Industrial Fire Safety Guidebook

Tatyana A. Davletshina

np

INDUSTRIAL FIRE SAFETY GUIDEBOOK

INDUSTRIAL FIRE SAFETY GUIDEBOOK

by

Tatyana A. Davletshina, M.S.
Technical Consultant
Environmental Policy and Technology Program
Ukraine and U.S.A.

np NOYES PUBLICATIONS
Westwood, New Jersey, U.S.A.

Copyright © 1998 by Tatyana Davletshina
No part of this book may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, recording or by any information storage and retrieval system, without permission in writing from the Publisher.
Library of Congress Catalog Card Number: 97-51236
ISBN: 0-8155-1420-4
Printed in the United States

Published in the United States of America by
Noyes Publications
369 Fairview Avenue
Westwood, New Jersey 07675

10 9 8 7 6 5 4 3 2 1

Library of Congress Cataloging-in-Publication Data

Davletshina, Tatyana.
Industrial fire safety guidebook / by Tatyana Davletshina.
p. cm.
Includes index.
ISBN 0-8155-1420-4
1. Industrial buildings--Fires and fire prevention. 2. Industrial safety. I. Title.
TH9445.M4D38 1998
628.9'2--dc21 97-51236
CIP



ENVIRONMENTALLY FRIENDLY
This book has been printed digitally because this process does not use any plates, ink, chemicals, or press solutions that are harmful to the environment. The paper used in this book has a 30% recycled content.

PREFACE

This reference has been written for emergency response personnel, plant safety specialists, and emergency response coordinators. It has been prepared at a practical level to assist both in training safety personnel and to provide technical information that can assist in responding to a hazardous incident that could lead to a fire hazard situation. Considerable information and technical data are given on petroleum based products since these are among the most widely consumed products, however, the reader will find ample information on other chemicals. Fire situations pose one of the most serious problems in an industrial setting, with the potential loss of lives and property, as well as damage to the environment. Proper response by trained personnel, as well as careful preplanning can minimize the risk and damage caused by fire. The volume is by no means definitive and the reader should consult the many references that are provided by OSHA, NFPA, ACGIH, API, NIOSH, World Health Organization, and others.

The guidebook is organized into 7 chapters and an appendix. Chapters 1 and 2 provide an overview of fire protection principles and general terminology used throughout the volume. Chapters 3 and 4 cover petroleum products and hydrocarbon derivatives. The chemistry of hydrocarbon fires is reviewed in detail and extensive properties data for petroleum products are given. Chapters 5 through 7 provide technical fire and explosion data on widely used chemicals of commerce. Information on explosion and fire propensity and typical responses to fires and non-fire spills are presented in these chapters. Much of this information is based on the U.S. Department of Transportation emerging response recommendations for fire and non-fire spills, and data provided by the National Institute of Occupational Safety and Health (NIOSH), and other well known sources.

Tatyana A. Davletshina

ABOUT THE AUTHOR

Tatyana A. Davletshina is a Safety Specialist and recognized authority in industrial safety management practices. She has been with the Environmental Policy and Technology Program which is a U.S. Agency for International Development assistance program to Ukraine since 1995, where she has helped to establish and co-manage an industry training center on environmental management and industrial worker safety. Ms. Davletshina received technical degrees in Sciences from the Donetsk State Technical University and West Virginia University, where she has also taught.

NOTICE

To the best of our knowledge the information in this publication is accurate; however, the Publisher does not assume any responsibility or liability for the accuracy or completeness of, or consequences arising from, such information. This book is intended for informational purposes only. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the Publisher. Final determination of the suitability of any information or product for use contemplated by any user, and the manner of that use, is the sole responsibility of the user. We recommend that anyone intending to rely on any recommendation of materials or procedures mentioned in this publication should satisfy himself as to such suitability, and that he can meet all applicable safety and health standards.

CONTENTS

1. FIRE PROTECTION PRINCIPLES 1
Introduction 1
Fire Prevention Principles 1
Inspection Programs 3
Fire Investigations 7

2. FIRE HAZARD TERMINOLOGY 9
Introduction 9
Glossary of Terms 9

3. PROPERTIES AND FLAMMABILITY OF HYDROCARBONS 22
Introduction 22
Chemistry Fundamentals 23
Alcohols 38
Ethers 40
Ketones 41
Aldehydes 41
Peroxides 42
Esters 42
Amines 42
Flammability and Pyrolysis 42
Categories of Petroleum Liquids 48
Fire Extinguishment 49
Flammability of Petroleum Products 51
Closure 78

4. ENGINEERING AND TECHNICAL DATA ON PETROLEUM PRODUCTS 79
Introduction 79

Physical Constants 79
Density of Hydrocarbons 91
Characteristics of Petroleum Fractions 115
Molecular Weight of Petroleum Fractions 134
Critical Properties 135
Thermal Properties 148

5. FIRE AND EXPLOSION GUIDE FOR COMMON CHEMICALS 219
Introduction 219
Alphabetical Listing of High Hazard Chemicals 219
Emergency Response Fact Sheets 283

6. CHEMICAL COMPATIBILITY INFORMATION 364

7. RESPONDING TO SPILLS AND LEAKS 395
Introduction 395
Preplans and Approaching the Scene 398
Initial Isolation and Protective Action Distances 401
Final Comments on Fire and Spill Control 413

APPENDIX - HAZARD CHEMICALS LISTING 415

INDEX 525

1

Fire Protection Principles

INTRODUCTION

Fire prevention is a major aspect of a total fire protection program. Well-planned fire prevention activities can save millions of dollars by preventing the destructiveness of fire, as well as saving lives in industry and the public.

For years, the cooperation of corporate management received by the fire protection specialist was based on the loss suffered by the industry. However, fires do not just happen but are almost always caused by an unsafe act or condition. Thus, most fires can be prevented by the elimination of the unsafe act or condition which contributes to the cause of the fire.

Justification for a fire prevention program (including budget, personnel, equipment, and time) can be proven by quantitative evidence. A proper record keeping system of all activities including inspections, hazard abatement, fire protection systems installations, and educational programs will prove valuable in this area. Using an analysis of the results in these areas can indicate the successfulness of plant fire prevention efforts.

This chapter highlights important concepts to fire prevention programs. It is an introduction to some of the preventive measures and managerial responsibilities of organizations in preventing fires.

FIRE PREVENTION PRINCIPLES

Fire prevention activities can be categorized as engineering, education, and enforcement functions. A brief description of each of these areas follows.

Engineering refers to the planning of fire safe buildings and processes. It also includes the interpretations of fire codes and the control of process hazards through the design and installation of fire protection and detection systems. Education includes those activities that promote fire safety consciousness among employees. This is accomplished by informing employees how to recognize and eliminate fire hazards around the workplace. It also includes special and seasonal fire prevention programs.

Enforcement deals with inspection practices to assure compliance with fire codes and regulations. Attention must also be given to the thoroughness and scheduling of fire inspections.

Engineering plays an extremely important role in any fire prevention program. Without a foundation of engineering principles, the best educational and enforcement programs will not prevent fires. Engineering principles related to fire prevention and fire protection include such subjects as building design and construction, building equipment, installed fire protection systems, and water supply.

The design and development of building plans, extinguishing systems, and water supply networks are all highly specialized engineering functions. However, the average industrial fire inspector may contribute valuable information to an engineer if the inspector has made a study of the fire prevention factors involved and has a knowledge of all applicable fire codes for the control of hazards.

Adequate fire protection and detection systems must be determined and installed for the protection of the plant buildings and occupants. The type and amount of suitable fire protection equipment will depend upon the process and storage hazards found in the plant. Water supplies and distribution systems for fire fighting are also considerations. The fire prevention authority must be responsible to see that all fire fighting systems and equipment are designed and installed to meet the fire protection needs of the plant.

Another facet of engineering for fire prevention is the interpretation of fire codes. Plant fire prevention personnel should be aware of all fire codes and regulations that apply to their particular industrial plant. These may include:

- Local and state fire codes and ordinances
- NFPA standards
- OSHA regulations
- Insurance carrier requirements
- Company policies

They should also be knowledgeable of the specific requirements of more commonly applied codes and regulations.

Modern plant operations include fire safety as a part of the total safety effort. However, if fire safety is not addressed as such, a local "fire safety committee" should be formed. The fire safety committee can function as an important aid in the work of the fire protection specialists. The committee's specific jobs may vary from plant to plant depending on conditions, but may include identification of hazards, inspections of specific processes, planning prevention activities, serving in a public relations capacity, interacting with peer groups, and serving as a sounding board for the fire protection specialists.

Enforcement is another important part of the fire prevention program. Enforcement deals with the activities of inspecting plant facilities to insure compliance with federal, state, and local codes, along with insurance and corporate requirements. Inspection practices are usually considered to be the most important non-fire fighting activity performed by plant personnel. A carefully planned inspection program carried out by conscientious, well-trained personnel can prevent many serious fires. Through inspection, many hazardous conditions are discovered and effective control measures taken before fires occur.

