect: **1/4**
- Reactivity -
  - Other Chemicals: **4/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** °F(cc); **PYROPHORIC**; Diffusivity: **NP**
Physical State: as Shipped: **SOLID**; as Released: **SOLID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **AIR, HYDROXIDES, AMMONIUM NITRATE, ANTIMONY PENTAFLUORIDE, BARIUM BROMATE, BARIUM CHLORATE AND SEVERAL OTHER MATERIALS.**
Corrosiveness: **NOT CORROSIVE IN ABSENCE OF AIR OR WATER.**
Behavior in Fire: **IGNITES ON CONTACT WITH AIR TO FORM INTENSE TOXIC SMOKE.**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **EXPOSURE TO AIR**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**1.4/ND/HMN/LDLO/ORAL**
Animals	**500 MGperM^3/0.2/MOUSE/LCLO/IHL**
Freshwater	**0.045ppm/96/BLUEGILL/LC50/ND**
Saltwater	**0.0025ppm/96/COD/LC50/ND**
Avian	**36/33/DUCK/LD100/ORAL**

-- OTHER INFORMATION --

SPONTANEOUSLY IGNITES IN AIR; TANK CAR EXPLOSION HAS BEEN REPORTED

Proper Shipping Name: **SODIUM, METAL or METALLIC**
Commodity: **SODIUM, METALLIC**
STCC: **4916456** DOT ID Number: **UN1428**
DOT Placard: **FLAMMABLE SOLID W**
Shipping Rate: **877** Tank Cars/Year **(1983)** RQ **1000** lb.

-- HAZARD SUMMARY --

NFPA Hazard Classification
Health Hazard: **3/4**; Flammability: **1/4**; Reactivity: **2/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** °F(cc); **NP**°F(oc); Diffusivity: **NP**
Physical State: as Shipped: **SOLID**; as Released: **SOLID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **VIOLENTLY TO FORM HYDROGEN (FLAMMABLE GAS) AND CAUSTIC SODIUM HYDROXIDE SOLUTION.**
Reactivity with Other Materials: **REACTS VIOLENTLY WITH NUMEROUS MATERIALS.**
Corrosiveness: **HIGHLY CORROSIVE TO TISSUE; REACTION WITH WATER ALSO PRODUCES CORROSIVE MATERIAL.**
Behavior in Fire: **PYROPHORIC; IGNITION SOURCE; MELTS AT 208°F**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **MOISTURE; ACID; COMBUSTIBLES; AIR**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**1.4/ND/HMN/LDLO/ORAL**
Animals	**1000ppm/ND/ANIMALS/CHRONIC TOXIC LIMIT/ND**
Freshwater	**ND**
Saltwater	**24,000-25,000ppm/48/MARINE FISH/TLM/ND**
Avian	**ND**

-- OTHER INFORMATION --

SPONTANEOUSLY IGNITES IN AIR

APPENDIX B-4
OXIDIZING MATERIALS

An oxidizing material is defined (49 CFR 173.151) as a substance such as a chlorate, permanganate, inorganic peroxide, or a nitrate that yields oxygen readily to stimulate the combustion of organic matter.

This appendix lists six commodities which are classified as oxidizing materials. These are:

(a) AMMONIUM NITRATE FERTILIZER, NO MORE THAN 0.2% CARBON

(b) HYDROGEN PEROXIDE SOLUTION, OVER 52% PEROXIDE

(c) NITRIC ACID, FUMING

(d) POTASSIUM NITRATE

(e) SODIUM CHLORATE

(f) SODIUM NITRATE

Proper Shipping Name: **AMMONIUM NITRATE FERTILIZER**
Commodity: **AMMONIUM NITRATE FERTILIZER, LESS THAN 0.2% CARBON**
STCC: **4918310** DOT ID Number: **UN2067**
DOT Placard: **OXIDIZER**
Shipping Rate: **ND**

-- HAZARD SUMMARY --

NFPA Hazard Classification
Health Hazard: **2/4**; Flammability: **0/4**; Reactivity: **3/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** ^{o}F(cc); **NP** 0^{o}F(oc); Diffusivity: **NP**
Physical State: as Shipped: **SOLID**: as Released: **SOLID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **ACETIC ACID; ALUMINUM; CARBON; ORGANIC MATERIALS; PHOSPHORUS**
Corrosiveness: **EYE AND RESPIRATORY IRRITANT**
Behavior in Fire: **MAY EXPLODE IN CONFINED AREA; SUPPORTS COMBUSTION OF ORGANIC MATTER: MAY PRODUCE TOXIC FUMES.**
Evacuation Guidelines: FIRE: **1 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **HEAT; FLAME; FRICTION; HIGH TEMPERATURES WHEN CONFINED (EXPLOSION)**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**15 MGperM^3/ND/HMN/TLV/ND**
Animals	**4500/ND/RAT/LD50/ORL**
Freshwater	**15ppm/40/ASPERGILLUS NIGER/LD50**
Saltwater	**GT 100-1000ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

-- OTHER INFORMATION --

EXPLOSION HAZARD IS LOW FOR FERTILIZER GRADE; INCREASES WITH CONTAMINATION. HEAT AND CONFINEMENT INCREASE EXPLOSION HAZARD. MAY BURN WITHOUT DETONATION.

Proper Shipping Name: **HYDROGEN PEROXIDE SOLUTION, OVER 52% PEROXIDE**
Commodity: **HYDROGEN PEROXIDE SOLUTION, OVER 52% PEROXIDE**
STCC: **4918335** DOT ID Number: **UN2015**
DOT Placard: **OXIDIZER; TANK MARKING REQUIRED**
Shipping Rate: **1571** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **0/4**
- Health -
  - Vapor Irritant: **2/4**; Liquid/Solid Irritant: **3/4**; Poison: **1/4**
- Water Pollution -
  - Human Toxicity: **1/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **1/4**
- Reactivity -
  - Other Chemicals: **4/4**; Water: **1/4**; Self-Reaction: **3/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** ^{o}F(cc); **NP** ^{o}F(oc); Diffusivity: **0.164 CM^2/SEC @ 15^{o}C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **ACETIC ACID; FORMIC ACID; BRASS; COPPER; ORGANIC MATTER; CHROMIUM; ETHANOL; IRON; LEAD; MANGANESE; NOBLE METALS; HYDRAZINE.**
Corrosiveness: **METALS MAY CATALYZE DECOMPOSITION, WHICH EMITS EXPLOSIVE HYDROGEN GAS. STRONGLY IRRITATING TO EYES, SKIN.**
Behavior in Fire: **CLOSED CONTAINERS MAY EXPLODE WHEN HEATED.**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **HEAT; SHOCK; HEAVY METALS AND THEIR SALTS; CONTAMINATION**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	ND
Animals	2000 MGperM^3/4/RAT/LC50/IHL
Freshwater	40ppm/48/FINGERLING TROUT/TOXIC
Saltwater	ND
Avian	ND

-- OTHER INFORMATION --

CLASSIFIED AS OXIDIZER IN HAZARDOUS MATERIALS TABLE; AUTHORIZED CONTAINERS LISTED IN SUBPART F —— CORROSIVE MATERIALS

Proper Shipping Name: **NITRIC ACID, FUMING**
Commodity: **NITRIC ACID, FUMING**
STCC: **4918529** DOT ID Number: **UN2032**
DOT Placard: **OXIDIZER; TANK MARKING REQUIRED**
Shipping Rate: **ND** RQ **1000** lb.

-- HAZARD SUMMARY --

NAS Hazard Rating
Fire - **0/4**
Health -
Vapor Irritant: **3/4**; Liquid/Solid Irritant: **4/4**; Poison: **3/4**
Water Pollution -
Human Toxicity: **3/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **2/4**
Reactivity -
Other Chemicals: **4/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** °F(cc); **NP** °F(oc); Diffusivity: **HN03-EST 0.12 CM^2/SEC @ 15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **MILD HEATING; PRODUCES TOXIC, CORROSIVE FUMES**
Reactivity with Other Materials: **CYANIDES; SULFIDES; OXIDIZABLE INORGANICS; VIGOROUSLY WITH ORGANIC COMBUSTIBLES, METALS.**
Corrosiveness: **HIGHLY CORROSIVE TO MOST METALS, PRODUCING HYDROGEN (FLAMMABLE GAS)**
Behavior in Fire: **DECOMPOSES TO POISONOUS NITROGEN OXIDES; COMBUSTIVE OXIDIZER**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **0.5 x 0.7 MILES**
Conditions to Avoid: **COMBUSTIBLE MATERIALS, METALS**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**110/ND/HMN/LDLO/ND**
Animals	**244ppm/ND/RAT/LC50/IHL**
Freshwater	**15.6ppm/24/TROUT/TOXIC/ND**
Saltwater	**100-330ppm/48/STARFISH/LC50**
Avian	**ND**

Proper Shipping Name: **POTASSIUM NITRATE**
Commodity: **POTASSIUM NITRATE**
STCC: **4918737**
DOT ID Number: **UN1486**
DOT Placard: **OXIDIZER**
Shipping Rate: **ND**

-- HAZARD SUMMARY --

NFPA Hazard Classification
Health Hazard: 1/4; Flammability: 0/4; Reactivity: 0/4

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** ^{o}F(cc); **NP** ^{o}F(oc); Diffusivity: **NP**
Physical State: as Shipped: **SOLID;** as Released: **SOLID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NONE**
Reactivity with Other Materials: **REDUCING AGENTS; SODIUM SALTS WITH ACETATE, TARTRATE, OXALATE, CITRATE, PHOSPHITE; TIN.**
Corrosiveness: **NP**
Behavior in Fire: **MAY EXPLODE, ESPECIALLY IN PRESENCE OF COMBUSTIBLES; VERY TOXIC FUMES WHEN HEATED TO DECOMPOSITION.**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **NONE**
Conditions to Avoid: **HEATING WITH OXIDIZABLE MATERIAL, PARTICULARLY IN CLOSED CONTAINERS.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**8000-39000 MG/ND/HMN/LETHAL/ORAL**
Animals	**3015/ND/RABBIT/LD5O/ORAL**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

Proper Shipping Name: **SODIUM CHLORATE**
Commodity: **SODIUM CHLORATE**
STCC: **4918723** DOT ID Number: **UN1495**
DOT Placard: **OXIDIZER**
Shipping Rate: **ND**

-- HAZARD SUMMARY --

NFPA Hazard Classification
Health Hazard: **1/4**; Flammability: **0/4**; Reactivity: **2/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** °F(cc); **NP** °F(oc); Diffusivity: **NP**
Physical State: as Shipped: **SOLID**; as Released: **SOLID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **ORGANIC MATTER; CARBON; ALUMINUM; COPPER; METAL SULFIDES, CYANIDES, THIOCYANATES; SULFUR; SULFURIC ACID; ZINC.**
Corrosiveness: **CORROSIVE TO STEEL, PARTICULARLY WHEN WET.**
Behavior in Fire: **COMBUSTIVE OXIDIZER; VIOLENTLY WITH SOME METALS AND ALL ORGANIC MATTER; THERMALLY DECOMPOSES TO TOXIC FUMES.**
Evacuation Guidelines: FIRE: **0.5 MILES**; NO FIRE: **NONE**
Conditions to Avoid: **MINGLING WITH ORGANICS, ACIDS, AND METALS.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	214/ND/HMN/LDLO/ND
Animals	500 MG/24/RABBIT/MILD IRR/SKIN
Freshwater	4200ppm/24/RAINBOW TROUT/LC50/ND
Saltwater	GT 1000ppm/96/AQUATIC LIFE/TLM/ND
Avian	ND

Proper Shipping Name: **SODIUM NITRATE**
Commodity: **SODIUM NITRATE**
STCC: **4918746** DOT ID Number: **UN1498**
DOT Placard: **OXIDIZER**
Shipping Rate: **ND**

-- HAZARD SUMMARY --

NFPA Hazard Classification
Health Hazard: **1/4**; Flammability: **0/4**; Reactivity: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** °F(cc); **NP** °F(oc); Diffusivity: **NP**
Physical State: as Shipped: **SOLID**; as Released: **SOLID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **OXIDIZABLE MATERIALS AND CYANIDES.**
Corrosiveness: **NONE**
Behavior in Fire: **CAN EXPLODE, ESPECIALLY WHEN HEATED WITH OXIDIZABLE MATERIALS; EMITS VERY TOXIC FUMES UPON HEATING TO DECOMPOSITION**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **HEATING; HEATING WHEN MIXED WITH CYANIDES.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**5 MGperM^3/ND/HMN/RESPIRABLE FRACTION-DUST/IHL**
Animals	**200/ND/RAT/LDLO/ORL**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

APPENDIX B-5
CORROSIVE MATERIALS

A corrosive material is defined (49 CFR 173.240) as a liquid or solid that causes visible destruction or irreversible 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. A material is considered to be destructive or to cause irreversible alteration in human skin tissue if, when tested on the intact skin of an albino rabbit by the technique specified in the regulations, the structure of the tissue at the site of contact is destroyed or changed irreversibly after an exposure period of four hours or less. A liquid is considered to have a severe corrosion rate if its corrosion rate exceeds 0.250 inches (0.635cm) per year on SAE 1020 steel at a test temperature of 130°F (54.4°C). However, if human experience or other data indicate that the hazard of a material is greater or less than indicated by the results of the tests specified, the Department of Transportation may revise its classification or make the material subject to the requirements of other classifications.

This appendix lists sixteen commodities which are classified as corrosive materials. These are:

(a) ACETIC ACID, GLACIAL
(b) ACETIC ANHYDRIDE
(c) CAUSTIC SODA AND CAUSTIC POTASSIUM, MIXED, IN SOLUTION
(d) FERRIC CHLORIDE SOLUTION, CRUDE, AT LEAST 50% WATER
(e) HEXAMETHYLENE DIAMINE SOLUTION
(f) HYDROCHLORIC ACID
(g) HYDROFLUOROSILICIC ACID
(h) HYDROGEN FLUORIDE, ANHYDROUS
(i) OLEUM
(j) PHOSPHORIC ACID (PHOSPHATIC FERTILIZER SOLUTION)
(k) POTASSIUM HYDROXIDE, LIQUID or SOLUTION
(l) SODIUM HYDROSULFIDE, SOLUTION
(m) SODIUM HYDROXIDE, LIQUID
(n) SODIUM HYDROXIDE, LIQUID or SOLUTION, AT LEAST 48% WATER
(o) SULFURIC ACID
(p) SULFURIC ACID, SPENT

Proper Shipping Name: **ACETIC ACID, GLACIAL**
Commodity: **ACETIC ACID, GLACIAL**
STCC: **4931303** DOT ID Number: **UN2789**
Synonyms: **VINEGAR ACID**
DOT Placard: **CORROSIVE**
Shipping Rate: **3399** Tank Cars/Year **(1983)** RQ **1000** lb.