INSPECTION PROGRAMS

The purpose of fire safety inspections is to produce a fire safe work environment. This can be assured only by regularly scheduled safety inspections that are followed by corrective action. These inspections require the cooperative involvement of all employees, fire safety personnel, and top management.

Fire safety inspections may be scheduled several different ways depending on the purpose of the inspection. However, inspections must occur frequently enough to insure satisfactory compliance with accepted fire safety practices. The types of inspections are as follows:

- Periodic Inspections -Periodic inspections should be conducted on a regular basis. These inspections should be general in nature and cover all grounds, facilities, and equipment. Inspections of this type should be recorded utilizing a standard inspection form.

- Intermittent Inspections - Intermittent inspections can be made unannounced or at irregular intervals. These inspections will usually be made by fire department, OSHA, or insurance company inspectors.

- Continuous Inspections - Continuous inspections are necessary for making daily checks of all fire fighting and personal protective equipment. They are also recommended for inspecting process, storage, and handling of high hazard materials.

- Special Inspections - Special inspections are usually conducted during the investigation of a fire. They may also be conducted during special fire safety campaigns, or by other inspecting authorities as needed.

Fire inspections are conducted to evaluate the effort being made to control and eliminate plant fire hazards. In order to make the most complete inspection possible, it is necessary to know what to look for. To begin with, fire inspectors should be familiar with fire protection and detection systems, life safety requirements, building codes, and conditions that may cause fire. Once familiar with the hazards leading to the cause of spread of fire, the effort can then be made to eliminate them. Those items to look for during an inspection may include the following:

- Building Condition
  - Potential spread of fire through unprotected vertical and horizontal openings
  - Construction materials commensurate with process and storage hazards
  - Condition of fire walls and opening protection devices

- Life Safety
  - Adequacy of exits
  - Condition of exit facilities
  - Evacuation procedures

- Common Hazards
  - Heating, ventilation, and air handling
  - Housekeeping
  - Smoking
  - Electrical

- Special Hazards
  - Processes using flammable liquids and gases
  - Finishing processes
  - Dust explosions
  - Paint spraying operations
  - Welding and cutting
  - Toxic and reactive materials

- Water Supply
  - Fire flow requirements
  - Sources of supply
  - Storage facilities
  - Fire pumps
  - Distribution system

- Fire Alarm and Detection Systems
  - Evacuation alarm systems

- Smoke and heat detection systems
- Alarm receiving equipment

- Fire Extinguishing Systems and Equipment
  - Automatic sprinkler systems
  - Special extinguishing systems
  - Portable fire extinguishers
  - Standpipes and hose systems

A common practice used to assure a complete inspection is for the inspector to use a prepared checklist. The checklist is prepared before conducting the inspection and would list items the inspector is to check. An example of a checklist is given in Table 1. The completed checklist provides the inspector with a large amount of information to assist in writing an inspection report. A checklist usually assists the inspector by helping speed up the inspection process, reduce the amount of writing done during the inspection, and provides for a more complete inspection.

Before conducting an inspection in any part of the plant the area manager should be contacted. This provides the inspector with the opportunity to solicit the participation and cooperation of the department manager. It can prove to be beneficial when making the inspection and expediting needed corrections.

All of the necessary information and equipment should be gathered prior to making an inspection. If previous inspections have been made, the inspection form or report should be reviewed to see what deficiencies were found and what corrective action was required. By reviewing prior inspection reports an inspector can become familiar with the hazards that are likely to be encountered.

Certain equipment must be available to the inspector for making an inspection. Reviewing prior inspection reports will give some indication as to what items may be needed. These items may include:

- Coveralls or a work uniform
- A clipboard, inspection forms, sketching materials, etc.
- Personal safety equipment
- Flashlight
- Pitot tube and gauges for water flow tests
- Appropriate reference materials

There is no set route that must be followed when conducting an inspection. However, inspections should be systematic and thorough. No area should be omitted. Many times an inspection will begin with an exterior tour of a building and then work from the roof downward. Other times the

Table 1. Self-inspection form for industrial plants.

HOUSEKEEPING	YES	NO
Are suitable containers provided for waste materials and trash?	G	G
Are there any combustible trash accumulations outside of proper containers?	G	G
Are flammable liquids safely handled and stored?	G	G
Are combustible packing materials kept in safe containers and is the packing area cleaned up at closing time?	G	G
Is storage in warehouses orderly with ample aisle space?	G	G
SMOKING		
Are "No Smoking" signs posted in hazardous areas?	G	G
Are "No Smoking" regulations enforced in restricted areas?	G	G
ELECTRICAL EQUIPMENT		
Is there any temporary wiring?	G	G
Are motors, fuse panels, and switch boxes clean?	G	G
Is all wiring, including connections to junction boxes, panel boxes, equipment, etc., in good condition?	G	G
FIRE DOORS AND FIRE EXITS		
Are all fire doors in good condition, operable, unobstructed and not blocked open?	G	G
Are automatic closing devices in operating condition?	G	G
Are all fire exits unobstructed, including access to them and discharge from them?	G	G
Are all fire exits clearly marked?	G	G
FIRE EXTINGUISHERS AND SMALL HOSE ($1\frac{1}{2}$ in.)		
Are all extinguishers properly charged and pressurized?	G	G
Are all extinguishers and small hose in good condition and readily accessible?	G	G
GUARD SERVICE		
Do watch-clock records indicate that complete rounds are made as required?	G	G

SPRINKLER SYSTEM	YES	NO
Are all sprinkler control valves open?	G	G
Are any sprinklers obstructed by partitions or high-piled storage?	G	G
Are there any areas where sprinklers are needed?	G	G
Are there any areas where sprinklers may be subject to freezing?	G	G
Do all sprinkler water flow alarms operate satisfactory?	G	G
Are any sprinkler heads painted, corroded, or loaded?	G	G
Is air pressure adequate on all dry pipe sprinkler systems?	G	G
Are all dry pipe valve enclosures heated sufficiently to prevent freezing?	G	G
HYDRANTS		
Are all hydrants accessible and unobstructed?	G	G
Are all hydrants in good operating condition and do they drain properly?	G	G
WATER SUPPLIES		
Are all valves in connections to public water mains open?	G	G
Public water pressure on gage, _____ psi.	G	G
Fire pumps turned over weekly?	G	G
Are pressure tanks 2/3 filled with water?	G	G
Air pressure on pressure tanks adequate?	G	G
Is gravity tank full ?	G	G
Adequately heated?	G	G
Are valves from the gravity tank open?	G	G
Is the fire pump suction supply full?	G	G
Adequately heated?	G	G
Are all fire pump suction supply and discharge valves open?	G	G

inspection route may follow the manufacturing process from raw material to finished product including storage areas.

In order to make a thorough inspection, sufficient time must be taken to make notes and sketches of all important features. Taking the time needed to discuss fire protection problems with the area manager is encouraged. This could prove to be valuable in developing, within the area manager, a positive attitude toward fire safety. A complete set of notes and a well-prepared sketch of the building will provide dependable information from which a complete report can be made.

An inspection report makes it possible to relate information back to plant management. The contents of a report should inform, analyze, and recommend. Such reports are generally concerned with the presentation of facts and evidence to prove a point, draw a conclusion, or justify a recommendation.

Each inspection report should include the following information on the cover sheet.

- Name of department or area inspected
- Date of inspection
- Name of inspector
- Names of others who participated in the inspection.

The main body of the report should contain a list of the hazards found and the recommendations for correcting them. Consideration should be given to the way the main body of the report is written.

- List the hazards, give definite corrections for each, and a short explanation of the recommendations.
- List any additional fire protection equipment needed, including type, size, amount, and desired location.
- If alterations or corrections are necessary, make the instructions specific.
- Avoid general recommendations.

Inspection reports are usually directed to the person responsible for the area inspected. However, copies of the report may be forwarded to top management as well as being retained in the files of the inspecting authority.

FIRE INVESTIGATIONS

A fire's cause is a combination of factors: fuel ignited, form of heat of ignition, source of heat of ignition, and, if there is a human involved, the act or omission by the human that helped bring all these together.

The benefits of a good fire investigation are numerous. An analysis of fire cause provides the information that can be used for making recommendations and developing programs that help prevent accidental or incendiary fires.

Investigation of all fires should begin immediately by plant supervisory personnel to determine the cause. A full investigation report should be made to document the cause and to assure follow-up action. Fire scene examination will produce the most accurate results if the investigator follows the basic steps of observation, reconstruction, evaluation, and conclusion.

The investigator should not examine a fire scene with preconceived ideas or opinions as to the origin and cause, but must remain open-minded until the entire scene and all evidence is considered. Fire scene examination should be characterized by organization, thoroughness, and caution, which are three essential conditions for a successful investigation. Essentially, there are three types of investigations: basic, technical, and arson investigation.