-- HAZARD SUMMARY --

NAS Hazard Rating
Fire - **2/4**
Health -
Vapor Irritant: **2/4**; Liquid/Solid Irritant: **3/4**; Poison: **2/4**
Water Pollution -
Human Toxicity: **1/4**; Aquatic Toxicity: **2/4**; Aesthetic Effect: **2/4**
Reactivity -
Other Chemicals: **2/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **5.4% - 16.0%**
Flash Point: **104** ^{o}F(cc); **112** ^{o}F(oc); Diffusivity: **0.1064 CM^2/SEC @ 0^{o}C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **AMMONIUM NITRATE; OXIDIZING ACIDS; HYDROGEN PEROXIDE; NITRIC ACID AND ACETONE; CAUSTICS; INORGANIC PEROXIDES.**
Corrosiveness: **CORROSIVE TO METALS WHEN DILUTED; SKIN AND RESPIRATORY IRRITANT; CORRODES RUBBER.**
Behavior in Fire: **VAPOR MAY EXPLODE IN AN ENCLOSED AREA. EMITS TOXIC FUMES WHEN HEATED TO DECOMPOSITION.**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **NONE**
Conditions to Avoid: **CONTACT WITH STRONG ALKALIES OR STRONG OXIDIZERS.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**10ppm/8/HMN/TLV/IHL**
Animals	**5000ppm/1/MOUSE/LC50/IHL**
Freshwater	**75ppm/96/BLUEGILL/TLM/ND**
Saltwater	**100-330ppm/48/SHRIMP/LC50/ND**
Avian	**ND**

Proper Shipping Name: **ACETIC ANHYDRIDE**
Commodity: **ACETIC ANHYDRIDE**
STCC: **4931304** DOT ID Number: **UN1715**
DOT Placard: **CORROSIVE**
Shipping Rate: **2022** Tank Cars/Year **(1983)** RQ **1000 lb.**

-- HAZARD SUMMARY --

NAS Hazard Rating
Fire - **2/4**
Health -
Vapor Irritant: **3/4**; Liquid/Solid Irritant: **3/4**; Poison: **3/4**
Water Pollution -
Human Toxicity: **1/4**; Aquatic Toxicity: **2/4**; Aesthetic Effect: **2/4**
Reactivity -
Other Chemicals: **3/4**; Water: **2/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **2.7% - 12.4%**
Flash Point: 120 ^{o}F(cc); 136 ^{o}F(oc); Diffusivity: **0.078 CM^2/SEC @ 15^{o}C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **FORMS ACETIC ACID; SPRAYS LIBERATE CONSIDERABLE HEAT**
Reactivity with Other Materials: **OXIDIZERS; WITH WATER -MAY IGNITE COMBUSTIBLES.**
Corrosiveness: **RESPIRATORY AND SEVERE SKIN IRRITANT. CORROSIVE TO METALS AND TISSUE.**
Behavior in Fire: **VAPOR MAY EXPLODE IF IGNITED; EXPLOSION POTENTIAL GREATER WITH WATER CONTACT IN A CONFINED SPACE. EMITS TOXIC FUMES WHEN HEATED TO DECOMPOSITION.**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **APPLICATION OF WATER; SKIN CONTACT; HEAT AND CONFINEMENT**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	5ppm/ND/HMN/TLV/ND
Animals	2000ppm/4/RAT/LC100/IHL
Freshwater	75ppm/96/BLUEGILL/TLM/ND
Saltwater	100-330ppm/48/SHRIMP/LC50/ND
Avian	ND

Proper Shipping Name: **CORROSIVE LIQUID, N.O.S.**
Commodity: **CAUSTIC SODA AND CAUSTIC POTASSIUM, MIXED, IN SOLUTION**
STCC: **4935245** DOT ID Number: **UN1824**
DOT Placard: **CORROSIVE**
Shipping Rate: **782** Tank Cars/Year **(1979)** RQ **1000** lb.

-- HAZARD SUMMARY --

NFPA Hazard Classification
Health Hazard: **3/4;** Flammability: **0/4;** Reactivity: **1/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** °F(cc); **NP** °F(oc); Diffusivity: **NP**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **DILUTION LIBERATES HEAT AND MAY PRODUCE STEAM AND SPATTER**
Reactivity with Other Materials: **ACIDS; ACROLEIN; ACRYLONITRILE; MALEIC ANHYDRIDE; ALDEHYDES; SOME ALCOHOLS.**
Corrosiveness: **CORROSIVE TO TISSUE; ATTACKS WOOL, LEATHER, ALUMINUM, LEAD, TIN, ZINC; SLOWLY CORRODES IRON, COPPER.**
Behavior in Fire: **NOT FLAMMABLE; MAY IGNITE COMBUSTIBLES; MAY FORM HYDROGEN (FLAMMABLE GAS) ON CONTACT WITH METAL.**
Evacuation Guidelines: FIRE: **NONE;** NO FIRE: **NONE**
Conditions to Avoid: **CONTACT WITH LIQUID, SOLID, MISTS; CONTAINER CORROSION; MOISTURE ABSORPTION; FREEZING**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**50 MG/24/HMN/SEV IRR/SKIN**
Animals	**600/ND/MOUSE/TDLO/SKIN**
Freshwater	**80ppm/24/MOSQUITO FISH/TLM/ND**
Saltwater	**10-100ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

-- OTHER INFORMATION --

HAZARD DATA BASED ON SEPARATE CONSTITUENTS; NO DATA ON MIXTURE

Proper Shipping Name: **FERRIC CHLORIDE SOLUTION**
Commodity: **FERRIC CHLORIDE SOLUTION, AT LEAST 50% WATER**
STCC: **4932342** DOT ID Number: **UN2582**
DOT Placard: **CORROSIVE**
Shipping Rate: **1728** Tank Cars/Year **(1983)** RQ **1000 lb.**

-- HAZARD SUMMARY --

NOT RATED

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP**°F(cc); **ND**°F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **VIOLENTLY WITH ALLYL CHLORIDE, ETHYLENE OXIDE, SODIUM, POTASSIUM**
Corrosiveness: **CORROSIVE TO MOST METALS. IRRITATING TO TISSUE.**
Behavior in Fire: **TOXIC FUMES EMITTED.**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **SKIN CONTACT**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	1 MGperM^3 AS IRON/TLV/ND
Animals	900/ND/RAT/LD50/ORAL
Freshwater	12ppm/144/STICKELBACK/HARMFUL/ND
Saltwater	ND
Avian	ND

-- OTHER INFORMATION --

USUALLY CONTAINS HYDROCHLORIC ACID TO MAINTAIN SOLUBILITY

Proper Shipping Name: **HEXAMETHYLENE DIAMINE, SOLUTION**
Commodity: **HEXAMETHYLENE DIAMINE, SOLUTION**
STCC: **4935645** DOT ID Number: **UN1783**
Synonyms: **1, 6-HEXANEDIAMINE**
DOT Placard: **CORROSIVE** Shipping Rate: **5683**
Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **1/4**
- Health -
  - Vapor Irritant: **1/4**; Liquid/Solid Irritant: **2/4**; Poison: **3/4**
- Water Pollution -
  - Human Toxicity: **2/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **1/4**
- Reactivity -
  - Other Chemicals: **3/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **.7% - 6.3%**
Flash Point: **ND** °F(cc); **160** °F(oc); Diffusivity: **0.063 CM^2/SEC @ 15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **OXIDIZING MATERIALS.**
Corrosiveness: **CORROSIVE TO ALUMINUM, COPPER, AND THEIR ALLOYS.**
Behavior in Fire: **SLIGHT FIRE HAZARD WHEN EXPOSED TO HEAT OR FLAME; EMITS TOXIC FUMES WHEN HEATED TO DECOMPOSITION.**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **OXIDIZING MATERIALS; EXCESSIVE HEAT.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**158ppm/0.2/MOUSE/LCLO/IHL**
Freshwater	**10-100ppm/96/AQUATIC LIFE/TLM/ND**
Saltwater	**10-100ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

Proper Shipping Name: **HYDROCHLORIC ACID**
Commodity: **HYDROCHLORIC ACID**
STCC: **4930228** DOT ID Number: **UN1789**
DOT Placard: **CORROSIVE**
Shipping Rate: **11165** Tank Cars/Year **(1983)** RQ **5000** lb.

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **0/4**
- Health -
  - Vapor Irritant: **3/4**; Liquid/Solid Irritant: **3/4**; Poison: **2/4**
- Water Pollution -
  - Human Toxicity: **2/4**; Aquatic Toxicity: **2/4**; Aesthetic Effect: **2/4**
- Reactivity -
  - Other Chemicals: **3/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** ^{o}F(cc); **ND** ^{o}F(oc); Diffusivity: **0.155 CM^2/SEC @ 15^{o}C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **PRODUCES TOXIC, CORROSIVE FUMES**
Reactivity with Other Materials: **VIGOROUSLY WITH METALS USUALLY PRODUCING HYDROGEN (FLAMMABLE GAS).**
Corrosiveness: **HIGHLY CORROSIVE TO METALS, TISSUE.**
Behavior in Fire: **MAY EVOLVE HYDROGEN CHLORIDE OR ACID FUMES.**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **1.0 x 1.4 MILES**
Conditions to Avoid: **INHALATION OF FUMES; CONTACT WITH METALS, WATER.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**1000/2/HMN/LCLO/IHL**
Animals	**2350ppm/1/RAT/LC50/IHL**
Freshwater	**3.6ppm/48/SUNFISH/LETHAL/ND**
Saltwater	**100-330ppm/48/SHRIMP/LC50/ND**
Avian	**ND**

Proper Shipping Name: **HYDROFLUOROSILICIC ACID**
Commodity: HYDROFLUOSILICIC ACID
STCC: **4930026** DOT ID Number: **NA1778**
Synonyms: **HEXAFLUOROSILICATE (2-1), DIHYDROGEN; FLUOSILICIC ACID**
DOT Placard: **CORROSIVE**
Shipping Rate: **961** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating
Fire - **0/4**
Health -
Vapor Irritant: **0/4**; Liquid/Solid Irritant: **3/4**; Poison: **3/4**
Water Pollution -
Human Toxicity: **ND**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **0/4**
Reactivity -
Other Chemicals: **1/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** °F(cc); **NP** °F(oc); Diffusivity: **NP**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **LIBERATES TOXIC, CORROSIVE FUMES**
Reactivity with Other Materials: **COMBUSTIBLES; ORGANIC PEROXIDES; SOME OXIDIZERS; MOST METALS, FORMING HYDROGEN (FLAMMABLE GAS).**
Corrosiveness: **HIGHLY CORROSIVE TO MOST METALS, TISSUE.**
Behavior in Fire: **DECOMPOSES TO FORM HYDROGEN FLUORIDE (TOXIC, CORROSIVE GAS).**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **CONTACT WITH METALS, TISSUE.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**5 MGperM^3/ND/HMN/EYE, RESP IRR/IHL**
Animals	**200/ND/GUINEA PIG/LDLO/ORL**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

Proper Shipping Name: **HYDROGEN FLUORIDE**
Commodity: **HYDROFLUORIC ACID, ANHYDROUS**
STCC: **4930024** DOT ID Number: **UN1052**
DOT Placard: **CORROSIVE**
Shipping Rate: **2008** Tank Cars/Year **(1983)** RQ 5000 lb.

-- HAZARD SUMMARY --

NAS Hazard Rating
Fire - **0/4**
Health -
Vapor Irritant: **4/4**; Liquid/Solid Irritant: **4/4**; Poison: **4/4**
Water Pollution -
Human Toxicity: **4/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **2/4**
Reactivity -
Other Chemicals: **4/4**; Water: **2/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** °F(cc); **NP** °F(oc); Diffusivity: **0.225 CM^2/SEC @ 15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID, VAPOR**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **LARGE QUANTITIES OF HEAT RELEASED; TOXIC AND CORROSIVE FUMES LIBERATED.**
Reactivity with Other Materials: **ARSENIC TRIOXIDE; PHOSPHORUS PENTOXIDE; BISMUTHIC ACID; FLUORINE; NATURAL RUBBER; CONCRETE; ORGANIC MATERIALS.**
Corrosiveness: **EXTREMELY CORROSIVE TO METALS, GLASS, RUBBER, LEATHER, AND OTHER ORGANIC MATERIALS. FUMES ARE HIGHLY CORROSIVE.**
Behavior in Fire: **NOT FLAMMABLE; REACTION WITH METAL PRODUCES HYDROGEN (FLAMMABLE GAS).**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **0.7 x 1.1 MILES**
Conditions to Avoid: **CONTACT WITH METALS, GLASS.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	32ppm/ND/HMN/TCLO/IHL
Animals	1310ppm/ND/RAT/LC50/IHL
Freshwater	40ppm/ND/FISH/HARMFUL/ND
Saltwater	300ppm/48/SHRIMP/LC50/ND
Avian	ND

Proper Shipping Name: **OLEUM**
Commodity: **OLEUM**
STCC: **4930030** DOT ID Number: **NA1831**
Synonyms: **FUMING SULFURIC ACID**
DOT Placard: **CORROSIVE**
Shipping Rate: **2549** Tank Cars/Year **(1983)** RQ **1000 lb.**

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **0/4**
- Health -
  - Vapor Irritant: **4/4**; Liquid/Solid Irritant: **4/4**; Poison: **3/4**
- Water Pollution -
  - Human Toxicity: **2/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **2/4**
- Reactivity -
  - Other Chemicals: **4/4**; Water: **3/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** °F(cc); **NP** °F(oc); Diffusivity: **est. H_2SO_4 - 0.087CM^2/SEC @ 15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID, VAPOR**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **VIGOROUS REACTION; VIOLENT SPLATTERING CAN OCCUR; CONSIDERABLE HEAT RELEASED**
Reactivity with Other Materials: **STRONG OXIDIZER; CAN REACT ON CONTACT WITH OTHER MATERIALS TO CAUSE FIRE. WHEN DILUTED WITH WATER REACTS WITH MOST METALS TO GENERATE HYDROGEN (FLAMMABLE GAS).**
Corrosiveness: **HIGHLY CORROSIVE TO METALS, TISSUE**
Behavior in Fire: **NOT FLAMMABLE**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **CONTACT WITH OTHER MATERIALS, TISSUE**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	5 MGperM^3/0.25/HMN/TCLO/IHL
Animals	500 MGperM^3/8/MOUSE/LC50/IHL
Freshwater	49ppm/48/BLUEGILL/TLM/ND
Saltwater	42.5ppm/48/PRAWN/LC50/ND
Avian	ND

Proper Shipping Name: **PHOSPHORIC ACID**
Commodity: **PHOSPHATIC FERTILIZER SOLUTION**
STCC: **4930247** DOT ID Number: **UN1805**
DOT Placard: **CORROSIVE**
Shipping Rate: **23947** Tank Cars/Year **(1983)** RQ **5000** lb.

-- HAZARD SUMMARY --

NAS Hazard Rating
Fire - **0/4**
Health -
Vapor Irritant: **0/4**; Liquid/Solid Irritant: **3/4**; Poison: **1/4**
Water Pollution -
Human Toxicity: **2/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **2/4**
Reactivity -
Other Chemicals: **3/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** °F(cc); **NP** °F(oc); Diffusivity: **0.085CM^2/SEC @ 15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **MILD EVOLUTION OF HEAT**
Reactivity with Other Materials: **DEHYDRATES IN STAGES TO POLYPHOSPHORIC ACIDS; REACTS WITH METALS TO FORM HYDROGEN (FLAMMABLE GAS).**
Corrosiveness: **VERY CORROSIVE TO IRON, ALUMINUM, AND THEIR ALLOYS.**
Behavior in Fire: **BURNS WITH DIFFICULTY**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **CONTACT WITH IRON CONTAINERS**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**100 MGperM^3/ND/HMN/TCLO/IHL**
Animals	**596 MG/24/RABBIT/SEV TFX/SKN**
Freshwater	**138ppm/24/MOSQUITO FISH/TLM/ND**
Saltwater	**100-1000ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

-- OTHER INFORMATION --

TYPICALLY CONTAINS 15%-25% WATER

Proper Shipping Name: **POTASSIUM HYDROXIDE, LIQUID OR SOLUTION**
Commodity: **POTASSIUM HYDROXIDE, LIQUID OR SOLUTION**
STCC: **4935230** DOT ID Number: UN1814
DOT Placard: CORROSIVE
Shipping Rate: **2458** Tank Cars/Year **(1983)** RQ 1000 lb.

-- HAZARD SUMMARY --

NFPA Hazard Classification
Health Hazard: **3/4**; Flammability: **0/4**; Reactivity: **1/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** ^{o}F(cc); **NP** ^{o}F(oc); Diffusivity: **NP**
Physical State: as Shipped: **SOLID, LIQUID**; as Released: **SOLID, LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **DILUTION LIBERATES HEAT, PRODUCES STEAM AND SPATTERING**
Reactivity with Other Materials: **ACIDS; ACROLEIN; ACRYLONITRILE; MALEIC ANHYDRIDE; DICHLOROETHYLENE**
Corrosiveness: **ATTACKS WOOL, LEATHER, ALUMINUM, LEAD, TIN, AND ZINC. CORROSIVE TO TISSUE.**
Behavior in Fire: **NOT FLAMMABLE; MAY IGNITE COMBUSTIBLES.**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **CONTACT WITH LIQUIDS, SOLIDS, VAPOR, AND DUST; CONTAINER CORROSION; MOISTURE ABSORPTION; FREEZING.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**50 MG/24/HMN/SEVERE IRR/SKIN**
Animals	**600/ND/MOUSE/TDLO/SKIN**
Freshwater	**80ppm/24/MOSQUITO FISH/TLM/ND**
Saltwater	**10-100ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

Proper Shipping Name: **SODIUM HYDROSULFIDE, SOLUTION**
Commodity: **SODIUM HYDROSULFIDE, SOLUTION**
STCC: **4935268** DOT ID Number: **NA2922**
Synonyms: **SODIUM BISULFIDE SOLUTION**
DOT Placard: **CORROSIVE**
Shipping Rate: **1268** Tank Cars/Year **(1983)** RQ **5000 lb.**

-- HAZARD SUMMARY --

NAS Hazard Rating
Fire - 0/4
Health -
Vapor Irritant: **2/4**; Liquid/Solid Irritant: **3/4**; Poison: **4/4**
Water Pollution -
Human Toxicity: **2/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **3/4**
Reactivity -
Other Chemicals: **3/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** °F(cc); **NP** °F(oc); Diffusivity: **NP**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **CORRODES MOST METALS, BUT REACTION IS NOT HAZARDOUS; ACIDS FORM HYDROGEN SULFIDE (TOXIC, FLAMMABLE GAS).**
Corrosiveness: **CORROSIVE TO METALS AND TISSUE**
Behavior in Fire: **EMITS TOXIC FUMES UPON HEATING TO DECOMPOSITION.**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **CONTACT WITH DIAZONIUM SALTS, ACIDS, HEAT.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**5 MGperM^3/ND/HMN/TLV/NP**
Animals	**30/ND/RAT/LD50/IPR**
Freshwater	**206ppm/96/MOSQUITO FISH/TLM/ND**
Saltwater	**206ppm/96/MOSQUITO FISH/TLM/ND**
Avian	**ND**

Proper Shipping Name: **SODIUM HYDROXIDE, LIQUID**
Commodity: **SODIUM HYDROXIDE, LIQUID**
STCC: **4935240** DOT ID Number: **UN1824**
DOT Placard: **CORROSIVE**
Shipping Rate: **27735** Tank Cars/Year **(1983)** RQ **1000** lb.

-- HAZARD SUMMARY --

NFPA Hazard Classification
Health Hazard: **3/4**; Flammability: **0/4**; Reactivity: **1/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** °F(cc); **NP** °F(oc); Diffusivity: **NP**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **DILUTES WITH LIBERATION OF HEAT**
Reactivity with Other Materials: **ACETALDEHYDE; ACROLEIN; ACRYLONITRILE; ALLYL ALCOHOL; ALUMINUM; CHLOROFORM; METHYL ALCOHOL.**
Corrosiveness: **HIGHLY CORROSIVE; ATTACKS WOOL, LEATHER, TIN, ALUMINUM, ZINC AND THEIR ALLOYS; SLOWLY CORROSIVE TO IRON, COPPER.**
Behavior in Fire: **MAY FORM HYDROGEN (FLAMMABLE GAS) ON CONTACT WITH METAL; EMITS TOXIC, CORROSIVE FUMES.**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **CONTACT WITH METALS, TISSUE**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**0.02 MGperM^3/ND/HMN/TLV/ND**
Animals	**1350/ND/RABBIT/LD50/SKIN**
Freshwater	**125ppm/96/MOSQUITO FISH/TLM/ND**
Saltwater	**33-100ppm/48/SHRIMP/LC50/ND**
Avian	**ND**

Proper Shipping Name: **SODIUM HYDROXIDE, LIQUID or SOLUTION**
Commodity: **SODIUM HYDROXIDE, LIQUID or SOLUTION, AT LEAST 48% WATER**
STCC: **4935243** DOT ID Number: UN1824
DOT Placard: **CORROSIVE**
Shipping Rate: **37158** Tank Cars/Year **(1983)** RQ 1000 lb.

-- HAZARD SUMMARY --

NFPA Hazard Classification
Health Hazard: **3/4**; Flammability: **0/4**; Reactivity: **1/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** ^{o}F(cc); **NP** ^{o}F(oc); Diffusivity: **NP**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **DILUTES WITH LIBERATION OF HEAT**
Reactivity with Other Materials: **ACETALDEHYDE; ACROLEIN; ACRYLONITRILE; ALLYL ALCOHOL; ALUMINUM; CHLOROFORM; METHYL ALCOHOL.**
Corrosiveness: **HIGHLY CORROSIVE; ATTACKS WOOL, LEATHER, TIN, ALUMINUM, ZINC AND THEIR ALLOYS; SLOWLY CORROSIVE TO IRON, COPPER.**
Behavior in Fire: **MAY FORM HYDROGEN (FLAMMABLE GAS) ON CONTACT WITH METAL; EMITS TOXIC, CORROSIVE FUMES.**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **CONTACT WITH METALS, TISSUE**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**0.02 MGperM^3/ND/HMN/TLV/ND**
Animals	**1350/ND/RABBIT/LD50/SKIN**
Freshwater	**125ppm/96/MOSQUITO FISH/TLM/ND**
Saltwater	**33-100ppm/48/SHRIMP/LC50/ND**
Avian	**ND**

-- OTHER INFORMATION --

CONTAINS AT LEAST 48% WATER BY WEIGHT

Proper Shipping Name: **SULFURIC ACID**
Commodity: **SULFURIC ACID**
STCC: **4930040** DOT ID Number: **UN1830**
Synonyms: **OIL OF VITRIOL; BATTERY ACID; FERTILIZER ACID**
DOT Placard: **CORROSIVE**
Shipping Rate: **42640** Tank Cars/Year **(1983)** RQ **1000** lb.

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **0/4**
- Health -
  - Vapor Irritant: **2/4**; Liquid/Solid Irritant: **4/4**; Poison: **2/4**
- Water Pollution -
  - Human Toxicity: **2/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **2/4**
- Reactivity -
  - Other Chemicals: **4/4**; Water: **3/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** ^oF(cc); **NP** ^oF(oc); Diffusivity: **0.15 CM^2/SEC @ 145^oC**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **MAY REACT VIOLENTLY PRODUCING LARGE AMOUNTS OF HEAT; MAY SPATTER.**
Reactivity with Other Materials: **NUMEROUS MATERIALS AND COMBUSTIBLES; DILUTED ACID REACTS WITH MOST METALS TO PRODUCE HYDROGEN (FLAMMABLE GAS). STRONG DEHYDRATING AGENT.**
Corrosiveness: **EXTREMELY CORROSIVE TO TISSUE, METALS, AND OTHER MATERIALS, REACTS WITH METALS TO PRODUCE HYDROGEN (FLAMMABLE GAS).**
Behavior in Fire: **NOT FLAMMABLE; MAY PRODUCE POISONOUS GAS.**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **CONTACT WITH OTHER MATERIALS, TISSUE**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	5 MGperM^3/0.25/HMN/TCLO/IHL
Animals	500 MGperM^3/8/MOUSE/LC50/IHL
Freshwater	49ppm/48/BLUEGILL/TLM/ND
Saltwater	42.5ppm/48/PRAWN/LC50/ND
Avian	ND

-- OTHER INFORMATION --

TANK CAR CONCENTRATION: 62%-98% BY WEIGHT

Proper Shipping Name: **SULFURIC ACID, SPENT**
Commodity: **SULFURIC ACID, SPENT**
STCC: **4930042** DOT ID Number: **UN1832**
DOT Placard: **CORROSIVE**
Shipping Rate: **3233** Tank Cars/Year **(1983)** RQ **1000** lb.

-- HAZARD SUMMARY --

NFPA Hazard Classification
Health Hazard: **3/4**; Flammability: **0/4**; Reactivity: **2/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** ^{o}F(cc); **NP** ^{o}F(oc); Diffusivity: **VARIABLE**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **DILUTION LIBERATES HEAT, MAY SPATTER**
Reactivity with Other Materials: **VARIABLE; CONTACT WITH MOST METALS PRODUCES HYDROGEN (FLAMMABLE GAS)**
Corrosiveness: **USUALLY CORROSIVE TO TISSUE, METALS.**
Behavior in Fire: **DEPENDS ON THE CONSTITUENTS IN THE MIXTURE; TOXIC FUMES MAY BE PRODUCED.**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **CONTACT WITH OTHER MATERIALS, TISSUE.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**5 MGperM^3/0.25/HMN/TCLO/IHL**
Animals	**500 MGperM^3/8/MOUSE/TC50/IHL**
Freshwater	**49ppm/48/BLUEGILL/TLM/ND**
Saltwater	**42.5ppm/48/PRAWN/LC50/ND**
Avian	**ND**

-- OTHER INFORMATION --

MATERIALS WITH VARIABLE COMPOSITION AND PROPERTIES, DEPENDING ON PRIOR USE. MAY CONTAIN WIDE VARIETY OF METALS AND ORGANIC MATERIALS IN SOLUTION. ACID CONCENTRATION TYPICALLY 80% OR LESS.

APPENDIX B-6
FLAMMABLE GASES

A flammable gas is defined (49 CFR 173.300 (b)) as any compressed gas (defined in 49 CFR 173.300 (a)) if:

(a) Either a mixture of 13 percent or less (by volume) with air forms a flammable mixture or the flammable range with air is wider than 12 percent regardless of the lower limit. These limits shall be determined at atmospheric temperature and pressure.

(b) Using the Bureau of Explosives' (BOE) Flame Projection Apparatus, the flame projects more than 18 inches (45.7 cm) beyond the ignition source with valve opened fully or, the flame flashes back and burns at the valve with any degree of valve opening.

(c) Using the BOE's Open Drum Apparatus, there is any significant propagation of flame away from the ignition source.

(d) Using the BOE's Closed Drum Apparatus, there is any explosion of the vapor-air mixture in the drum.

This appendix lists twelve commodities which are classified as flammable gases. These are:

(a) BUTADIENE, INHIBITED
(b) BUTANE
(c) BUTENE GAS, LIQUEFIED
(d) ETHYLENE
(e) ISOBUTANE
(f) ISOBUTANE, FOR FURTHER REFINERY PROCESSING
(g) ISOBUTYLENE
(h) LIQUEFIED PETROLEUM GAS
(i) PROPANE
(j) PROPYLENE
(k) METHYL CHLORIDE
(l) VINYL CHLORIDE

Proper Shipping Name: **BUTADIENE, INHIBITED**
Commodity: **BUTADIENE, INHIBITED**
STCC: **4905704** DOT ID Number: UN1010
Synonyms: **1, 3 - BUTADIENE; DIVINYL**
DOT Placard: **FLAMMABLE GAS; TANK MARKING REQUIRED**
Shipping Rate: **7412** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **4/4**
- Health -
  - Vapor Irritant: **1/4**; Liquid/Solid Irritant: **1/4**; Poison: **1/4**
- Water Pollution -
  - Human Toxicity: **0/4**; Aquatic Toxicity: **1/4**; Aesthetic Effect: **1/4**
- Reactivity -
  - Other Chemicals: **2/4**; Water: **0/4**; Self-Reaction: **3/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **2.0%-11.5%**
Flash Point: **-105°F(cc); LT 0°F(oc);** Diffusivity: **0.095CM^2/SEC@15°C**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID, GAS**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **OXIDIZERS, PHENOL, CROTONALDEHYDE**
Corrosiveness: **IRRITATING**
Behavior in Fire: **MAY BLASH BACK ALONG VAPOR TRAIL; MAY POLYMERIZE VIOLENTLY IN FIRE; EMITS ACRID FUMES WHEN HEATED**
Evacuation Guidelines: FIRE: **0.5 MILE** NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **KEEP FROM HEAT AND IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	8000ppm/8/HMN/IRR/IHL
Animals	250,000ppm/ND/RABBIT/LCLO/IHL
Freshwater	71.5ppm/24/PINPERCH/TLM/ND
Saltwater	10-100ppm/24/AQUATIC LIFE/TLM/ND
Avian	ND

Proper Shipping Name: **LIQUEFIED PETROLEUM GAS**
Commodity: **BUTANE**
STCC: **4905706** DOT ID Number: **UN1075**
DOT Placard: **FLAMMABLE GAS; TANK MARKING REQUIRED**
Shipping Rate: **10536** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating
Fire - **4/4**
Health -
Vapor Irritant: **0/4**; Liquid/Solid Irritant: **0/4**; Poison: **0/4**
Water Pollution -
Human Toxicity: **0/4**; Aquatic Toxicity: **0/4**; Aesthetic Effect: **0/4**
Reactivity -
Other Chemicals: **0/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.8%-8.5%**
Flash Point: -76^{o}F(cc); **ND** ^{o}F(oc); Diffusivity: 0.096-0.122**CM^2/SEC @ 15^{o}C**
Physical State: as Shipped: **LIQUID;** as Released: **GAS, LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **NONE, LIQUID MAY CAUSE FROSTBITE**
Behavior in Fire: **MAY FLASHBACK ALONG VAPOR TRAIL; EXTREMELY FLAMMABLE; CONTAINERS MAY EXPLODE IN FIRE**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION.**
Conditions to Avoid: **IGNITION SOURCES; CONTACT WITH LIQUID; HEAT**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	10,000ppm/0.2/HMN/DROWSINESS/IHL
Animals	620G per M^3/4/RAT/LC50/IHL
Freshwater	1000+ppm/96/AQUATIC LIFE/TLM/ND
Saltwater	1000+ppm/96/AQUATIC LIFE/TLM/ND
Avian	ND

-- OTHER INFORMATION --

ALSO A CONSTITUENT OF LIQUEFIED PETROLEUM GAS

Proper Shipping Name: **LIQUEFIED PETROLEUM GAS**
Commodity: **BUTENE GAS, LIQUEFIED**
STCC: **4905707** DOT ID Number: **UN1075**
Synonyms: **BUTYLENE; 1-BUTENE**
DOT Placard: **FLAMMABLE GAS; TANK MARKING REQUIRED**
Shipping Rate: 5520 Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NFPA Hazard Classification
Health Hazard: **1/4**; Flammability: **4/4**; Reactivity: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Shipping Condition: **AMBIENT** Flammability Limits: **1.6%-10%**
Flash Point: **-112°F(cc)**; **ND** °F(oc); Diffusivity: **0.091CM²/SEC@15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID, GAS**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **NONE**
Behavior in Fire: **CONTAINERS MAY EXPLODE IN FIRE. MAY FLASH BACK ALONG VAPOR TRAIL; VIOLENT RUPTURE AND ROCKETING POSSIBLE.**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **HEAT; IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**20%/2/MOUSE/RESPIRATORY FAILURE/IHL**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

Proper Shipping Name: **ETHYLENE or ETHYLENE, COMPRESSED**
Commodity: **ETHYLENE**
STCC: **4905734** DOT ID Number: **UN1962**
DOT Placard: **FLAMMABLE GAS; TANK MARKING REQUIRED**
Shipping Rate: **1006** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **4/4**
- Health -
  - Vapor Irritant: **0/4**; Liquid/Solid Irritant: **0/4**; Poison: **1/4**
- Water Pollution -
  - Human Toxicity: **0/4**; Aquatic Toxicity: **1/4**; Aesthetic Effect: **0/4**
- Reactivity -
  - Other Chemicals: **1/4**; Water: **0/4**; Self-Reaction: **2/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **2.74%-28.6%**
Flash Point: **0213°F(cc); ND °F(oc);** Diffusivity: **0.136 CM^2/SEC @ 15°C**
Physical State: as Shipped: **LIQUID;** as Released: **GAS**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **OXIDIZERS, CHLORINE IN SUNLIGHT HALOGENATED ORGANIC MATERIALS, ACIDS**
Corrosiveness: **NONE, LIQUID MAY CAUSE FROSTBITE**
Behavior in Fire: **MAY FLASHBACK ALONG VAPOR TRAIL; CONTAINER MAY VIOLENTLY RUPTURE AND ROCKET.**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION.**
Conditions to Avoid: **IGNITION SOURCES; CONTACT WITH LIQUID.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**51VOL%/0.01/HMN/PARALYSIS/IHL**
Animals	**950000ppm/ND/MOUSE/LC/IHL**
Freshwater	**22ppm/1/SUNFISH/LETHAL/ND**
Saltwater	**100-1000ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

Proper Shipping Name: **LIQUID PETROLEUM GAS**
Commodity: **ISOBUTANE**
STCC: **4905747** DOT ID Number: **UN1075**
Synonyms: **2-METHYLPROPANE**
DOT Placard: **FLAMMABLE GAS; TANK MARKING REQUIRED**
Shipping Rate: **5354** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NOT RATED

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.8%-8.4%**
Flash Point: **-117°F(cc); ND °F(oc);** Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID, GAS**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **ND**
Behavior in Fire: **MAY FLASH BACK ALONG VAPOR TRAIL; CONTAINER MAY RUPUTURE OR ROCKET IN FIRE.**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **SOURCES OF IGNITION; HEAT; OXIDIZING MATERIALS.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**ND**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

Proper Shipping Name: **LIQUIFIED PETROLEUM GAS**
Commodity: **ISOBUTANE, FOR FURTHER REFINERY PROCESSING**
STCC: **4905750** DOT ID Number: **UN1075**
Synonyms: **2-METHYLPROPANE**
DOT Placard: **FLAMMABLE GAS; TANK MARKING REQUIRED**
Shipping Rate: **3166** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NOT RATED