A basic investigation is accomplished on each and every fire incident. It is conducted to determine what property was damaged, what the causes and reasons were, the number and extent of injuries or fatalities, and the recommended corrective action to prevent a recurrence. The basic investigation will provide the information needed for submitting a fire investigation report and to establish the need for further investigation.

A technical investigation is an in-depth investigation to determine more specific details of the cause and effects. It is usually done by personnel other than plant employees.

Fire reports of all fires, regardless of size, should be completed. This report should be initiated and completed without delay. The contents of the fire report may contain the following information:

a. Time of incident
b. Location of incident
c. Size and nature of fire
d. Fire involvement
e. Fire department plant response
f. Injuries or fatalities
g. Time fire extinguished
h. Most probable cause
I. Follow-up and corrective action required

2

Fire Hazard Terminology

INTRODUCTION

This chapter is a glossary of fire hazard, prevention and engineering terms. The reader should scan this chapter to become familiar with those terms not previously encountered, and may refer back to this chapter in later discussions in the volume.

GLOSSARY OF TERMS

A

Acid gas: A gas that forms an acid when dissolved in water.

Adapter: A device for making a connection when threads do not match or when they are different sizes.

Alarm: Any signal indicating the need for emergency response; also, the device that transmits an alarm.

Alcohol: The hydrocarbon derivative in which a hydroxyl radical (-OH) is substituted for a hydrogen atom and which has the general formula R-OH.

Aldehyde: A hydrocarbon derivative with the general formula R-CHO.

Alkanes: An analogous series of saturated hydrocarbons with the general formula $C_nH_{2n+2.}$

Alkyl: The general name for a radical of an alkane; an alkyl halide is a halogenated hydrocarbon whose hydrocarbon backbone originated from an alkane.

Alkynes: An analogous series of unsaturated hydrocarbons with the general formula C_nH_{2n-2}; the alkynes all contain just one triple bond between carbon atoms.

Amine: The hydrocarbon derivative in which an amine group (NH_2) is substituted for a hydrogen atom and which has the general formula R-NH_2.

Analogue: A compound in one analogous series that has a property common with a compound in another analogous series; for example, methyl chloride is an analogue of methyl fluoride.

Aromatic: The name originally given to cyclical compounds containing the benzene "ring" because the first benzene-type compounds isolated smelled "good".

Arson: Arson is the willful and malicious burning of the property of another. This meaning has been broadened by statute in many jurisdictions to include one's own property.

B

Backdraft: The term given to a type of explosion caused by the sudden influx of air into a mixture of gases, which have been heated to above the ignition temperature of at least one of them.

BLEVE (Boiling Liquid Expanding Vapor Explosion): See Boilover; the same phenomenon may occur in a pressurized container, resulting in an explosion or bursting of the tank or vessel in which a fire is occurring. The term is almost exclusively used to describe a disastrous effect from a crude oil fire.

Boiling Point: The temperature at which the vapor pressure of a liquid just equals atmospheric pressure.

Boilover: Crude oil often contains some entrained water and/or an emulsion layer. In addition, crude-oil storage tanks will have some accumulations of water on the uneven tank bottoms. In a fire, when a heat wave is formed and comes in contact with any water, a steam explosion occurs, thus agitating the hot oil above it with great force. The evolution of the steam explosion can be understood by examining the reaction of water to high temperatures. When water is heated to its boiling point of 212°F., water vapor, or steam, is generated. The steam that is produced expands approximately 1,700 times in volume over the volume of the water that boiled away. Should a heat wave of a temperature well above 212°F. contact any water entrained in the oil, or some of the bottom water, which is usually in larger quantities, it can be readily imagined that this instantaneous generation of steam will act like a piston, causing the oil to be flung upward with considerable violence. When the reaction is so strong, it causes the oil to overflow the tank shell. This sudden eruption is what is known as a boilover. Boilovers of sufficient magnitude, to cascade enough burning crude oil out of the tank to not only cover the entire dike area but even enough to overflow the dike wall as well, have occurred. When the hot oil and steam reaction takes place, the oil is made frothy, or sudsy, which in turn further increases its volume. The reaction resulting from the heat wave contacting entrained water can be expected to be of lesser activity than from contact with bottom water. The reason for this difference is that the quantities of water converted to steam in a given spot are usually less. Of course, with entrained water, there possibly can be several of these "frothover"-type eruptions during the progress of the fire.

Branching: A configuration in which a carbon atom attaches itself to another carbon atom that has two or three other carbon atoms attached to it, forming

a branch, or side chain. When the carbon attaches to another carbon that has only one other carbon attached to it, a straight chain is formed, rather than a branched chain.

BTU: British Thermal Unit: The amount of energy required to raise one pound of water 1°F.

Building codes: There are several building codes that are widely adopted throughout the United States: (1) The Southern Standard Building Code; (2) The Uniform Building Code; (3) The Basic Building Code; (4) The National Building Code; and (5) Building Officials and Code Administrators (BOCA). The purpose of the building codes are to regulate the safe construction of buildings.

Building survey: That portion of the pre-fire planning process that involves the gathering of all the necessary information to develop a pre-fire plan of a building or property.

C

Calorie: The amount of energy required to raise one gram of water 1°C.

Carbonyl: The functional group with the structural formula -C-.

Carcinogen: A cancer-causing agent.

Chain: The way carbon atoms react with each other, producing covalent bonds between them, resembling a chain with carbon atoms as the links.

Combustible liquids: Any liquid having a flash point temperature above 100 °F.

Combustion: A chemical reaction caused by oxidation that produces light and heat. The production of light in the combustion process is the difference between oxidation and combustion: Oxidation, regardless of slowness, will give off heat but no light will be produced.

Common name: The name originally given to a compound upon its discovery, prior to the adoption of an organized system of assigning proper names.

Compressed gas: A gas that is under pressure, either still in the gaseous state, or liquified.

Conduction: The transfer of heat through a medium.

Convection: The transfer of heat with a medium.

Cracking: The breaking of covalent bonds, usually between carbon atoms.

Critical pressure: The pressure required to liquify a gas at its critical temperature.

Critical temperature: The temperature above which it is impossible to liquify a gas.

Cryogenic gas: A gas with a boiling point of -150°F. or lower.

Cyclical: The structure of certain molecules where there is no end to the carbon chain; the molecule is a closed structure resembling a ring, where what would be the "last" carbon in the chain is bonded to the "first" carbon in the chain. There are cyclical compounds in which the closed structure contains the atoms of other elements in addition to carbon.

D

Derivative: A compound made from a hydrocarbon by substituting another atom or group of atoms for one of the hydrogen atoms in the compound.

"**Di-**": The prefix that means two.
Diatomic: Two atoms, as in a diatomic molecule, which contains two atoms bound covalently to each other.
Diffusion flame: The flame produced by the spontaneous mixture of fuel vapors or gases and air.
Dry chemical: A term applied to an extinguishing agent suitable for use on flammable liquids and electrical fires.
Dry-pipe sprinkler systems: A fire protection sprinkler system that has air instead of water under pressure in its piping; dry systems are often installed in areas subject to freezing.
Dry-pipe valve: A valve in a dry-pipe sprinkler system designed so that moderate air pressure will hold back a much greater water pressure.
Dry powder: A term applied to the extinguishing agent suitable for use on combustible metals.

E

Elevated storage system: A system of storing impounded water supplies above the grade level at which the water will be used.
Emergency action plan: A written statement covering the actions employers and employees must take to insure employee safety from fire and other emergencies.
Endothermic: The absorption of heat.
Essential plant operations: Plant operations such as the monitoring of plant power supplies, water supplies, and other essential services which cannot be shut down for every emergency alarm. They may also include chemical or manufacturing processes that must be shut down in stages or steps.
Ester: The hydrocarbon derivative with the general formula R-C-O-O-R'.
Ether: A hydrocarbon derivative with the general formula R-O-R'.
Evacuation warden: An employee designated to assist in the evacuation of employees from the workplace.
Evaporation: The process by which molecules of a liquid escape through the surface of the liquid into the air space above.
Exothermic: The liberation of heat.
Explosive range: The explosive range tells us that a certain mixture of fuel vapor and air is required for the vapor to become ignitable. It is essentially a concentration range for fuel in air, in which the vapors of a flammable material will burn. The terms flammable limit and combustible limit are often used to describe the explosive range. These three terms have identical meaning and are interchangeable with each other. See lower explosion limit and upper explosion limit.
Exposure: Property that may be endangered by a fire.

F

Fire brigade: An organization of industrial plant personnel who are trained to use the fire fighting equipment and to carry out fire prevention activities within the plant.
Fire brigade organization statement: A written statement that identifies the scope of the fire brigade, organizational structure, training requirements, brigade size, and functions of the brigade members.