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.8%-8.4%**
Flash Point: **-117°F(cc); ND** °F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID, GAS**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **ND**
Behavior in Fire: **MAY FLASH BACK ALONG VAPOR TRAIL; CONTAINER MAY RUPUTURE VIOLENTLY IN FIRE.**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **SOURCES OF IGNITION; HEAT; OXIDIZING MATERIALS.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**ND**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

Proper Shipping Name: **LIQUID PETROLEUM GAS**
Commodity: **ISOBUTYLENE**
STCC: **4905748** DOT ID Number: **UN1075**
DOT Placard: **FLAMMABLE GAS; TANK MARKING REQUIRED**
Shipping Rate: **1254** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NFPA Hazard Classification
Health Hazard: **1/4**; Flammability: **4/4**; Reactivity: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.8%-9.6%**
Flash Point: **-105**°F(cc); **ND** °F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID, GAS**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **NONE**
Behavior in Fire: **CONTAINERS MAY EXPLODE IN FIRE. MAY FLASH BACK ALONG VAPOR TRAIL.**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **SOURCES OF IGNITION; HEAT; OXIDIZING MATERIALS**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	ND
Animals	620GM per M^3/RAT/LC50/IHL
Freshwater	ND
Saltwater	ND
Avian	ND

Proper Shipping Name: **LIQUEFIED PETROLEUM GAS**
Commodity: **LIQUIFIED PETROLEUM GAS**
STCC: **4905752** DOT ID Number: **UN1075**
DOT Placard: **FLAMMABLE GAS; TANK MARKING REQUIRED**
Shipping Rate: **31775** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **4/4**
- Health -
  - Vapor Irritant: **0/4**; Liquid/Solid Irritant: **0/4**; Poison: **0/4**
- Water Pollution -
  - Human Toxicity: **0/4**; Aquatic Toxicity: **0/4**; Aesthetic Effect: **0/4**
- Reactivity -
  - Other Chemicals: **0/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.8%-9.5%**
Flash Point: **VARIOUS**°F(cc); **ND** °F(oc); Diffusivity: **0.096-0.122CM^2/SEC @ 15°C**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID, GAS**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **OXIDIZERS**
Corrosiveness: **NONE**
Behavior in Fire: **CONTAINER MAY EXPLODE IN FIRE; MAY FLASH BACK ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION.**
Conditions to Avoid: **SOURCES OF IGNITION; HEAT; OXIDIZING MATERIALS**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**10,000ppm/0.2/HMN/DROWSINESS/IHL**
Animals	**620GM per M^3/4/RAT/LC50/IHL**
Freshwater	**1000+ppm/96/AQUATIC LIFE/TLM/ND**
Saltwater	**1000+ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

-- OTHER INFORMATION --

PRINCIPAL COMPONENTS ARE BUTANE AND PROPANE

Proper Shipping Name: **LIQUEFIED PETROLEUM GAS**
Commodity: **PROPANE**
STCC: **4905781** DOT ID Number: **UN1075**
DOT Placard: **FLAMMABLE GAS; TANK MARKING REQUIRED**
Shipping Rate: **26882** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating
Fire - **4/4**
Health -
Vapor Irritant: **0/4**; Liquid/Solid Irritant: **0/4**; Poison: **0/4**
Water Pollution -
Human Toxicity: **0/4**; Aquatic Toxicity: **0/4**; Aesthetic Effect: **0/4**
Reactivity -
Other Chemicals: **0/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **2.1%-9.5%**
Flash Point: **-156°F(cc); ND** °F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID, GAS**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **NP**
Behavior in Fire: **CONTAINERS MAY EXPLODE IN FIRE; MAY FLASH BACK ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION.**
Conditions to Avoid: **SOURCES OF IGNITION; HEAT; OXIDIZING MATERIALS**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**1,000ppm/ND/HMN/TLV/IHL**
Animals	**ND**
Freshwater	**1000+ppm/96/AQUATIC LIFE/TLM/ND**
Saltwater	**1000+ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

Proper Shipping Name: **LIQUEFIED PETROLEUM GAS**
Commodity: **PROPYLENE**
STCC: **4905782** DOT ID Number: **UN1075**
DOT Placard: **FLAMMABLE GAS; TANK MARKING REQUIRED**
Shipping Rate: **2844** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating
Fire - **4/4**
Health -
Vapor Irritant: **0/4**; Liquid/Solid Irritant: **0/4**; Poison: **0/4**
Water Pollution -
Human Toxicity: **0/4**; Aquatic Toxicity: **1/4**; Aesthetic Effect: **0/4**
Reactivity -
Other Chemicals: **1/4**; Water: **0/4**; Self-Reaction: **1/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **2.0%-11%**
Flash Point: **-162°F(cc); ND °F(oc)**; Diffusivity: **ND**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID, GAS**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **NP**
Behavior in Fire: **CONTAINERS MAY EXPLODE IN FIRE; MAY FLASH BACK ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION.**
Conditions to Avoid: **SOURCES OF IGNITION**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**4,000ppm/ND/HMN/TLV/IHL**
Animals	**ND**
Freshwater	**1000+ppm/96/AQUATIC LIFE/TLM/ND**
Saltwater	**1000+ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

Proper Shipping Name: **METHYL CHLORIDE**
Commodity: **METHYL CHLORIDE**
STCC: **4905761** DOT ID Number: **UN1063**
Synonyms: **CHLOROMETHANE**
DOT Placard: **FLAMMABLE GAS; TANK MARKING REQUIRED**
Shipping Rate: **1448** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **4/4**
- Health -
  - Vapor Irritant: **0/4**; Liquid/Solid Irritant: **0/4**; Poison: **2/4**
- Water Pollution -
  - Human Toxicity: **0/4**; Aquatic Toxicity: **1/4**; Aesthetic Effect: **0/4**
- Reactivity -
  - Other Chemicals: **1/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **8.1%-17.2%**
Flash Point: 32°F(cc); **ND** °F(oc); Diffusivity: **0.117CM^2/SEC @ 15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID, GAS**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **ALUMINUM; MAGNESIUM; POTASSIUM; SODIUM; SODIUM-POTASSIUM ALLOY**
Corrosiveness: **WHEN DRY, CORROSIVE TO ALUMINUM, ZINC, AND MAGNESIUM ALLOYS. WHEN MOIST, CORRODES LIKE HYDROCHLORIC ACID.**
Behavior in Fire: **EXTREMELY FLAMMABLE; MAY FLASH BACK ALONG VAPOR TRAIL; MAY DECOMPOSE RELEASING PRODUCTS OF GREATER HAZARDS**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **0.1 x 0.2 MILE**
Conditions to Avoid: **CONTACT WITH WATER, ALUMINUM, IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**3146ppm/ND/MOUSE/LC50/IHL**
Freshwater	**550ppm/96/BLUEGILL/TLM/ND**
Saltwater	**1000+ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

Proper Shipping Name: **VINYL CHLORIDE**
Commodity: **VINYL CHLORIDE**
STCC: **4905792** DOT ID Number: **UN1086**
DOT Placard: **FLAMMABLE GAS; TANK MARKING REQUIRED**
Shipping Rate: **18773** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **4/4**
- Health -
  - Vapor Irritant: **2/4**; Liquid/Solid Irritant: **1/4**; Poison: **2/4**
- Water Pollution -
  - Human Toxicity: **0/4**; Aquatic Toxicity: **0/4**; Aesthetic Effect: **0/4**
- Reactivity -
  - Other Chemicals: **2/4**; Water: **0/4**; Self-Reaction: **2/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **4%-26%**
Flash Point: **ND^{o}F(cc); -110^{o}F(oc);** Diffusivity: **0.102CM^{2}/SEC@15^{o}C**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID, GAS**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **PEROXIDES INITIATE POLYMERIZATION**
Corrosiveness: **ATTACKS IRON AND STEEL WHEN MOIST**
Behavior in Fire: **CONTAINERS MAY POLYMERIZE AND EXPLODE IN FIRE; MAY FLASH BACK ALONG VAPOR TRAIL**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION.**
Conditions to Avoid: **HEAT, SPARKS, OPEN FLAME**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	1ppm/ND/HMN/TLV/ND
Animals	500/ND/RAT/LD50/ORL
Freshwater	1000+ppm/96/AQUATIC LIFE/TLM/ND
Saltwater	1000+ppm/96/AQUATIC LIFE/TLM/ND
Avian	ND

APPENDIX B-7
NON-FLAMMABLE GASES

The name non-flammable gas is a contraction of the category properly termed non-flammable compressed gas. A compressed gas is defined (49 CFR 173.300(a)) as any material or mixture having in the container an absolute pressure exceeding 40 psi (275.5 kPa) at 70°F (21.1°C) or, regardless of the pressure at 70°F (21.1°C), having an absolute pressure exceeding 104 psi (716.6 kPa) at 130°F (54.5°C), or any liquid flammable material having a vapor pressure exceeding 40 psi (275.6 kPa) absolute at 100°F (37.8°C) as determined by ASTM test D-323.

This appendix contains four commodities which are classified as non-flammable compressed gases. These are:

(a) AMMONIA, ANHYDROUS

(b) CARBON DIOXIDE, LIQUEFIED

(c) CHLORINE

(d) SULFUR DIOXIDE

Proper Shipping Name: **AMMONIA, ANHYDROUS**
Commodity: **ANHYDROUS AMMONIA**
STCC: **4904210** DOT ID Number: **UN1005**
Synonyms: **LIQUID AMMONIA**
DOT Placard: **NONFLAMMABLE GAS; TANK MARKING REQUIRED**
Shipping Rate: **37097** Tank Cars/Year **(1983)** RQ **100** lb.

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **1/4**
- Health -
  - Vapor Irritant: **4/4**; Liquid/Solid Irritant: **2/4**; Poison: **2/4**
- Water Pollution -
  - Human Toxicity: **2/4**; Aquatic Toxicity: **2/4**; Aesthetic Effect: **2/4**
- Reactivity -
  - Other Chemicals: **3/4**; Water: **2/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **15.5 - 27.0%**
Flash Point: **ND** °F(cc); **ND** °F(oc); Diffusivity: **0.200 CM^2/SEC @ 15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID, GAS**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **DISSOLVES IN WATER WITH MILD HEAT EFFECT**
Reactivity with Other Materials: **ALDEHYDES; EXPOXIDES; HALOGENS; ACIDS; OXIDIZERS; LEAD, TIN, COPPER, ZINC, ALUMINUM, AND THEIR ALLOYS.**
Corrosiveness: **STRONG SKIN, EYE, AND RESPIRATORY IRRITANT; LIQUID MAY CAUSE FROSTBITE; INHALATION CAN BE FATAL; CAN CAUSE BLINDNESS.**
Behavior in Fire: **FLAMMABLE MIXTURES FORMED WITH AIR AT HIGH CONCENTRATIONS. EMITS TOXIC VAPORS.**
Evacuation Guidelines: FIRE: **NONE;** NO FIRE: **0.4 x 0.6 MILES**
Conditions to Avoid: **CONTACT WITH LIQUID; INHALATION**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**3000ppm/0.1/HMN/LCLO/IHL**
Animals	**7338ppm/1/RAT/LC50/IHL**
Freshwater	**0.5ppm/24/RAINBOW TROUT/LC50/ND**
Saltwater	**1-10ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**120ppm/ND/WATERFOWL/TFX/ND**

Proper Shipping Name: **CARBON DIOXIDE, REFRIGERATED LIQUID**
Commodity: **CARBON DIOXIDE, LIQUEFIED**
STCC: **4904509** DOT ID Number: **UN2187**
DOT Placard: **NONFLAMMABLE GAS; TANK MARKING REQUIRED**
Shipping Rate: **6175** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --
NOT RATED

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** ^{o}F(cc); **NP** ^{o}F(oc); Diffusivity: **1.138 CM^2/SEC @ 15^{o}C**
Physical State: as Shipped: **LIQUID;** as Released: **GAS**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **FORMS CARBONIC ACID (NON-HAZARDOUS)**
Reactivity with Other Materials: **REACTS WITH ALKALINE OR AMINE COMPOUNDS**
Corrosiveness: **NP**
Behavior in Fire: **CONTAINERS MAY EXPLODE WHEN HEATED**
Evacuation Guidelines: FIRE: **NONE;** NO FIRE: **NONE**
Conditions to Avoid: **SOLID, LIQUID MAY CAUSE FROSTBITE; VAPORS MAY CAUSE DIZZINESS OR SUFFOCATION**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**100,000ppm/0.02/HMN/LCLO/IHL**
Animals	**90,000ppm/0.1/MAMMAL/LCLO/IHL**
Freshwater	**100-200ppm/ND/ND/LETHAL/ND**
Saltwater	**ND**
Avian	**ND**

-- OTHER INFORMATION --

HIGHLY PRESSURIZED LIQUID; RAPID RELEASE USUALLY RESULTS IN SUFFICIENT COOLING TO PRODUCE A SIGNIFICANT AMOUNT OF SOLID. SOLID SUBLIMES.

Proper Shipping Name: **CHLORINE**
Commodity: **CHLORINE**
STCC: **4904120** DOT ID Number: **UN1017**
DOT Placard: **CHLORINE; TANK MARKING REQUIRED**
Shipping Rate: **37870** Tank Cars/Year **(1983)** RQ **10** lb.

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **0/4**
- Health -
  - Vapor Irritant: **4/4**; Liquid/Solid Irritant: **2/4**; Poison: **4/4**
- Water Pollution -
  - Human Toxicity: **2/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **2/4**
- Reactivity -
  - Other Chemicals: **4/4**; Water: **1/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** °F(cc); **NP** °F(oc); Diffusivity: **0.115 CM^2/SEC @ 15°C**
Physical State: as Shipped: **LIQUID**; as Released: **GAS, LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **FORMS A CORROSIVE SOLUTION**
Reactivity with Other Materials: **ACETYLENE; TURPENTINE; ETHER; AMMONIA; FUEL GAS; HYDROCARBONS; HYDROGEN; FINELY-DIVIDED METALS; ALUMINUM.**
Corrosiveness: **HIGHLY CORROSIVE IN PRESENCE OF MOISTURE**
Behavior in Fire: **MOST COMBUSTIBLES WILL BURN IN CHLORINE TO PRODUCE TOXIC PRODUCTS. EMITS TOXIC AND IRRITATING FUMES.**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **0.7 x 1.0 MILES**
Conditions to Avoid: **LIQUID (FROSTBITE); WATER; INHALATION.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**430ppm/0.5/HMN/LCLO/IHL**
Animals	**293ppm/1/RAT/LC50/IHL**
Freshwater	**0.07-0.15ppm/96/FATHEAD MINNOW/LC50/ND**
Saltwater	**1ppm/ND/MARINE FISH/SLIGHT IRR/ND**
Avian	**ND**

Proper Shipping Name: **SULFUR DIOXIDE**
Commodity: **SULFUR DIOXIDE**
STCC: **4904290** DOT ID Number: **UN1079**
DOT Placard: **NONFLAMMABLE GAS; TANK MARKING REQUIRED**
Shipping Rate: 2910 Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **0/4**
- Health -
  - Vapor Irritant: **4/4**; Liquid/Solid Irritant: **1/4**; Poison: **4/4**
- Water Pollution -
  - Human Toxicity: **0/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **1/4**
- Reactivity -
  - Other Chemicals: **1/4**; Water: **1/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** ^{o}F(cc); **NP** ^{o}F(oc); Diffusivity: **0.117 CM^2/SEC @ 15^{o}C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID, VAPOR**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **REACTS TO FORM CORROSIVE SOLUTION; REACTION NOT HAZARDOUS**
Reactivity with Other Materials: **METAL OXIDES; METAL ACETYLENE CARBIDES; CHLORATES; FLUORINE**
Corrosiveness: **AQUEOUS SOLUTION MILDLY CORROSIVE TO METALS**
Behavior in Fire: **CONTAINERS MAY RUPTURE AND RELEASE IRRITATING, TOXIC SULFUR DIOXIDE**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **0.6 x 0.9 MILES**
Conditions to Avoid: **ND**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**400ppm/0.02/HMN/LCLO/IHL**
Animals	**611ppm/5/RAT/LC100/IHL**
Freshwater	**1ppm/2/TENCH/LETHAL/ND**
Saltwater	**ND**
Avian	**ND**

APPENDIX B-8
POISON A MATERIALS

A Poison A material is defined (49 CFR 173.326(a)) as a poisonous gas or liquid of such nature that a very small amount of the gas, or vapor of the liquid, mixed with air is dangerous to life. This appendix lists three commodities which are classified as Poison A substances. These are:

(a) CYANOGEN CHLORIDE

(b) HYDROCYANIC ACID

(c) PHOSGENE

Proper Shipping Name: **CYANOGEN CHLORIDE**
Commodity: **CYANOGEN CHLORIDE, LESS THAN 0.9% WATER**
STCC: **4920506** DOT ID Number: **UN1589**
DOT Placard: **POISON GAS AND FLAMMABLE GAS LABELS**
Shipping Rate: **ND** RQ **10** lb.

-- HAZARD SUMMARY --

NOT RATED

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** °F(cc); **NP** °F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID, GAS;** as Released: **LIQUID, GAS**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **WATER (VERY SLOWLY) OR STEAM TO PRODUCE HIGHLY TOXIC AND CORROSIVE VAPORS**
Reactivity with Other Materials: **SLOW. NOT IMMEDIATELY HAZARDOUS**
Corrosiveness: **HYDROLYSIS PRODUCES HIGHLY CORROSIVE VAPORS; LACRIMATOR; IRRITATING TO EYES AND RESPIRATORY SYSTEM**
Behavior in Fire: **CYLINDERS MAY VIOLENTLY RUPTURE, ROCKET**
Evacuation Guidelines: FIRE: **NONE;** NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **CONTACT WITH WATER, STEAM**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**10 MGperM^3/ND/HMN/TCLO/IHL**
Animals	**780 MGperM^3/0.1/MOUSE/LCLO/IHL**
Freshwater	**0.08ppm/ND/FISH/LETHAL/ND**
Saltwater	**LT 1ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

-- OTHER INFORMATION --

CYLINDERS ARE ONLY AUTHORIZED CONTAINERS (49CFR173, SECTIONS 328, 332(a)(2))

Proper Shipping Name: **HYDROCYANIC ACID, LIQUEFIED**
Commodity: **HYDROCYANIC ACID, LIQUEFIED**
STCC: **4920125** DOT ID Number: **NA1051**
DOT Placard: **POISON GAS, FLAMMABLE GAS**
Shipping Rate: **866** Tank Cars/Year **(1983)** RQ **10** lb.

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **4/4**
- Health -
  - Vapor Irritant: **2/4**; Liquid/Solid Irritant: **1/4**; Poison: **4/4**
- Water Pollution -
  - Human Toxicity: **4/4**; Aquatic Toxicity: **4/4**; Aesthetic Effect: **1/4**
- Reactivity -
  - Other Chemicals: **3/4**; Water: **0/4**; Self-Reaction: **3/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **5.6% - 40%**
Flash Point: 0 °F(cc); **ND** °F(oc); Diffusivity: **0.15CM^2/SEC @ 15°C**
Physical State: as Shipped: **LIQUID, GAS**; as Released: **LIQUID, GAS**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **DISSOLVES TO FORM HYDROCYANIC ACID (WEAK ACID)**
Reactivity with Other Materials: **REACTS WITH CAUSTICS, WATER, STEAM**
Corrosiveness: **NP**
Behavior in Fire: **EXTREMELY FLAMMABLE; FLASHBACK MAY OCCUR ALONG VAPOR TRAIL; ENCLOSED VAPOR MAY EXPLODE IF IGNITED. EMITS LETHAL VAPORS.**
Evacuation Guidelines: FIRE: **0.5 MILE**; NO FIRE: **0.5 x 0.7 MILE**
Conditions to Avoid: **MOISTURE; CAUSTICS; IGNITION SOURCES; HEAT.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	10ppm/ND/HMN/UNSATISFACTORY/IHL
Animals	323ppm/0.1/MOUSE/LD50/IHL
Freshwater	0.07ppm/24/RAINBOW TROUT/TLM/ND
Saltwater	0.05ppm/24/PIN PERCH/TLM/ND
Avian	0.1/ND/BIRD/LDLO

-- OTHER INFORMATION --

EXCEEDINGLY TOXIC POISON GAS.

Proper Shipping Name: **PHOSGENE**
Commodity: **PHOSGENE**
STCC: **4920540** DOT ID Number: UN1076
Synonyms: **CARBONYL CHLORIDE, CHLOROFORMYL CHLORIDE**
DOT Placard: **POISON GAS**
Shipping Rate: **ND** RQ **5000** lb.

-- HAZARD SUMMARY --

NFPA Hazard Classification
Health Hazard: **4/4**; Flammability: **0/4**; Reactivity: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** °F(cc); °F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID, GAS**; as Released: **LIQUID, GAS**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **DECOMPOSES SLOWLY TO TOXIC, CORROSIVE FUMES**
Reactivity with Other Materials: **VIGOROUSLY WITH: ALUMINUM, ISOPROPYL ALCOHOL, POTASSIUM, SODIUM, AND LITHIUM METALS**
Corrosiveness: **SLOWLY CORRODES METALS WHEN MOIST**
Behavior in Fire: **NP**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **3.3 x 5.2 MILES**
Conditions to Avoid: **CONTACT WITH WATER, STEAM**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**25ppm/0.5/HMN/TCLO/IHL**
Animals	**50ppm/0.5/RAT/LCLO/IHL**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

APPENDIX B-9
POISON B MATERIAL

A Poison B material is defined (49 CFR 173.343(a) and (b)) as a substance liquid or solid (including pastes and semisolids), other than Class A poisons or irritating materials, which are known to be so toxic to man as to afford a hazard to health during transportation; or which, in the absence of adequate data on human toxicity, are presumed to be toxic to man because they fall within any one of the following categories when tested on laboratory animals:

(a) Those which produce death within 48 hours in half or more than half of a group of 10 or more white laboratory rats weighing 200 to 300 grams at a single dose of 50 milligrams or less per kilogram of body weight when administered orally.

(b) Those which produce death within 48 hours in half or more than half of a group of 10 or more white laboratory rats weighing 200-300 grams when inhaled continuously for a period of one hour or less as a concentration of 2 milligrams or less per liter of vapor, mist, or dust, provided such concentration is likely to be encountered by man when the chemical product is used in any reasonable foreseeable manner.

(c) Those which produce death within 48 hours in half or more than half of a group of 10 or more rabbits tested at a dosage of 200 milligrams or less per kilogram body weight when administered by continuous contact with the bare skin for 24 hours or less.

The foregoing categories shall not apply if the physical characteristics or the probable hazards to humans as shown by experience indicate that the substances will not cause serious sickness or death.

This appendix lists four commodities which are categorized as Poison B substances. These are:

(a) ANILINE OIL

(b) MOTOR FUEL ANTI-KNOCK COMPOUND

(c) PHENOL

(d) TOLUENE DIISOCYANATE

Proper Shipping Name: **ANALINE OIL, LIQUID**
Commodity: **ANALINE OIL, LIQUID**
STCC: **4921410** DOT ID Number: **UN1547**
Synonyms: **AMINOBENZENE, BLUE OIL**
DOT Placard: **POISON**
Shipping Rate: **928** Tank Cars/Year **(1983)** RQ **1000** lb.

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **1/4**
- Health -
  - Vapor Irritant: **1/4**; Liquid/Solid Irritant: **1/4**; Poison: **3/4**
- Water Pollution -
  - Human Toxicity: **3/4**; Aquatic Toxicity: **2/4**; Aesthetic Effect: **4/4**
- Reactivity -
  - Other Chemicals: **3/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.3% - ?**
Flash Point: 158 °F(cc); 168 °F(oc); Diffusivity: **0.075 CM^2/SEC @ 30°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **ACIDS; OXIDIZERS; ALDEHYDES; KETONES; DIISOCYANATES.**
Corrosiveness: **SKIN IRRITANT. CORRODES COPPER AND ITS ALLOYS.**
Behavior in Fire: **COMBUSTION REQUIRES PREHEATING; TOXIC COMBUSTION FUMES PRODUCED**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **IF LEAKING, DOWNWIND EVACUATION MUST BE CONSIDERED**
Conditions to Avoid: **TOXIC BY SKIN ABSORPTION AND INHALATION; KEEP FROM OXIDIZERS.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	20ppm/ND/HMN/TCLO/IHL
Animals	250ppm/4/RAT/LCLO/IHL
Freshwater	0.4ppm/48/DAPHNIA/TLM/TLC/ND
Saltwater	10-100ppm/96/AQUATIC LIFE/TLM/ND
Avian	ND

Proper Shipping Name: **MOTOR FUEL ANTIKNOCK COMPOUND or ANTIKNOCK COMPOUND**
Commodity: **MOTOR FUEL ANTIKNOCK COMPOUND**
STCC: **4921445** DOT ID Number: **UN1649**
DOT Placard: **POISON**
Shipping Rate: **3458** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NFPA Hazard Classification
Health Hazard: **3/4**; Flammability: **3/4**; Reactivity: **3/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **ND**
Flash Point: **30-228** ^{o}F(cc); **89-265** ^{o}F(oc); Diffusivity: **NP**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **OXIDIZABLE MATERIALS; ACTIVE METALS; RUST.**
Corrosiveness: **SOME SOLVENT ACTION ON RUBBER AND POLYMERS.**
Behavior in Fire: **CONTAINERS MAY EXPLODE.**
Evacuation Guidelines: FIRE: **0.25 MILE**; NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **CONTACT WITH IGNITION SOURCES, HEAT, OXIDIZING AGENTS.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**0.07-0.075 MGperM^3/8/HMN/TLV/SKIN**
Animals	**0.85 ppm/ND/RAT/LC50/IHL**
Freshwater	**0.2 ppm/96/BLUEGILL/TLM/ND**
Saltwater	**13.5 ppm/96/TIDEWATER SILVERSIDE/TL50/ND**
Avian	**ND**

-- OTHER INFORMATION --

TYPICAL MATERIAL COMPOSED OF ONE OR MORE TETRAALKYL LEAD COMPOUNDS; BEST KNOWN OF THESE IS TETRAETHYL LEAD ("ETHYL").

Proper Shipping Name: **PHENOL**
Commodity: **PHENOL or CARBOLIC ACID**
STCC: **4921220** DOT ID Number: **UN1671**
DOT Placard: **POISON**
Shipping Rate: **6916** Tank Cars/Year **(1983)** RQ **1000** lb.

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **1/4**
- Health -
  - Vapor Irritant: **2/4**; Liquid/Solid Irritant: **3/4**; Poison: **3/4**
- Water Pollution -
  - Human Toxicity: **2/4**; Aquatic Toxicity: **3/4**; Aesthetic Effect: **3/4**
- Reactivity -
  - Other Chemicals: **2/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.7% - 8.6%**
Flash Point: 175 °F(cc); 185 °F(oc); Diffusivity: **0.078 CM^2/SEC @ 15°C**
Physical State: as Shipped: **SOLID, LIQUID**; as Released: **SOLID, LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **ALUMINUM CHLORIDE; NITROBENZENE; BUTADIENE; CAUSTICS; ACIDS.**
Corrosiveness: **CORRODES RUBBER, ALUMINUM, ALUMINUM ALLOYS, AND LEAD.**
Behavior in Fire: **WILL BURN WITH MODERATE HEATING. YIELDS FLAMMABLE VAPORS WHICH MAY FORM EXPLOSIVE MIXTURES WITH AIR. EMITS TOXIC VAPORS.**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **SOURCES OF IGNITION.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	140/ND/HMN/LDLO/ORAL
Animals	669/ND/RAT/LD50/SKIN
Freshwater	7.5ppm/48/RAINBOW TROUT/TLM/ND
Saltwater	1.5ppm/48/RAINBOW TROUT/TLM/ND
Avian	25ppm/CHRONIC/WATERFOWL/MAX LIMIT

Proper Shipping Name: **TOLUENE DIISOCYANATE**
Commodity: **TOLUENE DIISOCYANATE**
STCC: **4921575** DOT ID Number: **UN2078**
DOT Placard: **POISON**
Shipping Rate: **2515** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NAS Hazard Rating
Fire - **1/4**
Health -
Vapor Irritant: **3/4**; Liquid/Solid Irritant: **3/4**; Poison: **4/4**
Water Pollution -
Human Toxicity: **2/4**; Aquatic Toxicity: **0/4**; Aesthetic Effect: **4/4**
Reactivity -
Other Chemicals: **3/4**; Water: **3/4**; Self-Reaction: **3/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **0.9% - 9.5%**
Flash Point: **ND** °F(cc); **270** °F(oc); Diffusivity: **0.59 CM^2/SEC @ 15°C**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID, VAPOR**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **RAPIDLY FORMS CARBON DIOXIDE (NON-FLAMMABLE GAS) AND AN ORGANIC BASE.**
Reactivity with Other Materials: **AMINES; ANILINE; AMMONIA; ALCOHOLS.**
Corrosiveness: **NP**
Behavior in Fire: **REQUIRES PREHEATING TO IGNITE; EMITS VERY TOXIC FUMES.**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **MIXING WITH WATER OR AMINES IN CLOSED CONTAINER.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**0.8ppm/ND/HMN/TCLO-IRR/IHL**
Animals	**12ppm/ND/RAT/LCLO/IHL**
Freshwater	**1-10ppm/96/AQUATIC LIFE/TLM/ND**
Saltwater	**1-10ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

APPENDIX B-10
OTHER REGULATED MATERIAL - CLASS A

A commodity that has been placed in the Other Regulated Material - Class A (ORM-A) class is a material which has an anesthetic, irritating, noxious, toxic, or other similar property and which can cause extreme annoyance or discomfort to passengers and crew in the event of leakage during transportation (49 CFR 173.500(b)(1)).

This appendix includes two ORM-A commodities. These are:

(a) CARBON TETRACHLORIDE

(b) MALEIC ANHYDRIDE

Proper Shipping Name: **CARBON TETRACHLORIDE**
Commodity: **CARBON TETRACHLORIDE**
STCC: **4940320** DOT ID Number: **UN1846**
Synonyms: **CARBONA; CARBON TET**
DOT Placard: **NONE**
Shipping Rate: **1100** Tank Cars/Year **(1983)** RQ **5000** lb.

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **0/4**
- Health -
  - Vapor Irritant: **2/4**; Liquid/Solid Irritant: **1/4**; Poison: **4/4**
- Water Pollution -
  - Human Toxicity: **2/4**; Aquatic Toxicity: **2/4**; Aesthetic Effect: **2/4**
- Reactivity -
  - Other Chemicals: **1/4**; Water: **0/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **NP** ^{o}F(cc); **NP** ^{o}F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **METALS; FLUORINE; ALUMINUM TRICHLORIDE; DIBENZOYL PEROXIDE.**
Corrosiveness: **NONE**
Behavior in Fire: **DECOMPOSES TO FORM CHLORINE AND PHOSGENE (POISONOUS GASES).**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **FLUORINE; METALS.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**317ppm/0.5/HMN/TCLO/IHL**
Animals	**4000ppm/4/RAT/LCLO/IHL**
Freshwater	**10-100ppm/96/AQUATIC LIFE/TLM/ND**
Saltwater	**10-100ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

Proper Shipping Name: **MALEIC ANHYDRIDE**
Commodity: **MALEIC ANHYDRIDE**
STCC: **4941161** DOT ID Number: **UN2215**
DOT Placard: **NONE**
Shipping Rate: **976** Tank Cars/Year **(1983)** RQ **5000** lb.

-- HAZARD SUMMARY --

NAS Hazard Rating
- Fire - **1/4**
- Health -
  - Vapor Irritant: **2/4**; Liquid/Solid Irritant: **2/4**; Poison: **1/4**
- Water Pollution -
  - Human Toxicity: **2/4**; Aquatic Toxicity: **2/4**; Aesthetic Effect: **1/4**
- Reactivity -
  - Other Chemicals: **3/4**; Water: **2/4**; Self-Reaction: **0/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **1.4% - 7.1%**
Flash Point: **215** ^{o}F(cc); **230** ^{o}F(oc); Diffusivity: **NP**
Physical State: as Shipped: **SOLID**; as Released: **SOLID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **HOT WATER MAY CAUSE FROTHING. REACTION WITH COLD WATER IS SLOW, NON-HAZARDOUS.**
Reactivity with Other Materials: **VIOLENT REACTION WITH ALKALI METALS AND THEIR HYDROXIDES.**
Corrosiveness: **ND**
Behavior in Fire: **WHEN HEATED ABOVE 300^{o}F WITH VARIOUS MATERIALS GENERATES HEAT, TOXIC FUMES, CARBON DIOXIDE. EXPLODES IF CONFINED.**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **OXIDIZING MATERIALS.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**0.25ppm/TLV**
Animals	**2620/ND/RABBIT/LD50/SKIN**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

APPENDIX B-11

OTHER REGULATED MATERIAL - CLASS E

A commodity which has been classified in the Other Regulated Material - Class E (ORM-E) category is a material that is not included in any other hazard class, but is subject to the requirements of the regulations (49 CFR 173.500(b)(5)). Materials in this class include:

- Hazardous waste
- Hazardous substance as defined in 49 CFR 171.8

This appendix contains one ORM-E material, DINITROTOLUENE.