Fire department connection: Connections provided at ground level through which the fire department supplies sprinkler systems or standpipe systems.
Fire detection devices: The devices and connections installed in a building for the purpose of detecting the presence of heat, smoke, and/or flame.
Fire door: A specially constructed, tested, and approved door installed for the purpose of preventing the spread of fire.
Fire hazards: Conditions that are conducive to fire or are likely to increase the extent or severity of fire. The terms hazard or hazardous are also used to indicate the type of material or rate of burning.
Fire point temperature: The temperature a liquid must be before the released vapor is in sufficient quantity to continue to burn, once ignited.
Fire prevention: Fire protection activities that deal with preventing fires starting by eliminating fire hazards through inspection and education programs.
Fire prevention code or ordinance: A law enacted in a political jurisdiction for the purpose of enforcing fire prevention and safety regulations.
Fireproof: The word fireproof is a misnomer as it means that something absolutely will not burn. Other terms such as fire resistive or fire resistant should be used to indicate the degree of resistance to fire.
Fire protection engineer: A graduate of an accredited institution of higher learning who has specialized in engineering problems related to fire protection.
Fire pump: A water pump used in private fire protection for providing additional water supply to installed fire protection systems.
Fire report: The official report of a fire, generally prepared by the person in charge of the fire incident.
Fire resistive: Material and design of building construction meant to withstand the maximum effect of a fire for a specific period of time.
Fire stream: A stream of water from a fire nozzle, used to control and combat fires.
Fire tetrahedron: A four-sided, solid geometric figure that resembles a pyramid, with one of the sides forming the base. Each side indicates one of the four elements required to have fire.
Fire triangle: A plane geometric figure in which the three sides of an equilateral triangle represent oxygen, heat, and fuel, the elements necessary to sustain combustion.
Flammable liquids: Any liquid having a flash point temperature below 100 °F.
Flashover: The stage of a fire in which a room or other confined area becomes heated to the point that flames flash over the entire surface of the area.
Flash point temperature: The lowest temperature a liquid may be and still have the capability of liberating flammable vapor at a sufficient rate that, when united with the proper amounts of air, the air-fuel mixture will flash if a source of ignition is presented. The amounts of vapor being released at the exact flash point temperature will not sustain the fire and, after flashing across the liquid surface, the flame will go out.

Foam: A sudslike extinguishing agent formed by mixing a foam-producing compound with water. Mechanical foam is produced by agitation, chemical foam is produced when two or more chemicals react.
Foam generators: Devices for mixing chemical or mechanical foam in proper proportion with a stream of water to produce foam.
Fog stream: A water stream of finely divided particles used for fire control.
Frangible disc: A safety release device that will burst at a predetermined pressure.
Free burning: The second phase of burning in which materials or structures are burning in the presence of adequate oxygen.
Free radical: An atom or group of atoms bound together chemically with at least one unpaired electron. A free radical is formed by the introduction of energy to a covalently bonded molecule, when that molecule is broken apart by the energy. It cannot exist free in nature and, therefore, must react quickly with other free radicals present.
Freezing point: The temperature at which a liquid changes to a solid.
Fuel: Anything that will burn.
Functional Group: An atom or group of atoms, bound together chemically, that has an unpaired electron, which when it attaches itself to the hydrocarbon backbone, imparts special properties to the new compound thus formed.
Fusible link: A connecting link device that fuses or melts when exposed to heat. Used in sprinkler heads, fire doors, and ventilators.
Fusible plug: A safety relief device that will melt at a predetermined temperature.

G

Gas: A state of matter defined as a fluid with a vapor pressure exceeding 40 psia at 100° F.
Gated wye: A hose appliance that has one female inlet and two or more male outlets with a gate valve on each of the male outlets.
General formula: The general molecular formula for an analogous series of compounds that will give the actual molecular formula for any member of the series as long as the number of carbon atoms in the compound is known. This number is substituted for the letter "n" in the formula.
Glycerol: A series of substituted hydrocarbons with three hydroxyl radicals substituted for hydrogen atoms.
Glycol: A hydrocarbon derivative with two hydroxyl radicals substituted for two hydrogen atoms.
Gravity tank: An aboveground water storage tank for fire protection and water service. A water level of 100 feet provides a static pressure head of 43.3 psi minus friction loss in piping when water is flowing.
Grid system water mains: An interconnecting system of water mains in a criss-cross or rectangular pattern.

H

H.A.D.(Heat Actuating Devices): Thermostatically controlled devices used to activate fire equipment, alarms, or appliances.
Halide: A halogenated compound.

Halogenated: A compound that has had a halogen atom substituted for another hydrogen atom. A halogenated hydrocarbon is a hydrocarbon that has had at least one hydrogen atom removed and replaced by a halogen.
Halogenation: The chemical reaction whereby a halogen is substituted for another atom, usually a hydrogen atom.
Halogens: The elements of group VIIA: fluorine, chlorine, bromine, iodine, and astatine.
Halon: Halogenated extinguishing agent. Halon extinguishes fires by inhibiting the chemical reaction of fuel and oxygen.
Handline: Small hoselines that can be handled and maneuvered without mechanical assistance.
Heat: A form of energy; the total amount of vibration in a group of molecules.
Heat transfer: The movement and dispersion of heat by conduction, convection, or radiation.
Hose cabinet (rack): A recessed cabinet in a wall that contains a wall hydrant and connected length of hose.
Hose clamp: A mechanical device for compressing fire hose to stop the flow of water.
Hose reel: Cylinders around which fire hose may be manually or mechanically rolled to keep it neat and orderly.
Hydrant hose house: A structure built around a yard hydrant containing fire hose, nozzles, axes, and other fire fighting tools.
Hydrant wrench: A specially designed tool used to open or close a hydrant and to remove hydrant caps.
Hydrocarbon: A covalent compound containing only hydrogen and carbon.
Hydrocarbon Backbone: The molecular fragment that remains after hydrogen atom is removed from a hydrocarbon; the hydrocarbon portion of a hydrocarbon derivative.
Hydrocarbon Derivative: A compound that began as a hydrocarbon, had a hydrogen atom removed from the chain somewhere, and had functional group attached to replace the hydrogen atom.
Hydroxyl: The functional group of the alcohols; the structural formula is -O-H, usually written -OH.

I

Ignition continuity: The continuation of burning caused by the radiated heat of the flame.
Ignition temperature: The exact minimum temperature that has the capability of igniting a flammable vapor mixture.
Incipient stage fire: A fire in its beginning stage that can be controlled or extinguished using portable fire extinguishers, Class II standpipe, or small hose systems without the need for protective clothing or breathing equipment.
Indirect application: A method of extinguishing fire by applying water fog into a superheated atmosphere to obtain the maximum heat absorption and steam generation for smothering and cooling the fire area.
Input heat: The amount of heat required to produce the evolution of vapors

from a solid or liquid.

Interior structural fire fighting: The act of fire suppression and rescue inside buildings or enclosed structures where a fire has gone beyond the incipient stage.

"**Iso:** The prefix (meaning the same) given to a compound having the same number and kind of atoms as another compound, as in isomer.

Isomer: A compound with a molecular formula identical to another compound but with a different structural formula. That is, a compound may possess exactly the same elements, and exactly the same number of atoms of those elements as another compound, but those atoms are arranged in a different order from the first compound.

K

Ketone: A hydrocarbon derivative with the general formula R-C-R'.

Kinetic molecular theory: A theory that states all molecules are in constant motion at all temperatures above absolute zero; molecules will move (or vibrate) faster at higher temperatures because of the energy absorbed.

L

Latent heat of vaporization: The amount of heat a substance must absorb when it changes from a liquid to a vapor or gas.

Liquid: A fluid with a vapor pressure no higher than 40 psia.

Liquified gas: A gas that has been converted to a liquid by pressure and/or cooling.

Local alarm system: A combination of alarm components designed to detect a fire and to transmit an alarm on the immediate premises.

Looped water main: A water main arranged in a complete circuit so water will be supplied to a given point from more than one direction. Also called a grid system.

Lower explosion limit (LEL) : The LEL is expressed as a percentage of the total volume of the air-fuel mixture; it is the lowest concentration of vapor fuel in air under which spontaneous combustion will occur. An example is gasoline. A mixture containing 1.5% gasoline vapor in air (concentration of air being 98.5% in this mixture) will spontaneously combust. The LEL in this example is 1.5% or simply 1.5. Below this concentration, the mixture is described as being too "lean"; or in other words, there is insufficient fuel for spontaneous combustion to occur.

M

Melting point: The temperature at which a solid changes to a liquid.

Molecular formula: A method of representing a molecule by a written formula, listing which atoms and how many of them are in the molecule, without showing how they are bonded to each other.

"**Mono-**": The prefix that means one.

Monomer: A simple, small molecule that has the special capability of reacting with itself to form a giant molecule called a polymer.

N

"**Neo-**": A prefix given to an isomer of another compound. It exists in compounds that were named long ago and is used only when the compound it best known by its common name.

NFPA : National Fire Protection Association

"Normal": The designation given to a straight-chain compound that has isomers. The designation in the molecular formula is an "n-" in front of the formula.