Proper Shipping Name: **DINITROTOLUENE, LIQUID**
Commodity: **DINITROTOLUENE, LIQUID**
STCC: **4963120** DOT ID Number: **UN1600**
DOT Placard: **NONE**
Shipping Rate: **790** Tank Cars/Year **(1983)** RQ **1000** lb.

-- HAZARD SUMMARY --

NFPA Hazard Classification
Health Hazard: **3/4**; Flammability: **1/4**; Reactivity: **3/4**

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **NP**
Flash Point: **404** °F(cc); **ND** °F(oc); Diffusivity: **NP**
Physical State: as Shipped: **LIQUID**; as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NO REACTION**
Reactivity with Other Materials: **NO REACTION**
Corrosiveness: **IRRITATING TO SKIN AND EYES**
Behavior in Fire: **DIFFICULTY - IGNITABLE COMBUSTIBLE MATERIAL; COMBUSTION PRODUCES TOXIC VAPORS**
Evacuation Guidelines: FIRE: **NONE**; NO FIRE: **NONE**
Conditions to Avoid: **HEAT; IGNITION SOURCES**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**1.5MGperM^3/ND/HMN/TLV/IHL**
Animals	**30/ND/RAT/LD50/ORAL**
Freshwater	**10-100ppm/96/AQUATIC LIFE/TLM/ND**
Saltwater	**10-100ppm/96/AQUATIC LIFE/TLM/ND**
Avian	**ND**

APPENDIX B-12

GENERIC COMMODITIES

For purposes explained earlier in Chapter III of this report, several commodities with proper shipping names with the suffix n.o.s. (not otherwise specified), generally referred to as generic commodities, are listed together in this appendix. These are:

(a) ALCOHOL, N.O.S. (FLAMMABLE LIQUID)

(b) ALKALINE LIQUID, N.O.S.

(c) COMBUSTIBLE LIQUID, N.O.S.

(d) CORROSIVE LIQUID, N.O.S.

(e) FLAMMABLE LIQUID, N.O.S.

(f) POISONOUS LIQUID, N.O.S.

Proper Shipping Name: **ALCOHOL, N.O.S.**
Commodity: **ALCOHOL, N.O.S.**
STCC: **4909105** DOT ID Number: **UN1987**
DOT Placard: **FLAMMABLE**
Shipping Rate: **1060** Tank Cars/Year **(1979)**

-- HAZARD SUMMARY --

NOT RATED

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **ND**
Flash Point: **LT 100** °F(cc); **ND** °F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **USUALLY SOLUBLE.**
Reactivity with Other Materials: **MAY REACT WITH SEVERAL COMMON MATERIALS.**
Corrosiveness: **MAY IRRITATE SKIN OR EYES. MAY SLIGHTLY CORRODE METALS.**
Behavior in Fire: **FLASHBACK ALONG VAPOR TRAIL POSSIBLE; MAY PRODUCE IRRITATING OR TOXIC COMBUSTION PRODUCTS.**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **NONE**
Conditions to Avoid: **AVOID HEAT OR SOURCES OF IGNITION.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**ND**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

-- OTHER INFORMATION --

PRIMARY ALCOHOLS ABOVE C8 MAY BE SOLIDS AT AMBIENT CONDITIONS. ISOMERISM HAS UNPREDICTABLE EFFECTS.

Proper Shipping Name: **ALKALINE LIQUID, N.O.S.**
Commodity: **ALKALINE CORROSIVE LIQUID, N.O.S.**
STCC: **4935220** DOT ID Number: **NA1719**
DOT Placard: **CORROSIVE**
Shipping Rate: **1411** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NOT RATED

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **ND**
Flash Point: **ND** ^{o}F(cc); **ND** ^{o}F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **MAY BE VIOLENT.**
Reactivity with Other Materials: **MAY REACT WITH SEVERAL MATERIALS.**
Corrosiveness: **SKIN AND EYE IRRITANT (POSSIBLY SEVERE); MAY ATTACK METALS.**
Behavior in Fire: **NOT READILY IGNITABLE; MAY IGNITE COMBUSTIBLES. MAY EMIT TOXIC AND CORROSIVE FUMES.**
Evacuation Guidelines: FIRE: **NONE;** NO FIRE: **NONE**
Conditions to Avoid: **ND**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**ND**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

Proper Shipping Name: **COMBUSTIBLE LIQUID, N.O.S.**
Commodity: **COMBUSTIBLE LIQUID, N.O.S.**
STCC: **4915185** DOT ID Number: NA1993
DOT Placard: COMBUSTIBLE
Shipping Rate: **2343** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NOT RATED

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **ND**
Flash Point: **100-199** ^{o}F(cc); **ND** ^{o}F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **ND**
Reactivity with Other Materials: **ND**
Corrosiveness: **ND**
Behavior in Fire: **MAY PRODUCE IRRITATING OR POISONOUS GASES.**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **NONE**
Conditions to Avoid: **KEEP FROM FIRE AND IGNITION SOURCES; AVOID CONTACT.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**ND**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

Proper Shipping Name: **CORROSIVE LIQUID, N.O.S.**
Commodity: **CORROSIVE LIQUID, N.O.S.**
STCC: **4936540** DOT ID Number: **UN1760**
DOT Placard: **CORROSIVE**
Shipping Rate: **1653** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NOT RATED

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **ND**
Flash Point: **ND** °F(cc); **ND** °F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **ND**
Reactivity with Other Materials: **ATTACKS METALS, EYE, OR TISSUE.**
Corrosiveness: **CORRODES METALS, EYES OR TISSUE.**
Behavior in Fire: **MAY BE COMBUSTIBLE, NOT READILY IGNITABLE.**
Evacuation Guidelines: FIRE: **NONE;** NO FIRE: **NONE**
Conditions to Avoid: **USE OF WATER; IGNITION SOURCES; BODILY CONTACT; VAPOR INHALATION; CONTAIN RUNOFF.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**ND**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

Proper Shipping Name: **FLAMMABLE LIQUID, N.O.S.**
Commodity: **FLAMMABLE LIQUID, N.O.S.**
STCC: **4910185** DOT ID Number: **UN1993**
DOT Placard: **FLAMMABLE**
Shipping Rate: **1785** Tank Cars/Year **(1983)**

-- HAZARD SUMMARY --

NOT RATED

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **ND**
Flash Point: **LT100** °F(cc); **ND** °F(oc); Diffusivity: **ND**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **NONE**
Reactivity with Other Materials: **ND**
Corrosiveness: **ND**
Behavior in Fire: **MAY EMIT TOXIC FUMES. MAY FLASHBACK ALONG VAPOR TRAIL.**
Evacuation Guidelines: FIRE: **0.5 MILE;** NO FIRE: **NONE**
Conditions to Avoid: **HEAT AND OTHER SOURCES OF IGNITION.**

-- TOXICITY DATA --

Species	DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE
Humans	**ND**
Animals	**ND**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

Proper Shipping Name: **POISONOUS LIQUID, N.O.S. or POISON B LIQUID, N.O.S.**
Commodity: **POISONOUS LIQUID, N.O.S.**
STCC: **4921475** DOT ID Number: **UN2810**
DOT Placard: **POISON**
Shipping Rate: **846** Tank Cars/Year **(1979)**

-- HAZARD SUMMARY --

NOT RATED

-- SHIPPING PHYSICAL AND CHEMICAL DATA --

Flammability Limits: **VARIES**
Flash Point: **VARIES** °F(cc); **ND** °F(oc); Diffusivity: **VARIES**
Physical State: as Shipped: **LIQUID;** as Released: **LIQUID**

-- SPILL AND CLEANUP HAZARDS --

Reactivity with Water: **VARIES**
Reactivity with Other Materials: **VARIES**
Corrosiveness: **VARIES**
Behavior in Fire: **VARIES**
Evacuation Guidelines: FIRE: **NONE;** NO FIRE: **IF LEAKING, CONSIDER DOWNWIND EVACUATION**
Conditions to Avoid: **ND**

-- TOXICITY DATA --

DOSE/EXPOSURE/SPECIES/EFFECT/ROUTE

Species	
Humans	**ND**
Animals	**ND**
Freshwater	**ND**
Saltwater	**ND**
Avian	**ND**

APPENDIX B-13

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APPENDIX C

REMOTE SENSING TECHNOLOGY

A. INTRODUCTION

1. General

When a rail accident involving hazardous materials occurs, one of the first problems that needs to be addressed is the identification in the shortest possible time of the contents of the rail cars involved in the accident. Any plan formulated to contain, mitigate the effects of, and eventually clean up spilled hazardous material is, of necessity, directly based on the properties of the spilled material. As graphically illustrated by the commodity sheets in Appendix B, the approach of a clean-up crew to spilled sulfuric acid would be considerably different than that used for metallic sodium.

Unfortunately, not all train wrecks occur during daylight under ideal weather conditions. During periods of limited visibility such as night, fog, haze, smoke, etc., it can be difficult, if not impossible, to visually determine from a distance, identifying numbers and placards on a car involved in an accident. Current practice suggests that many police and fire chiefs are likely to keep their people a prudent distance from an unidentified car or one which is suspected of containing hazardous materials. Until these cars can be positively identified, the pace of the hazard containment mitigation and clean-up processes may be slowed considerably. Employment of procedures incompatible with the spilled material must also be guarded against.

2. Overview

There are two approaches to the identification of rail cars involved in an accident. The first approach is to identify each car automatically as it leaves the rail yard. A computerized system can detect each car, store its location (both in the train and on the rail system), and make this information available for virtually instantaneous rapid dissemination. If there subsequently is an accident, the stored information can be quickly accessed to determine the identity and contents of each car along with its position in the train. This approach has the advantage that it can be implemented under the controlled environment of a freight yard. The disavantage of this approach is that if the accident occurs away from the freight yard, as it most likely will, information about the position and content of each car in the train, while certainly of some use, may not provide adequate information to the On-Scene Coordinator (OSC), particularly if the rail cars are shifted around during the derailment to the extent that their original relative positions cannot be easily discerned.

The second approach is to have available a device which allows the identification of a rail car once the accident has taken place. Such an identification scheme would undoubtedly provide the OSC with more flexibility to determine the exact nature of the hazardous situation he is facing. Unfortunately, as detailed below, the current state of technology has not advanced to the point where an easily portable, accurate, and inexpensive detector is generally available.

3. Purpose

The purpose of this appendix is to examine several means of identifying a freight car and to assess the practicality of each scheme under conditions of limited visibility that often surround a hazardous material rail accident site. In addition, common rail yard identification systems will be examined for potential use at a hazardous material spill scene.

B. OPTICAL SCANNING SYSTEMS

1. General

Optical scanning systems make use of a label that is placed on the item to be identified. This label typically contains bar-coded information that uniquely identifies each item. A visible or, in some cases, an infrared light beam is scanned over the label, and the light reflected back to a detector circuit is collected and analyzed by electronic circuitry to extract the identification information from it.

The rail industry had attempted to use the so-called automatic car identification (ACI) optical scanning in the past to automatically identify rail cars. For a variety of reasons, this was not economically successful. Three optical scanning systems will be examined, followed by descriptions of the bar code and optical character recognition schemes typically used for optical scanning. Important characteristics of all of these three systems can be found in Tables C-1 and C-2.

2. <u>Automatic Car Identification System</u>

The Automatic Car Identification (ACI) System was the first major attempt by the rail industry to identify rail cars and their locations automatically. In October of 1967, the AAR announced that the system would be operational by 1970 in conjunction with the AAR's TeleRail Automated Information Network (TRAIN) computer system. The ACI system was based on the mounting of red, blue, black, and white striped markings on each of the long sides of the rail car. A numeric value unique to each rail car was encoded in the position and number of red and blue stripes. The black stripes served as timing calibration marks for the ACI scanners, while the white stripes acted merely as background separators for the other stripes. A xenon light was beamed at the placard from the side of the track as the rail car passed by the scanner, and the light reflected back to the scanner from the placard was collected. The numeric code for each rail car was extracted from the color coding and forwarded by wire to a central computer which identified the car the unique code belonged to. The location and identity of the rail car were both stored in the computer's memory and forwarded to the AAR's master computer. This information was to be used to track the progress of the freight car through the nation's rail network.

Unfortunately, inadequate testing of the ACI system failed to uncover several factors that would later lead to its demise. These were as follows.

Dirt which adhered to the face of the coded placard often caused a misreading of the car's identity number. When this occurred, a check sum embedded in the code information caused the system to recognize that it had not correctly identified the rail car. The computer was programmed

TABLE C-1. SUMMARY OF FIELD CHARACTERISTICS OF DEVICES FOR REMOTE SENSING OF RAIL CAR IDENTIFICATION INFORMATION

TECHNOLOGY	RANGE	POWER REQUIREMENTS	PORTABILITY	COMPUTER REQUIREMENTS
		OPTICAL SCANNING SYSTEMS		
AUTOMATIC CAR IDENTIFICATION (ACI)	8 TO 10 FEET	MODERATE	VEHICLE REQUIRED	REQUIRED; HIGHLY COMPATIBLE
BAR CODE	6 FEET	LOW	EXCELLENT; HAND-HELD	REQUIRED; HIGHLY COMPATIBLE
OPTICAL CHARACTER RECOGNITION (OCR)	4 FEET	LOW	VEHICLE REQUIRED	REQUIRED; HIGHLY COMPATIBLE
		NON-OPTICAL SCANNING SYSTEMS		
IDENTRA	SHORT	MODERATE	POOR	REQUIRED; COMPATIBLE
SYSTEM I.D.	SHORT	MODERATE	POOR	REQUIRED; COMPATIBLE
RAILOCATOR	AT LEAST 12 FEET	MODERATE	POOR	REQUIRED; COMPATIBLE
SICARID	12 TO 32 INCHES	MODERATE	POOR	REQUIRED; COMPATIBLE
IDENTIFIER	20 FEET	MODERATE	POOR	REQUIRED; COMPATIBLE
RAILROAD ELECTRONIC IDENTIFICATION SYSTEM (REIS)	6 FEET	VERY LOW	GOOD	REQUIRED; COMPATIBLE

TABLE C-1. SUMMARY OF FIELD CHARACTERISTICS OF DEVICES FOR REMOTE SENSING OF RAIL CAR IDENTIFICATION INFORMATION (CONTINUED)

TECHNOLOGY	RANGE	POWER REQUIREMENTS	PORTABILITY	COMPUTER REQUIREMENTS
INFRARED SYSTEMS				
MILITARY IR	LESS THAN 1 MILE	HIGH	VEHICLE REQUIRED	REQUIRED; HIGHLY COMPATIBLE
CIVILIAN IR	¼ TO ½ MILE	MODERATE	VEHICLE REQUIRED	NOT REQUIRED; COMPATIBLE
HAND-HELD IR	40 FEET	LOW	EXCELLENT; HAND HELD	NOT READILY COMPATIBLE
SAW TECHNIQUES				
SURFACE ACOUSTICAL WAVE (SAW)	6 FEET	LOW	GOOD	REQUIRED; HIGHLY COMPATIBLE

TABLE C-2. DEPLOYMENT CONSIDERATIONS FOR DEVICES FOR REMOTE SENSING OF RAIL CAR IDENTIFICATION INFORMATION

TECHNOLOGY	ADVANTAGES	DISADVANTAGES	ANTICIPATED TECHNOLOGY ADVANCES	COST	REPRESENTATIVE MANUFACTURERS
		OPTICAL SCANNING SYSTEMS			
AUTOMATIC CAR IDENTIFICATION (ACI)	LOW COST LABELS; MATURE TECHNOLOGY	EXPENSIVE SCANNERS; DIRT AND OTHER MATERIALS AFFECT RELIABILITY; SHORT RANGE	NONE	LABEL: $5; SCANNER: $30,000 TO $40,000	GTE SYLVANIA
BAR CODE	LOW COST LABELS AND SCANNERS; EXCELLENT PORTABILITY; MATURE TECHNOLOGY	SHORT RANGE; DIRT AND OTHER MATERIALS AFFECT RELIABILITY; NO BAR CODE STANDARD IS UNIVERSALLY ACCEPTED; MANY CODING SCHEMES DO NOT IMPLEMENT ERROR CHECKING.	FASTER SCANNING RATES; EXTENDED RANGE	LABELS: LESS THAN $5 SCANNERS: $750 TO $7,500	SYMBOL TECHNOLOGIES COMPUTER IDENTICS; INTERMEC
OPTICAL CHARACTER RECOGNITION (OCR)	LABELS EASILY READ BY HUMANS; STANDARDIZED FONTS	MORE SOPHISTICATED SCANNING AND PROCESSING REQUIRED; INCREASED ERROR INCIDENCE	EXTENSION OF RECOGNITION TO MORE FONTS	LABELS: $5 SCANNER: $6,000 TO $10,000	OBERON INTERNATIONAL DEST CORPORATION; HENDRIX TECHNOLOGIES; TOTEC, LTD.