O

Olefins: A synonym for the alkene series.

OS & Y Valve: A type of outside screw and yoke valve used on piping or in pits connected to sprinkler systems. The position of the stem shows the valve to be either open or closed.

Oxidation: The chemical combination of any substance with oxygen.

P

Paraffin series: An older name given to the alkanes.

Pendent sprinkler: An automatic sprinkler head designed for placement and operation with the head pointing downward from the piping.

Peroxide: The hydrocarbon derivative with the general formula R-O-O-R'; also the name of the peroxide radical which has the structural formula -O-O-.

Personal protective clothing: Clothing and equipment such as coat, boots, pants, helmet, gloves, and breathing apparatus that shield the body from heat, smoke, fumes, and other harmful conditions.

Phases of fire: A degree of flame progression. Phase I, fire in incipient stage and beginning to grow. Phase II, freeburning, flame propagation is at its greatest. Phase III, oxygen is deficient in the burn area, producing a smoldering phase.

Phenyl: The general name for the radical of benzene.

Polymerization: The chemical reaction in which a special compound, called a monomer, combines with itself to form a long-chain molecule called a polymer.

Polymerize: The chemical reaction whereby a compound reacts with itself to form a polymer.

Post indicator valve (PIV): A post-type valve that provides a visual means of indicating "open" or "shut" position. It is found on the supply main of installed fire protection systems.

Pre-action system: A type of automatic sprinkler system in which thermostatic devices are employed to charge the system with water before individual sprinkler heads are fused.

Pre-fire planning: The act of preparing to fight a fire in a particular building or group of buildings by advance planning of possible fire fighting operations.

Pressurized gas: A gas that is still in the gaseous state, but under higher pressure than 14.7 psia.

Products-of-combustion: Materials given off or released during the burning process.

Proper name: An agreed-upon system of naming organic compounds according the longest carbon chain in the compound.

Proportioner: A device for inducing the correct amount of agent into streams of water, especially for foam and wetting agents.

Proportioning: The occurrence of intermolecular collisions between oxygen

and hydrocarbon molecules.

Proprietary system: A fire protection system that is owned and operated by the owner of the property.

Pyrolysis: The breakdown of a molecule by heat.

R

Radiation: The transfer of heat with no medium.

Radiation heat: The transmission of heat through the medium of heat rays.

Radical: An atom or group of atoms bound together chemically that has one or more unpaired electrons; it cannot exist in nature in that form, so it reacts very fast with another radical present, to form a new compound; also known as a "free" radical.

Rate-of-rise alarm system: One of the systems installed for detecting fire by an abnormal rate of increase of heat; operates when a normal amount of air in a pneumatic tube expands rapidly when heated and exerts pressure on diaphragms.

Reducer couplings: Couplings with a large and small connector for connecting hose couplings of two different sizes.

Remote alarm system: An alarm signaling system with a direct, privately owned circuit that goes to a fire department into privately owned receiving equipment.

Resonance: A phenomenon whereby a structure, to satisfy the rules of covalent bonding, should be fluctuating (resonating) back and forth between two alternate molecular structures, both of which are "correct" for the molecule. It is a way of explaining what cannot be explained using only the rules of covalent bonding.

Rope hose tool: A piece of rope spliced to form a loop through the eye of a metal hook. Used for securing hose to ladders or other objects.

S

Saturated: A hydrocarbon possessing only single covalent bonds between carbon atoms.

Siamese: A hose appliance that has two or more female inlets and one male outlet; two or more inlets for one outlet.

Slopover: see also Boilover. Basically, the same principles that are responsible for a boilover are the cause of a "slopover". The fundamental difference is that in a slopover the reaction is from water that has entered the tank since the start of a fire. Usually this introduction is the result of the firefighters' activities as they attempt to extinguish the crude oil (or liquid of similar characteristics) fire. A slopover will occur at some moment after the heat wave has been formed - which may be from only a few minutes of burning - and water or foam is being applied to the liquid surface. Either the water from the hose streams or, after the bubbles collapse, the water in the foam will sink into the oil, contacting the heat wave, where it is converted to steam, and the agitation of the liquid surface spills some amount of oil over the tank rim. Historically, slopovers, although still exposing the firefighters to the danger of the escaping, burning oil, are not as violent as are boilovers. Regardless of the term used to describe the occurrence - that is, boilover, slopover, frothover, or whatever - the likelihood of some event

that will cause the oil to cascade over the tank shell and down into the dike area is always present when crude oil burns.

Solid stream: A hose stream that stays together as a solid mass, as opposed to a fog or spray.

Spanner wrench: A tool used by firefighters for tightening or loosening couplings.

Specific gravity: A measure of the weight of a material (liquid or solid) as related to the weight of an equal volume of water.

Specific heat: The ratio between the amount of heat necessary to raise the temperature of a substance and the amount of heat necessary to raise the same weight of water the same number of degrees.

Sprinkler connection: A siamese connection used by the fire department for increasing the water supply and pressure to a sprinkler system.

STEL: Short Term Exposure Limit (STEL) refers to a safe level of exposure (see also TLV) from inhalation for a continuous period of time that is short (by OSHA standards either a 15 minutes or 5 minutes of continuous exposure). The concentration established by the STEL (usually in ppm) should not be exceeded during that period of exposure, and further, the time limit of continuous exposure should not be exceeded, else there is a health risk.

Straight chain: The configuration of the molecule of a hydrocarbon when a carbon atom attaches itself to another carbon atom that has only one other carbon atom already attached to it.

Structural effect: The effect upon certain properties of an analogous series of compounds by branching. Properties such as boiling point, flash point, ignition temperature, and others change as branches are added to compounds, including isomers.

Structural formula: A drawing of the molecule, showing all the atoms of the molecule and how they are bonded to each other atom.

Substituted: A compound that has had one or more of its atoms removed and replaced by atoms of other elements in the molecule. A substituted hydrocarbon is a compound that has had a hydrogen atom removed and another atom substituted for it.

Synthesize: To make a molecule to duplicate a molecule made in nature.

T

"Tetra-": The prefix that means four.

Thermal degradation: The term refers to the decomposition or degradation of a material due to exposure to heat or energy. Materials can be thermally degraded into three principal ways: anaerobic pyrolysis, oxidative pyrolysis ("smoldering"), and flaming combustion.

TLV: The TLV or Threshold Limit Value refers to a safe level of exposure by inhalation. The definition was established by the American Conference of Governmental Hygienists. There are several variations or criteria levels for the TLV. As an example, hydrogen sulfide has a TLV for short-term exposure limits (STEL) of 15 minutes of only 5 ppm. Comparing this to the TLV-STEL of 400 ppm for carbon monoxide provides an indication of the need to be extremely careful when H_2S is suspected. Under OSHA Standards,

and particularly on MSDS (Material Safety Data Sheets) compounds are associated with a time weighted average (TWA) TLV, which is the allowable concentration for an 8-hour continuous exposure period. For firefighting purposes, the short-term exposure is likely more realistic.

"**Tri-**": The prefix that means three.

U

Unit: A molecular fragment that repeats itself in a series.

Unsaturated: A hydrocarbon with at least one multiple bond between two carbon atoms somewhere in the molecule.

Upper explosion limit: The UEL is expressed as a percentage of the total volume of the air-fuel mixture; it is the highest concentration of vapor fuel in air under which spontaneous combustion will occur. An example is gasoline. A mixture containing 7.6% gasoline vapor in air (concentration of air being 92.4% in this mixture) will spontaneously combust. The UEL in this example is 7.6% or simply 7.6. Above this concentration, the mixture is described as being too "rich"; or in other words, there is too much fuel and not enough oxygen for spontaneous combustion to occur.

V

Vapor density: A measurement of the weight of vapor compared to the weight of air.

Vapor pressure: The pressure exerted by vapor molecules on the sides of a container, at equilibrium.

Venting devices: A device that is designed to relieve excessive pressure from the vapor space of a container. To accomplish this, the device will be located on the tops of containers above the normal level of liquid of the full tank. Some vents are installed to allow for the venting of the tank during routine operations. Movement of liquid into or out of a container without the space above the liquid level having the ability to breathe will result in damage to the shell. Additional venting capacity is required to keep the internal pressures at a safe level during fire emergencies. The various types of venting devices in use include fusible plugs, spring-loaded relief valves, pop-up-type hatch covers, pressure/vacuum vents, and weighted caps.

Vinyl: The general name for the radical of ethylene.

Volatilization: The changing of a liquid to a vapor.

W

Water solubility: A measure of the ability of a liquid to mix with water.

Weight effect: The change produced in certain properties, including flash point, boiling point, and water solubility, as the molecular weight (calculated by adding the atomic weights of all the atoms in the molecule) of compounds in an analogous series is increased or decreased.

Wet-pipe sprinkler system: An automatic sprinkler system in which the pipes are constantly filled with water under pressure.