TABLE C-2. DEPLOYMENT CONSIDERATIONS FOR DEVICES FOR REMOTE SENSING OF RAIL CAR IDENTIFICATION INFORMATION (CONTINUED)

TECHNOLOGY	ADVANTAGES	DISADVANTAGES	ANTICIPATED TECHNOLOGY ADVANCES	COST	REPRESENTATIVE MANUFACTURERS
		NON-OPTICAL SCANNING SYSTEMS			
IDENTRA	TRANSPONDER NEEDS NO ON-BOARD POWER SUPPLY; SIMPLE OPERATING PRINCIPLE	SHORT RANGE; LIMITED NUMBER OF UNIQUE CODES	WIDER SELECTION OF SWITCH-SELECTED FREQUENCIES		UNION SWITCH AND SIGNAL
SYSTEM I.D.	TRANSPONDER CAN ENCODE CAR OWNER AND 2,000,000 SERIAL NUMBERS; TRANSPONDER USES NO ON-BOARD POWER SUPPLY; TRANSPONDER WITHSTANDS EXTREME TEMPERATURES	SHORT RANGE	NONE		IDENTIFICATION DEVICES, INC.
RAILOCATOR	EXTREMELY HIGH RELIABILITY; TRANSPONDER USES NO ON-BOARD POWER SUPPLY; THOROUGHLY TESTED SYSTEM	SHORT RANGE	INCREMENTAL IMPROVEMENTS ONLY		GLENAYRE ELECTRONICS, LTD.

TABLE C-2. DEPLOYMENT CONSIDERATIONS FOR DEVICES FOR REMOTE SENSING OF RAIL CAR IDENTIFICATION INFORMATION (CONTINUED)

TECHNOLOGY	ADVANTAGES	DISADVANTAGES	ANTICIPATED TECHNOLOGY ADVANCES	COST	REPRESENTATIVE MANUFACTURERS
		NON-OPTICAL SCANNING SYSTEMS			
SICARID	WELL TESTED SYSTEM; TRANSPONDER USES NO ON-BOARD POWER SUPPLY; EXTRAORDINARILY HIGH RELIABILITY; IN USE ON LONG ISLAND RAILROAD	VERY SHORT RANGE	INCREMENTAL IMPROVEMENTS ONLY		TRANSCONTROL (SIEMENS)
IDENTIFIER	WELL TESTED SYSTEM; TRANSPONDER USES NO ON-BOARD POWER SUPPLY; VERY HIGH RELIABILITY; FIELD PROGRAMMABLE; EXCELLENT MANUFACTURER SUPPORT	SHORT RANGE	INCREMENTAL IMPROVEMENTS ONLY		GENERAL RAILWAY SIGNAL
RAILWAY ELECTRONIC IDENTIFICATION SYSTEM (REIS)	PARTIALLY FIELD PROGRAMMABLE; SOME FLEXIBILITY IN COMPONENT AND FREQUENCY CHOICE; WELL TESTED SYSTEM	TRANSDUCER REQUIRES BATTERY; SHORT RANGE	ADD-ON PANCAKE PACKAGE CAPABLE OF TRANSLATING OTHER TRANSDUCER OUTPUTS		CANADIAN NATIONAL RAILWAYS/EID SYSTEMS, LTD.

TABLE C-2. DEPLOYMENT CONSIDERATIONS FOR DEVICES FOR REMOTE SENSING OF RAIL CAR IDENTIFICATION INFORMATION (CONTINUED)

TECHNOLOGY	ADVANTAGES	DISADVANTAGES	ANTICIPATED TECHNOLOGY ADVANCES	COST	REPRESENTATIVE MANUFACTURERS
			INFRARED SYSTEMS		
MILITARY IR	EXTREMELY HIGH RESOLUTION IMAGES; EXCELLENT RANGE; COMPUTER INTERFACE ALLOWS IMAGE PROCESSING	HIGH POWER REQUIREMENTS; LARGE WEIGHT AND SPACE REQUIREMENTS; COST	FAST DEVELOPING FIELD; SIGNIFICANT IMPROVEMENTS IN ALL AREAS CAN BE EXPECTED	UPWARDS OF $200,000	FORD AEROSPACE; TEXAS INSTRUMENTS; ITT AVIONICS; GEC AVIONICS (GENERAL ELECTRIC)
CIVILIAN IR	GOOD RESOLUTION; LOWER COST THAN MILITARY SYSTEMS	LARGE SPACE AND WEIGHT REQUIREMENTS; HIGH POWER REQUIREMENTS	ADVANCES WILL MIRROR MILITARY IR DEVELOPMENTS, ALTHOUGH AT LOWER CAPABILITIES AND COST	$50,000 TO $80,000	FLIR SYSTEMS
HAND-HELD IR	LOW WEIGHT; SMALL SIZE; LOW COST; LOW POWER REQUIREMENTS	LIMITED RANGE	ADVANCES WILL MIRROR CIVILIAN IR DEVELOPMENTS	$15,000 TO $20,000	EEV, INC.
			SAW TECHNIQUES		
SURFACE ACOUSTICAL WAVE (SAW)	LOW COST; LARGE NUMBER OF UNIQUE CODES; IMMUNITY TO DIRT AND WEATHER	SHORT RANGE	FAST DEVELOPING FIELD. ANTICIPATE LONGER RANGE AND INCREASED CODE SIZES	TRANSDUCER: $10 INTERROGATOR: $1700 TO $3700	X-CYTE, INC.

to put a special character next to the incorrect car number and disregard it in future data manipulation; the misread car identification code did little to help enable the computer to track the associated rail car across the country.

The response of the ACI system to the car labels was degraded with age due to natural weathering of the paint and by random abrasions of the placard. These factors caused problems similar to those described previously for dirty labels.

There was an optimal height for the ACI labels to be placed on the freight car. If a label was not positioned fairly accurately, the reliability of the scanning process decreased dramatically.

The original ACI concept called for a $5 per car limit for labeling. This restriction could usually be met (in the late 1960's) for regular box cars, but flat-, tank-, and other car types often required a special metal bracket be placed on both sides of the rail car to properly position the placard for scanning. The labor and material involved in constructing these brackets and attaching them to the car could easily run in excess of $100 per car.

When the ACI system was originally placed into operation, it was assessed that the system needed to deliver 97 percent accuracy in car identification to be economically viable. For the reasons just described, and for lesser reasons, the system was only 80 to 85 percent accurate.

A number of proposed solutions to the problems of the ACI system were developed and implemented, the most successful of which was probably the coating on each coded label with polytetrafluoroethylene to cut down on soil adhesion and abrasion to the label. Introduced in 1974, this concept did increase the reading-accuracy level of the ACI system, but was too late to convince a considerable number of dissatisfied railroads ready to abandon the entire ACI system. In November 1977, mandatory ACI labelling of rail cars was terminated by vote of railroad executives in accordance with AAR procedures.

3. Bar Coding System

The bar code technique is an adaptation of the technology presently in commercial use at many supermarkets all over the country. A small portion of the exterior container or wrapping of each food product is imprinted with a Universal Product Code (UPC), which is unique for each and every food product and sold in the United States. While the assigned UPC for each commodity is a number which can be entered into an electronic cash register at the supermarket checkout counter, it is more efficient to have the system itself read the number on the container. Until recently this required very expensive equipment and was quite time-consuming. For this reason, the UPC bar code, developed to overcome these problems, is based on the assignment of a series of dark lines of varying widths and spacing to uniquely represent each of the ten digits. A small moving light source illuminates the bar code and the light reflected from the surface is collected by a lens and focused onto a photosensitive electronic device. The output from this device is amplified and electronically filtered to provide a clean analog signal with an amplitude directly proportional to the light incident on the photodetector device. The proportionality is dependent on the coding imprinted on the product package. An analog to digital conversion is performed on the filtered signal and the resultant digital code information is stored in an associated computer memory. This code is then compared with a pre-stored list that includes the code, associated pricing, and other pertinent information for every item in the store. The computer automatically calculates the total cost of the goods selected by the customer, prints a listing of each item, and updates the store's inventory stock list.

The UPC code consists of a 10-digit numbering system which is composed of two five-digit parts. The first five digits are uniquely assigned to each participating manufacturer. The remaining five digits are assigned to product categories such as canned peas, catsup, paper towels, etc. Further elaboration is possible for product size and color. The combination of these two five-digit parts uniquely identifies each product in the supermarket by manufacturer and commodity. The 10-digit number, called UPC-A is combined with error-checking features and encoded. Certain small items such as cigarettes use the UPC-E code which contains only five characters without a checksum. Because of the lack of the checksum information, the E code is less reliable than the regular A code.

Bar code technology is not particularly expensive to implement. Labels placed on merchandise cost pennies to produce, or can be preprinted, while laser light scanners/detectors cost $750 to $3000, with the associated computer hardware extra. Several hand-held scanners are available for lower cost, but their reliability is generally less, and their scanners must be placed directly over the label to be scanned.

4. <u>Optical and Magnetic Character Recognition</u>

Optical/magnetic character recognition (O/MCR) technology is an enhancement of the bar code system. The advantage of O/MCR has over the bar code system is that the former scans open (unencoded) information easily readable by the human eye. However, M/OCR does use special typefonts which are readable both by the M/OCR scanner and humans. One of the earliest M/OCR fonts was introduced in 1956 by the American Banker's Association. This font, known as Magnetic Ink Character Recognition (MICR), was printed with a special magnetic ink that allowed high-speed machine reading while still maintaining human readability. Other early O/MCR's read only special typefaces that were usually marketed by manufacturers of specific equipment with little regard for standardization. In 1966, the American National Standards Institute (ANSI) adopted a font standard called OCR-A. A second standard, OCR-B, was developed in Europe. Most present O/MCRs will read both standards. In the 1970's, O/MCR developers perfected omnifont capabilities, and now many widely used ordinary typefonts can be reliably read by many O/MCRs.

Optical character recognition devices (OCR's) operate much the same as do bar code readers, except that considerably more sophisticated scanning schemes and character pattern recognition algorithms must be used. Bar code technology reads only the width of the dark lines. The height of the bands allows the reading device to scan the code accurately without having to hold the label in any particular position. OCR identification schemes are more error-prone than bar systems because:

- The alignment of characters in a line must be straight
- Only small deviations are allowed in the angle of contact of the head of the scanner wand with the surface
- Characters may not be read upside down

- More sophisticated computer algorithms must be used to translate the characters into machine-useable data
- Small amounts of dirt on the surface of the character can cause either erroneous or total lack of recognition

OCR systems are usually expensive, with scanners that can only read certain typefaces in a clean, controlled-atmosphere office. Typical costs are $6,000 to $11,000. Systems designed for use in rugged environments such as those experienced in railroad operations would be expected to cost considerably more.

5. Discussion of Optical Scanning Systems

Present bar code scanner systems are limited to a distance between scanner and label of approximately six feet, with OCR systems having a somewhat shorter range. These distances severely limit the applicability of the bar code and OCR systems at the scene of a hazardous material spill since the user of the scanner would need to get much too close for safety to the damaged rail car to determine its identity. Indeed, at a range of six feet, the user would probably find it easier simply to read the identification number directly from the side of the car. Labels made of special reflective materials have been shown in the laboratory to extend the range of the bar code system to approximately 20 feet, although no commercial applications of this improvement are envisioned by the manufacturer unless some well-heeled customer is willing to finance further product development. This distance is still insufficient for safety at an accident scene. Enlarging the size of the label would undoubtedly extend the range of the scanning process for both bar code and OCR technologies, although practical limitations in the intensity and aiming of the light source used, the difficulties associated with discerning small lines and characters at longer distances, and fluctuating atmospheric conditions between the label and the scanner would limit such range extension to considerably less than 100 feet, a restriction unacceptable for field use at a hazardous material spill site. However, use of a bar code or OCR system to monitor the rail cars leaving a railyard to determine if Federal, state, and carrier regulations regarding positioning of freight cars hauling hazardous materials are being complied with may be a viable option. Such information would be much more reliably retrievable in real-time by a computer data base that contains information on all freight cars presently in use, along with appropriate regulatory information, than by a railyard worker who has only the train consist information and a thick book of regulations to go by.

Labels used for such a system could be of the disposable type or, more practically, be permanently painted on or attached to each rail car. If the disposable type of label is used, it could be attached by the shipper, the railroad employee who physically takes possession of the rail car from the shipper, or by a railroad employee at the first railyard the car is parked in. To decrease the chances of error, and to ensure centralization of the coding process, the latter choice is probably preferable. If either disposable or permanent labels are used, some action would have to be taken by the railroad to ensure that waybill information is entered into the data base in such a manner that the rail car and its comments can be connected to the coded label in a short period of time. To a large extent, such information is already available in the TRAINS II data base.

It is undoubtedly true that many of the problems that plagued the ACI system would pose potential pitfalls for such a system, although the lessons learned form the ACI system and the advances in technology since mandatory ACI labelling was terminated in 1977 could be used to overcome many of them. As an example, some rather simple enhancements to the now largely defunct ACI system improved its performance to such an extent that some railroads continued using it for several years, and at least one railroad still uses it. The Duluth, Missabe, and Iron Range Railroad still remains an enthusiastic user of a slightly modified version of the original ACI system, and reports essentially 100 percent read-out accuracy for dedicated service situations. The Canadian National Railroad, along with its subsidiary, the Grand Trunk Western, has reluctantly turned off its ACI readers in a gradual manner because the percentage of non-labelled American rail cars increased to the point where the system no longer was economically viable. In its heyday, the ACI system was a key component of the CN's traffic management improvement scheme. Many knowledgeable observers agree that present technology could make optical scanning car identification techniques a viable means of inventory control, but further work in this area has been largely abandoned in favor of the more reliable non-optical techniques.

C. NON-OPTICAL SCANNING SYSTEMS

1. General

Due to both the reliability problems experienced by the rail industry using the optically-based ACI system and the resultant skepticism of railroads for automatic rail car identification schemes in general, and optical schemes for the process in particular, the past several years have not seen a big rush among manufacturers to advance new products to accomplish the goal of capturing car identities automatically for direct entry into a centralized data system. However, several manufacturers have been quietly conducting research and development on several techniques that have shown promise, and are now beginning to operationally test and cautiously advertise them. All of these schemes use radio frequency signals of one sort or another to scan the label devices attached to the rail cars rather than relying on classical optical methods. Each of the label devices (transponders) contains electronic circuitry that in some way modifies the signal beamed to it, and returns the modified signal to the scanner devices (interrogator) which can interpret the modifications to the original signal as an identification code that is unique for each and every rail car.

As previously pointed out, the main problem with the ACI system was the unreliability of the car-reading system when the car labels became dirty, a problem that should be greatly minimized, if not eliminated, in the new systems. Also, interference from snowfall, icing, and other adverse weather conditions that plagued the ACI system is much less bothersome when using a radio frequency-based system.

This section briefly outlines each of these new systems, followed by a discussion of the utility of each of these systems for remote car detection. Important characteristics of these systems can be found in Tables C-1 and C-2.

2. Identra System

The Identra System uses a series of switches on the transponder that vary the frequency characteristics of a tuneable coil. When the transponder coil nears the interrogator coil, the latter oscillates at a frequency determined by the former. This frequency is characteristic of the switch settings entered on the transponder, and can therefore uniquely identify the specific rail car.