Wet-standpipe system: A building standpipe system constantly filled with water. Sections of small diameter fire hose are connected to the standpipe system on each floor.

Y

Yard hydrant: Similar to all other fire hydrants; they derive their name from being located in the yard of an industrial complex and are installed for private fire protection.

3

Properties and Flammability of Hydrocarbons

INTRODUCTION

Hydrocarbons are compounds containing only hydrogen and carbon atoms. Since a hydrocarbon is a chemical combination of hydrogen and carbons, both of which are non-metals, hydrocarbons are convalently bonded. Hydrogen has only one electron in the outer ring and, therefore, will form only one bond, by donating one electron to the bond. Carbon, on the other hand, occupies a unique position in the Periodic Table, being halfway to stability with its four electrons in the outer ring. None of these electrons are paired, so carbon uses all of them to form covalent bonds. Carbon's unique structure makes it the basis of organic chemistry.

Carbon not only combines covalently with other non-metals, but also with itself. Oxygen also reacts with itself to form O_2, hydrogen reacts with itself to form H_2, nitrogen reacts with itself to form N_2, fluorine reacts with itself to form F_2, and chlorine reacts with itself to form Cl_2. Forming diatomic molecules, however, is the extent of the self-reaction of the elemental gases, while carbon has the ability to combine with itself almost indefinitely. Although the elemental gases form molecules when they combine with themselves, the carbon-to-carbon combination must include another element or elements, generally hydrogen. This combination of carbon with itself (plus hydrogen) forms a larger molecule with every carbon atom that is added to the chain. When the chain is strictly carbon-to-carbon with no branching, the resulting hydrocarbon is referred to as a straight-chain hydrocarbon. Where there are carbon atoms joined to carbon atoms to form side branches off the straight chain, the resulting compound is known as a branched hydrocarbon, or an isomer.

The carbon-to-hydrogen bond is always a single bond. While the resulting bond between carbon and hydrogen is always a single bond, carbon does have the capability to form double and triple bonds between itself and other carbon atoms, and/or any other atom that has the ability to form more than one bond. When a hydrocarbon contains only single bonds between carbon atoms, it is known as a saturated hydrocarbon; when there is at least one double or triple bond between two carbon atoms anywhere in the molecule, it is an unsaturated hydrocarbon. When determining the saturation or unsaturation of a hydrocarbon, only the carbon-to-carbon bonds are considered, since the carbon-to-hydrogen bond is always single.

This chapter provides an overview of the chemistry, properties and fire hazards of hydrocarbons. Hydrocarbons are among the most useful materials to mankind, but are also among the most dangerous in terms of their fire potential.

CHEMISTRY FUNDAMENTALS

An analogous series of hydrocarbons, and one of the simplest, are the compounds known as the alkanes. In this series, the names of all the compounds end in -ane. The first compound in this series is methane. Methane's molecular formula is CH_4. Methane is a gas and is the principal ingredient in the mixture of gases known as natural gas. The next compound is this series is ethane, whose molecular formula is C_2H_6. It is also a gas present in natural gas, although in a much lower percentage than methane. The difference in the molecular formulas of methane and ethane is one carbon and two hydrogen atoms.

Propane is the next hydrocarbon in this series, and its molecular formula is C_3H_8 which is one carbon and two hydrogen atoms different from ethane. Propane is an easily liquified gas which is used as fuel.

The next hydrocarbon in the series is butane, another rather easily liquified gas used as a fuel. Together, butane and propane are known as the LP (liquified petroleum) gases. Butane's molecular formula is C_4H_{10}, which is CH_2 bigger than propane.

Hence, the series begins with a one-carbon-atom compound, methane, and proceeds to add one carbon atom to the chain for each succeeding compound. Since carbon will form four convalent bonds, it must also add two hydrogen atoms to satisfy those two unpaired electrons and allow carbon to satisfy the octet rule, thus achieving eight electrons in the outer ring. In every hydrocarbon, whether saturated or unsaturated, all atoms must reach stability. There are only two elements involved in a hydrocarbon, hydrogen and carbon; hydrogen must have two electrons in the outer ring, and carbon must have eight electrons in the outer ring. Since the carbon-hydrogen bond is always single, the rest of the bonds must be carbon-carbon, and these bonds must be single, double, or triple, depending on the compound.

Continuing in the alkane series (also called the paraffin series because the first solid hydrocarbon in the series is paraffin, or candle wax), the next compound is pentane. This name is derived from the Greek word penta, for five. As its name implies, it has five carbon atoms, and its molecular formula is C_5H_{12}.

From pentane on, the Greek prefix for the numbers five, six, seven, eight, nine, ten, and so on are used to name the alkanes, the Greek prefix corresponding to the number of carbon atoms in the molecule. The first four members of the alkane series do not use the Greek prefix method of naming, simply because their common names are so universally accepted: thus the names methane, ethane, propane, and butane.

The next six alkanes are named pentane, hexane, heptane, octane, nonane, and decane. Their molecular formulas are C_5H_{12}, C_6H_{14}, C_7H_{16}, C_8H_{18}, C_9H_{20} and $C_{10}H_{22}$. The alkanes do not stop at the ten-carbon chain however. Since these first ten represent flammable gases and liquids and most of the derivatives of these compounds comprise the vast majority of hazardous materials encountered, we have no need to go any further in the series. The general formula for the alkanes is C_nH_{2n+2}. The letter n stands for the number of carbon atoms in the molecule. The number of hydrogen atoms then becomes two more than twice the number of carbon atoms. Since there is more than one analogous series of hydrocarbons, you must remember that each series is unique; the alkanes are defined as the analogous series of saturated hydrocarbons with the general formula C_nH_{2n+2}.

Isomers

Within each analogous series of hydrocarbons there exist isomers of the compounds within that series. An isomer is defined as a compound with the same molecular formula as another compound but with a different structural formula. In other words, if there is a different way in which the carbon atoms can align themselves in the molecule, a different compound with different properties will exist.

Beginning with the fourth alkane, butane, we find we can draw a structural formula of a compound with four atoms and ten hydrogen atoms in two ways; the first is as the normal butane exists and the second is as shown in Figure 1, with the name isobutane. With isobutane, no matter how you count the carbon atoms in the longest chain, you will always end with three. Notice that the structural formula is different - one carbon atom attached to the other carbon atoms - while in butane (also called normal butane), the largest number of carbon atoms another carbon atom can be attached to is two. This fact does make a difference in certain properties of compounds. The molecular formulas of butane and isobutane are the same and, therefore, so are the molecular weights. However, there is a 38-degree difference in melting points, 20-degree difference in boiling points, and the 310-degree difference in ignition temperatures. The structure of the molecule

clearly plays part in the properties of the compounds.

With the five-carbon alkane, pentane, there are three ways to draw the structural formula of this compound with five carbon atoms and twelve hydrogen atoms. The isomers of normal pentane are isopentane and neopentane. The structural formulas of these compounds are shown in Figure 1, while typical properties are given in Table 1. Note the three identical molecular formulas and three identical molecular weights, but significantly different melting, boiling, and flash points and different ignition temperatures. These property differences are referred to as the "structural effect", i.e., differences in the properties of compounds exist for materials having the same molecular formulas but different structural arrangements. This particular structure effect is called the branching effect, and the isomers of all the straight-chain hydrocarbons are called branched hydrocarbons.

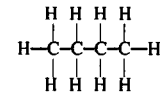
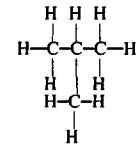
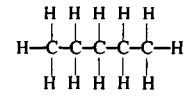
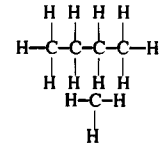
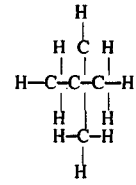
Compound	Molecular Formula	Structural Formula
Butane	C_4H_{10}	
Isobutane	C_4H_{10}	
Pentane	C_5H_{12}	
Isopentane	C_5H_{12}	
Neopentane	C_5H_{12}	

Figure 1. Illustrates the structural formulas for isomers of butane and pentane.

There is another structural effect; it is produced simply by the length of the chain formed by consecutively attached carbon atoms.

In noting the increasing length of the carbon chain from methane through decane, the difference in each succeeding alkane is that "unit" made up of one carbon atom and two hydrogen atoms; that "unit" is not a chemical compound itself, but it has a molecular weight of fourteen. Therefore, each succeeding alkane in the analogous series weighs fourteen atomic mass units more than the one before it and fourteen less than the one after it. This weight effect is the reason for the increasing melting and boiling points, the increasing flash points, and the decreasing ignition temperatures. The increasing weights of the compounds also account for the changes from the gaseous state of the first four alkanes, to the liquid state of the next thirteen alkanes, and finally to the solid state of the alkanes, starting with the 17-carbon atom alkane, heptadecane.

Table 1. Typical properties of alkanes (general literature values).