3. System I.D.

The System I.D. technique uses low frequency waves to transmit a factory-programmed message of five data words. With error checking codes, this works out to sufficient space to encode the owner of the car and 2,000,000 serial numbers. The message is contained in a non-powered package that is placed on the bottom or side of the rail car. The interrogator unit generates an electromagnetic field which couples to the coil inside the package. This powers the generation of an identity code in the coil for coupling to the interrogator unit for decoding.

4. Railocator System

The Railocator System is similar to the System I.D. technique in that it uses a signal below the AM broadcast band to radiate power to an inert transponder unit. The transponder returns its signal by reflecting the incident signal via a higher radio frequency, rather than by rebroadcast of the original interrogator signal. The signal from the transponder must be analyzed by the interrogator to decode the 10-decimal-digit code buried in it.

5. SICARID System

The SICARID System is a microwave-based system that is designed exclusively for between-the-rails placement. The interrogator sweeps through the frequencies of 2.9 to 4.1 GHz at a rate of 4,000 cycles per second. The microwave-horn transponder is a plastic encased die-cast aluminum body with 66 different resonator cavities factory tuned to different frequencies in the microwave frequency sweep range. Individual transponders are field-programmed by inserting plastic pins into those cavities which are not to resonate and thus prevent a specific segment of the microwave pulse from being reflected to the interrogator. Thirteen decimal digits (including parity check) can be encoded with the system.

6. Identifier System

The Identifier System uses a 6.4 ounce, eight-inch long polycarbonate-encased transponder unit mounted on the bottom of the freight car. It can be factory programmed with 12 alpha-numeric characters, or can be partially reprogrammed in the field. The trackside interrogator unit is usually set to the so-called "sniff" mode, in which its 906 MHz transmitter sends out a low-level signal. When a transponder unit enters its field of view, the transmitter is stepped up to its higher operational state and emits eight-watt pulses 30 milliseconds in duration. These pulses energize the transponder code circuitry, causing an 1812 MHz coded signal to be repetitively beamed back to the interrogator for decoding. The Identifier System has been extensively tested by the AAR at the Transportation Test Center at Pueblo, Colorado, where it correctly identified 55,129 freight cars over a several week period with an accuracy of 99.9 percent.

7. REIS System

The Railway Electronic Identification System (REIS) is the only system presently nearing or actually being field-tested that relies on a transponder with its own integral power supply. The extremely low power drain of complementary-metal oxide semiconductor (CMOS) electronic circuitry and the long-lived (up to 20 years) solid-lithium battery are combined in a polycarbonate-encapsulated transponder unit. In operation, the interrogator unit transmits a low level triggering signal at 10.8 GHz which triggers the transponder unit to transmit a repetitive 5 to 10 milliwatt coded identification signal at 2.4 GHz. The interrogator receives and decodes the 64 binary bit car identification information coded in the signal. Field tested enhancements of this system include a transponder with field programmable memory, and an add-on "pancake unit" transponder with the capability of translating 10 to 12 transducer inputs (from pressure, temperature, and other car functions) into programmed bits in the transponder. Such a unit would find valuable application in refrigeration or other specialty freight cars.

8. Discussion of Non-Optical Scanning Systems

All of the systems described in this section would provide an excellent means for identifying a rail car at a hazardous material rail spill except for one basic factor - range. None of these systems is designed for long range operation. Although at least one of these systems (Identifier) touts the fact that the antenna which picks up the signals reflected or beamed back form the rail car-mounted transponder can be located up to 100 feet from the interrogator unit itself, the fact remains that the antenna must be placed in rather close proximity (a few feet) to the rail car in order to detect a signal of sufficient strength. In fact, many of the system interrogator units are designed to be placed between the rails with the transponder mounted on the bottom side of the freight car.

By use of stronger emitter powers, many of these systems could be modified to perform their functions at a longer range. Of course, this would involve upgrading the electrical circuitry inside the interrogator units to handle the increased power load. In those systems where the transponder derives its power from the interrogator signal, a very large increase in radiated interrogator power would be necessary to provide the transponder sufficient energy for operation. In either case, once the units were modified to operate at a longer range, the sensitivity of the interrogator's detector would need to be improved to enable it to pick up the weaker signals transmitted or reflected by the transponder.

Once the units were modified to operate at a longer range, another problem would undoubtedly arise. At the present time, the Federal Communications Commission (FCC) is quite concerned about interference caused by electronic devices to individuals attempting to operate communications equipment within the law. For example, the SICARID system was investigated and considered for three years by the FCC until it granted permission for users to operate the system without individual licenses at limited ranges for the identification of transport vehicles.

It is extremely unlikely the FCC will extend this use permission to cover higher-powered, longer-distance microwave-frequency systems.

The low-powered System I.D. and Railocator systems operate at frequencies below the broadcast radio spectrum. Because of the nature of electromagnetic waves in this region of the spectrum, larger antennae and much greater radiated power would need to be used for a viable longer range system. These requirements are likely to run afoul of FCC regulations which prohibit unlicensed parties from broadcasting signals in portions of the spectrum reserved for certain applications approved specifically by law.

Any or all of these systems would be excellent candidates for a scheme to succeed the now largely defunct ACI scheme. The elimination of the dependence on an optical scan rids these newer systems of the main weak link in the ACI model. The reliabilities of several of these systems have already been shown in field trials to exceed that of the ACI, and improvements are expected to increase reliabilities well into the 99 percent region. The advent of inexpensive, rugged microprocessor chips and associated electronic circuitry allow these units to process information more quickly, as well as be more compact and compatible with wayside weather conditions. The cost of a complete interrogator installation is expected to be significantly lower than the $30,000 to $45,000 unit price (1970 costs - including foundation, alignment, 220 volt power, and shelter air conditioning) for each ACI scanner.

The placement of interrogator units between the rails not only puts the transponder in closer proximity to the interrogator unit, but insures that only one transponder is needed for each rail car, compared with the two that would be needed if the interrogator were mounted on the side of the railbed as in the ACI system. This would significantly reduce the cost of implementing and maintaining such a system. Unfortunately, this placement has the disadvantage of lessening the probability of any such system being used by remote sensing techniques (e.g., at the site of a derailment) even if the technology advances were such that the range of the system could be significantly enhanced.

Another significant problem involved in utilizing non-optical scanning systems at the scene of a hazardous material accident is in determing how the interrogator unit would be made available at the accident site. Most of the interrogator units described above are not designed to be easily transportable, and the cost of such units make it impractical to provide each train crew with its own equipment. However, the same can be said of many of the pieces of other equipment that the OSC may decide to make use of at an accident site. Assuming that the interrogator units could be designed for greater portability, the emergency environmental response team of any railroad would certainly be expected to carry such a unit with them. Industries that generate or use significant quantities of hazardous material that is transported by rail, and the local and state governments responsible for the communities through which such material is transported may want to investigate the desirability of procuring their own interrogator units. It is safe to say, though, that both industry and government officials would be much more likely to consider procuring an interrogator unit if the identification scheme were already in place and proven under actual conditions of use.

D. INFRARED SYSTEMS

1. General

The basic principles behind the use of the infrared portion of the electromagnetic spectrum for image recognition is quite simple. All objects give off infrared (IR) radiation in direct proportion to their temperatures. Hot objects emit more IR radiation than do cool objects. Although IR radiation is invisible to the naked eye, several types of IR sensors can detect these temperature differences and convert them to a form that can be assimilated by humans. Two particularly useful properties of IR imaging are:

- No ambient light source is required since the imaging process does not depend on the object reflecting light to the detector

- Cooler objects such as clouds, haze, and smoke do not obscure hotter objects to the same extent they do in visible imagery.

These properties make IR imaging of particular use to those who must see at night, and those who must see in smoke. The initial work with IR imaging was done with the use of photographic film or plates that were specially manufactured to be sensitive to IR radiation. Modern electronic instrumentation permits the direct viewing of the scene in real time on a television monitor where objects of different temperature are seen as different colors or shadings of grey.

Although the basic principles of IR imagery are simple, they are not quite so simple to implement. Three basic problems present themselves. These are:

- The intensity of IR radiation drops off quickly with range, making it much less sensitive than an active technique such as radar. If a single IR detector, or a few detectors in a linear array are used, the system must be mechanically scanned over a large area, providing only a small amount of time for each detector to collect sufficient IR energy from the object.
- Since many portions of the object may be at the same temperature, the resolution of images from different parts of the same object is generally not as good as it would be in visible imagery.
- Several atmospheric conditions can cause severe degradation to the performance of the IR imagery system. In particular, since water vapor is a particularly strong absorber at certain IR frequencies, atmospheric humidity variations can irreproducibly alter the character of IR images and provide varying degrees of obscuration of portions of the IR spectral region.

In part because of these drawbacks, British scientists rejected infrared systems in favor of radar during the early phases of World War II. However, the use of IR has received a great deal of attention over the past decade due to the introduction of small, yet powerful, image analysis systems along with significant advances in infrared sensor technology.

In this section, military IR systems will be examined first, followed by civilian and hand-held systems, and followed in turn by a discussion of all of the IR systems covered. Important characteristics of each of these systems is found in Tables C-1 and C-2.

2. Military IR Systems

MIlitary IR systems provide the greatest sensitivity and flexibility of operation available on the market today. In contrast with civilian systems which generally use a single thermal detector which is scanned across the screen several hundred times to create one image, military systems use a parallel scan technique that utilizes a separate thermal detector for generating each pair of lines displayed from top to bottom of the video screen. Each detector is mechanically swept across the screen to create an image. This technique requires a separate preamplifier and amplifier for each of the approximately 180 detectors. Each must be separately balanced to give a uniform light output level for the same thermal input to the detector, greatly increasing the initial setup complexity and in-service maintenance requirements.

With the two dimensional "mosaic" sensor set-up, the sensor unit can operate in a "staring mode" which means that the detectors have time to collect much more energy from the objects imaged, greatly increasing overall sensitivity and detection range. The use of microprocessors in combination with mosaic-type sensors now permits the use of elaborate signal processing techniques to discriminate between targets and background clutter, as well as compensate, to a large extent, for atmospheric interferences. It is entirely possible for a state-of-the-art Forward Looking Infrared (FLIR) system to read the name on the side of a ship at night from an aircraft passing overhead.

Future technological advances promise to make military IR systems even more sensitive in operation. For example, in 1982, General Electric announced the fabrication of an infrared mosaic-type array containing 16,384 detectors in a 128 x 128 matrix. Development of a full-fledged system that uses this detector matrix is continuing, and shows promise of making large improvements over the already impressive present-day systems.

3. Civilian IR Systems

Although state-of-the-art FLIR system with truly remarkable capabilities are available, their high cost (well in excess of $200,000) limits their use almost exclusively to military purposes. However, if the user is willing to sacrifice some sensitivity and several optional (but useful) features, a less costly ($80,000) FLIR device can be purchased that will read the side number of a freight car at a distance of at least one quarter mile under good conditions. This distance would be less under poor visibility conditions. The unit weighs approximately 50 pounds and, like almost all IR imaging systems, is meant to be mounted on a helicopter. Compressed argon gas is used as a coolant for the detector cell, with a coolant run time of six to eight hours of continuous operation. Several large metropolitan police units have procured these devices for use in surveillance and fire-fighting operations.

4. Hand-Held IR Systems

A hand-held IR imaging camera with real-time display has recently been introduced into the United States from England. The EEV Model P4428 is a small, light-weight thermal imaging camera that uses a pyroelectric vidicon detector. Use of this detector decreases the size, weight, and cost of the camera, along with eliminating the need for special cooling of the detector component of the camera. Unfortunately, the pyroelectric vidicon detector is less sensitive than conventional IR detectors, meaning that temperature differences, particularly small ones, are much less easy to see. In addition, the cathode ray display tube on the camera has a diagonal measure of only 40 mm (1.57 inches). Even though a magnifying and collimating lens is positioned over the face of the display tube, the viewed image is still very small. Resolution beyond 40 feet is usually quite poor with this hand-held camera.

5. Discussion of Infrared Systems

Except for the hand-held Model P4428 camera, all of the infrared sensors discussed here are suited for the identification of rail cars from distances in excess of one quarter mile. The military systems are able to extend this range to approximately one mile. It should be pointed out that under conditions of intense fire, none of these systems may be of use because of the inability of the infrared detectors to differentiate between the intense heat of the background and the slightly less intense heat of the object of interest.

The basic factors associated with the selection of IR systems are size, weight, and cost. Most military and civilian systems are designed to be transported and operated while attached to the underside of helicopters or jet aircraft. These systems are large, heavy systems with quite intricate computer-assisted positioning controls. The military systems are generally considerably more sensitive, and are equipped with very sophisticated signal processing capabilities to acquire, analyze, and track potential targets. State-of-the-art military systems cost at least $200,000 which places them beyond the budgetary reach of all but the most affluent organizations.

IR systems built for civilian use are more basic models that do not have the sensitivity or the range of application of military models. They are produced primarily for forest fire and police surveillance operations. Even so, at least one model is available which will provide adequate performance for an investment of 50 to 60 thousand dollars. Several large and some not-so-large police and sheriff departments around the country have procured and routinely use civilian IR systems. Emergency planning for both local communities and railroads can and probably should be extended to ascertain the nearest organization which possesses such equipment and its availability in times of need.

Hand-held IR cameras are used primarily for individual fire-fighting applications, where the immediate vicinity of the user is the area of interest. The small display on the camera provides adequate resolution at short distances, but rapidly loses detail as the range to the target object increases. The short range characteristics of the hand-held camera limit its usefulness to those situations where the identification information on the rail car cannot be read even at close range due to smoke or darkness. Most large fire departments possess handheld IR cameras which, in many cases, can be made available on short notice to the emergency clean-up crew. As in the case of aircraft-mounted

IR imagery equipment, advance planning and coordination can ensure that such gear is available for use when it is needed.

E. SURFACE ACOUSTICAL WAVE SYSTEM

1. General

The Surface Acoustical Wave (SAW) scheme has three separate components. These are:

- The identification (ID) tag
- The remote recognition reader
- The computer interface unit

The ID tag is an entirely non-powered device consisting of a small antenna and a man-made lithium niobate crystal encased in a small, lightweight, but extremely rugged plastic case. A thin layer of metal is deposited on the crystal by use of a high resolution photolithographic masking process, creating a unique pattern for each crystal. The remote recognition reader transmits and receives radio signals at a frequency of 915 MHz with a maximum power of three milliwatts. The signal transmitted from the reader is beamed at the ID tag, captured by the antenna inside the tag, and propagated across the surface of the crystal. The piezo-electric properties of the crystal generate a SAW. The metallized coating on the crystal interrupts the progress of the wave as it propagates across the crystal, creating a wave with phase-modulated characteristics unique to that particular ID tag. The antenna then returns the modified signal to the reader where it is converted into an audio band signal carrying the recognition data. The audio bandwidth allows the signal to be transmitted over inexpensive shielded telephone-type twisted-pair cable for a distance of up to 10,000 feet. It also allows the use of a modem to transfer the audio-signal over standard telephone lines to a remotely located host computer.

The computer interface unit receives the ID tag recognition information from the reader and converts the analog signal to digital data. Signal processing techniques decode the digital information into a

If a hazardous material spill involves a large fire, the cardboard or plastic placards on the rail car would be one of the first items to be consumed, and the numbers painted on the side of the car would probably follow in short order. In such an eventuality, none of the devices mentioned here may be of much use. A crude but potentially effective means of preserving the car identification information in such situations would be to require the mounting of a rigid metal plate on each side of the rail car that has holes drilled through it in the pattern of the rail car's identification number. In a fire, the survivability of such a plate would be much greater than that of cardboard placards, painted numbers, or any other identification scheme. If made of a reasonable size, such a plate would be fairly easy to see from at least one quarter mile away if binoculars or other image enhancing devices were used. The difference in temperature between the plate and the holes drilled in it should provide adequate resolution for IR imagery techniques.

Finally, the automatic car identification systems examined also have a role to play in assisting the On Scene Coordinator (OSC) at a hazardous material accident scene. Accurate information on the identity of, and hazards associated with, the contents of each car in the train would be of great use to the planning and decision-making process of the OSC. Disregarding the other obvious economic advantages that would accrue to the railroads by implementing a successor to the virtually defunct ACI system, the timely, accurate information that such a system could provide at an accident site could be of great benefit to the clean-up operation. The simple addition to the computer data bank of information relating to the handling of emergencies resulting from spill of the materials would also constitute an advance in providing useful information in case of an accident. Timely, informed decisions can often avoid or lessen the potentially catastrophic results of a serious railroad mishap.

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