Compound	Formula	Atomic Weight (°F)	Melting Point (°F)	Boiling Point (°F)	Flash Point (°F)	Ignition Temperature (°F)
Methane	CH_4	16	-296.5	-259	gas	999
Ethane	C_2H_6	30	-298	-127	gas	882
Propane	C_3H_8	44	-306	-44	gas	842
Butane	C_4H_{10}	58	-217	31	gas	550
Pentane	C_5H_{12}	72	-201.5	97	< -40	500
Hexane	C_6H_{14}	86	- 139.5	156	-7	437
Heptane	C_7H_{16}	100	-131.1	209	25	399
Octane	C_8H_{18}	114	-70.2	258	56	403
Nonane	C_9H_{20}	128	-64.5	303	88	401
Decane	$C_{10}H_{22}$	142	-21.5	345	115	410
Butane	C_4H_{10}	58	-217	31	gas	550
Isobutane	C_4H_{10}	58	-255	11	gas	860
Pentane	C_5H_{12}	72	-201.5	97	< -40	500
Isopentane	C_5H_{12}	72	-256	82	< -60	788
Neopentane	C_5H_{12}	72	2	49	< -20	842

We may now state a very general rule of chemistry: the larger a molecule (that is, the greater the molecular weight), the greater affinity each molecule will have for each other molecule, therefore, slowing down the movement. The molecules, duly slowed from their frantic movement as gases, become liquids, and, as the molecules continue to get larger, they are

further slowed from their still rapid movement as liquids and become solids.

The straight-chain hydrocarbons represent just one group of straight-chain hydrocarbons, the saturated hydrocarbons known as the alkanes. There are other series of hydrocarbons that are unsaturated; one of those is important in the study of hazardous materials. Additionally, the first hydrocarbon in another series is the only hydrocarbon important in that series. Each of these hydrocarbon series are briefly described below.

Alkenes

The series of unsaturated hydrocarbons that contain just one double bond in the structural formula of each of its members is the analogous series known as the alkenes. Notice that the name of the analogous series is similar to the analogous series of saturated hydrocarbons known as the alkanes, but the structural formula is significantly different. Remembering that the definition of a saturated hydrocarbon is a hydrocarbon with nothing but single bonds in the structural formula and that an unsaturated hydrocarbon is a hydrogen-carbon with at least one multiple bond in the structural formula, then we would expect to find a multiple bond in the structural formulas of the alkenes. The names of all the hydrocarbons in this series end in -ene. The corresponding names for this series of hydrocarbons is similar to the alkanes, with the only difference being the above-mentioned ending. Thus, in the alkene series ethane becomes ethene, propane is propene, butane is butene; the five-carbon straight-chain hydrocarbon in the alkene series is pentene, as opposed to pentane in the alkane series, and so on.

Note that these compounds are covalently bonded compounds containing only hydrogen and carbon. The differences in their structural formulas are apparent; the alkanes have only single bonds in their structural formulas, while the alkenes have one (and only one) double bond in their structural formulas. There are different numbers of hydrogen atoms in the two analogous series. This difference is due to the octet rule that carbon must satisfy. Since one pair of carbon atoms shares a double bond, this fact reduces the number of electrons the carbons need (collectively) by two, so there are two fewer hydrogen atoms in the alkene than in the corresponding alkane.

In any hydrocarbon compound, carbon will form four covalent bonds. In saturated hydrocarbons the four bonds will all be single bonds. The definition of an unsaturated hydrocarbon, however, is a hydrocarbon with at least one multiple bond, and the alkenes are an analogous series of unsaturated hydrocarbons containing just one double bond (which is a multiple bond). The double bond must be formed with another carbon atom since hydrogen atoms can form only single bonds and, in a hydrocarbon compounds there are no other elements but hydrogen and carbon. In forming a double bond with another carbon atom and to satisfy the octet rule, the

alkene must form fewer bonds with hydrogen, resulting in less hydrogen in the structural formula of each alkene than in the corresponding alkane. There are two fewer hydrogen atoms in each of the alkenes than in the alkane with the same number of carbon atoms. This is also shown by the general molecular formula of the alkenes, C_nH_{2n}, as opposed to the general molecular formula of the alkanes, which is C_nH_{2n+2}.

Note that there is no one-carbon alkene corresponding to methane, since hydrogen can never form more than one covalent bond, and there is no other carbon atom in the structural formula. Therefore, the first compound in the alkene series is ethene, while the corresponding two-carbon compound in the alkane series, ethane, is the second compound in the series, with methane the first.

Although the naming of the alkenes is the same as the alkanes, with only the ending changed from -ane to -ene, there is a problem with the names of the first three alkenes. The systematic names of hydrocarbons came a long while after the simplest (that is, the shortest chain) of the compounds in each series was known and named. In naming the alkanes, the system of using the Greek names for numbers as prefixes begins with pentane, rather than with methane. That situation occurred because methane, ethane, propane, and butane were known and named long before it was known that there was an almost infinite length to the chain that carbon could form and that a systematic naming procedure would be needed. Before the new system was adopted, the common names for the shortest-chain compounds had become so entrenched that those names survived unchanged. Therefore, not only are the first four compounds in the alkane series named differently from the rest of the series, the corresponding two-, three-, and four-carbon compounds are not generally known as ethene, propene, and butene. Their common names are ethylene, propylene, and butylene.

As noted earlier, more than one compound may have the same molecular formula (isomers), but a structural formula is unique to one compound. In addition, there are many chemicals which possess more than one chemical name, for the same reason mentioned above. The most common organic chemicals are those that have the shortest carbon chains. This fact is also true of their derivatives. The inclusion of a double bond in the structural formula has a profound effect on the properties of a compound. Table 2 illustrates those differences through the properties of alkenes. The presence of a double bond (and, indeed, a triple bond) between two carbon atoms in a hydrocarbon increases the chemical activity of the compound tremendously over its corresponding saturated hydrocarbon. The smaller the molecule (that is, the shorter the chain), the more pronounced this activity is. A case in point is the unsaturated hydrocarbon ethylene. Disregarding the present the differences in combustion properties between it and ethane, ethylene is so chemically active that, under the proper conditions, instead of burning, polymerization, which, if it is uncontrolled, is a much more violent reaction than combustion. This tendency to

polymerize is due to the presence of the double bond. The tendency to polymerize decreases as the molecule gets bigger (the chain is longer). Only the first four or five of the straight-chain hydrocarbons are important in the study of hazardous materials. Few, if any, of the isomers of the alkenes are common.

There are other hydrocarbon compounds that contain multiple bonds, however, discussion here is limited to those compounds containing just one multiple bond in their molecules. This is because the compounds containing just one multiple bond are the most valuable commercially and, therefore, the most common. There is, however, a simple way to recognize when you are dealing with a compound that may contain two double bonds; that is a name in which the Greek prefix "di-" is used. As example would be the compound butadiene. Recognize from the first part of the name ("buta-") that there are four carbon atoms in the chain, and that there is a double bond present (the ending "-ene"), however, just before the -ene ending is the prefix "di-," meaning two. Therefore, recognize that you are dealing with a four-carbon hydrocarbon with two double bonds.

As in the alkanes, it is possible for carbon atoms to align themselves in different orders to form isomers. Not only is it possible for the carbon atoms to form branches which produce isomers, but it is also possible for the double bond to be situated between different carbon atoms in different compounds. This different position of the double bond also results in different structural formulas, which, of course, are isomers. Just as in the alkanes, isomers of the alkenes have different properties. The unsaturated hydrocarbons and their derivatives are more active chemically than the saturated hydrocarbons and their derivatives.

Table 2. Typical properties of alkenes.

Compound	Formula	Molecular Weight	Melting Point (°F)	Boiling Point (°F)	Flash Point (°F)	Ignition Temperature (°F)
Ethylene	C_2H_4	28	-272.2	-155.0	gas	1,009
Propylene	C_3H_6	42	-301.4	-53.9	gas	927
1-Butene	C_4H_8	56	-300.0	21.7	gas	700
2-Butene	C_4H_8	56	-218.2	38.7	gas	615
1-Pentene	C_5H_{10}	70	-265.0	86.0	32	523
2-Pentene	C_5H_{10}	70	-292.0	98.6	32	NA
1-Hexene	C_6H_{12}	84	-219.6	146.4	-15	487
2-Hexene	C_6H_{12}	84	-230.8	154.4	-5	473
1-Heptene	C_7H_{14}	98	-119.2	199.9	28	500
1-Octene	C_8H_{16}	112	-152.3	250.3	70	446

NA= Not Applicable

Alkynes

Another analogous series of unsaturated hydrocarbons that contain just one multiple bond, but, instead of being a double bond, it is a triple bond is the alkynes. The names of all the compounds end in -yne. The only compound in this series that is at all common happens to be an extremely hazardous material. It is a highly unstable (to heat, shock, and pressure), highly flammable gas that is the first compound in the series. This two-carbon unsaturated hydrocarbon with a triple bond between its two carbon atoms is called ethyne, and indeed this is its proper name. It is, however, known by its common name, acetylene. The -ene ending could be confusing, so one must memorize the fact that acetylene is an alkyne rather than an alkene. Its molecular formula is C_2H_2. The fact that it contains this triple bond makes it extremely active chemically, that is what is meant by its instability to heat, shock, and pressure. It takes energy to start a chemical reaction, and heat, shock, and pressure are forms of energy. The fact that the triple bond contains so much energy tied up in the structure means that it will release this energy, which is the input of some slight amount of external energy. When this input energy strikes the molecule of acetylene, the triple bond breaks, releasing the internal energy of the bonds. This produces either great amounts of heat or an explosion, depending on the way in which the external energy was applied.

There are no other alkynes that are of commercial importance, and so acetylene will be the only member of this series that is considered in fire discussions. There are other alkynes, however, along with hydrocarbons that might have one double bond and a triple bond present in the molecule.

Straight-Chain Hydrocarbon Nomenclature

The system for naming the straight-chain hydrocarbons is based on an agreed-upon method of retaining the first three or four common names, then using Greek prefixes that indicate the number of carbon atoms in the chain. For isomers, the same system is used, always using the name of the compound that is attached to the chain and the name of the chain.

Recall the first analogous series of hydrocarbons the alkanes, a series of saturated hydrocarbons, all ending in -ane. For these hydrocarbons and other hydrocarbons to react, a place on the hydrocarbon chain must exist for the reaction to take place. Since all the bonds from carbon to hydrogen are already used, an "opening" on one of the carbon atoms must exist for it to be able to react with something else. This "opening" occurs when one of the hydrogen atoms is removed from its bond with a carbon atom, thus causing that carbon to revert back to a condition of instability, with seven electrons in its outer ring, or, as we now state, with one unpaired electron. This one unpaired electron (or half of a covalent bond, or "dangling" bond) wants to react with something, and it will, as soon as another particle which is ready to react is brought near. This chain of carbon atoms (from one carbon to

another to another, and so on) with a hydrogen atom missing is a particle that was once a compound, and its name is a radical.

Radicals are created by energy being applied to them in a chemical reaction or in a fire. Remember that a hydrocarbon compound with at least one hydrogen atom removed is no longer a compound, but a chemical particle known as a radical. Radicals have names of their own; they are derived from the name of the alkane. When a hydrogen atom is removed from the alkane hydrocarbon, the name is changed from -ane to -yl. Therefore, when a hydrogen is removed from the compound methane, the methyl radical is formed. When a hydrogen atom is removed from the compound ethane, the ethyl radical is formed. In the same manner, the propyl radical comes from propane, the butyl radical comes from butane, and so on. Similarily, isobutane will produce the isobutyl radical, and isopentane will produce the isopentyl radical. A list of hydrocarbons and the radicals produced from them when a hydrogen is removed is shown is Table 3. Note that there are only a few radicals from compounds other than the alkanes which are important.

Radicals are referred to as hydrocarbon "backbones". As an example, isobutane is more properly named methyl propane. Another isomer with a different proper name is isopentane, more properly called methyl butane. Neopentane is also named 2,2-dimethyl propane.

Table 3. A listing of common radicals.

Methane	CH_4	Methyl	$-CH_3$
Ethane	C_2H_6	Ethyl	$-C_2H_5$
Propane	C_3H_8	n-Propyl	$-C_3H_7$
		Isopropyl	$-C_3H_7$
Butane	C_4H_{10}	n-Butyl	$-C_4H_9$
Isobutane	C_4H_{10}	Isobutyl	$-C_4H_9$
		sec-Butyl	$-C_4H_9$
		tert-Butyl	$-C_4H_9$
Ethylene	C_2H_4	Vinyl	$-C_2H_3$
Benzene	C_6H_6	Phenyl	$-C_6H_5$

The following is a list of rules for proper nomenclature of the isomers and their derivatives.

1. Find the longest continuous chain and name it as if it were an alkane.
2. Name the side branches in the same manner.
3. Identify the number of the carbon atom on the longest chain to which the branch is attached by counting from the end of the chain nearest to

the branch.

4. If it is possible that there could be any confusion as to which carbon atom is meant, put the number in front of the name of the compound, followed by a dash.
5. If there is more than one branch, you must use the numbers to identify the carbon atom to which they are attached.
6. If the branches are identical, use the prefixes di- for two, tri- for three, tetra- for four, and so on.

In this manner, the four isomers of hexane are named 2-methyl pentane, 3-methyl pentane, 2,2,-dimethyl butane, and 2,3-dimethyl butane.

Aromatic Hydrocarbons

The above discussions have concentrated on hydrocarbons, both saturated and unsaturated, with the unsaturated hydrocarbons containing only one multiple bond. The unsaturated hydrocarbons are the alkenes with one double bond and the alkynes with one triple bond. There are other straight-chain hydrocarbons that are unsaturated containing more than one multiple bond, some with more than one double bond, and some with a mixture of double bonds and triple bonds. The combinations and permutations are endless, but there are only a few of the highly unstable materials.

From a commercial standpoint, there is a large body of hydrocarbons that is very important and hence these are of relevance to first responders to a hazardous-materials incidents. These hydrocarbons are different in that they are not straight-chain hydrocarbons but have a structural formula that can only be called cyclical. The most common and most important hydrocarbon in this group is benzene. It is the first and simplest of the six-carbon cyclical hydrocarbons referred to as aromatic hydrocarbons.

Benzene's molecular formula is C_6H_6, but it does not behave like hexane, hexene, or any of their isomers. One would expect it to be similar to these other six-carbon hydrocarbons in its properties. Table 4 provides a comparison between benzene, hexane and 1-hexene. The table shows that there are major differences between benzene and the straight-chain hydrocarbons of the same carbon content. Hexene's ignition temperature is very near to hexane's. The flash point difference is not great, however, there are significant differences in melting points. The explanation for these differences is structure; which in the case of benzene is a cyclical form with alternating double bonds.

Table 4. Comparison between properties of benzene and of straight-chain hydrocarbons

Compound	Formula	Melting Point (°F)	Boiling Point (°F)	Flash Point (°F)	Ignition Temperature (°F)	Molecular weight
Hexane	C_6H_{14}	-139.5	156.0	-7	500	86
1-Hexene	C_6H_{12}	-219.6	146.4	<-20	487	84
Benzene	C_6H_6	41.9	176.2	12	1,044	78

The alternating double bonds are illustrated in Figure 2A. Initially, it was believed that the alternating double bonds impart very different properties to benzene, however, and the fact is that they do not. The only possible way for the benzene molecule to exist is illustrated in Figure 2B, in which a circle is drawn within the hexagonal structural to show that the electrons that should form a series of alternating double bonds are really spread among all six carbon atoms. It is the only structure possible that would explain the unique properties of benzene. This structural formula suggests resonance; that is, the possibility that the electrons represented by the circle are alternating back and forth between and among the six carbon atoms.

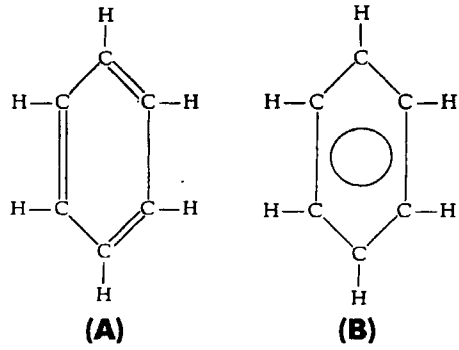


Figure 2. Illustrates the structure of benzene: (A) conventional illustration of double bonds, (B) illustration implying resonance.

This particular hexagonal structure is found throughout nature in many forms, almost always in a more complicated way, usually connected to many other "benzene rings" to form many exotic compounds. Of importance to the immediate discussions are benzene and a few of its derivatives. Benzene's derivatives include toluene and xylene, whose structural formulas are illustrated in Figure 3 along with that of benzene.

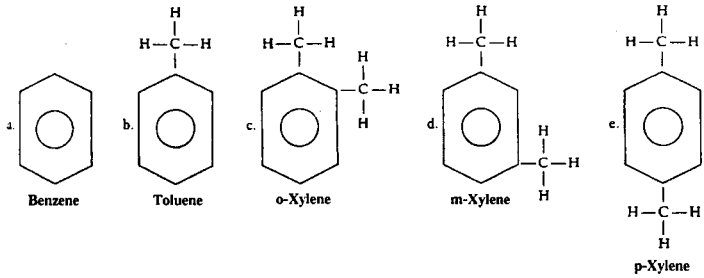


Figure 3. Illustrates the structures of benzene and some of its common derivatives.

Some typical properties are given in Table 5, which illustrates the differences caused by molecular weight and structural formulas. There are other cyclical hydrocarbons, but they do not have the structural formulas of the aromatics, unless they are benzene-based. These cyclical hydrocarbons may have three, four, five, or seven carbons in the cyclical structure, in addition to the six-carbon ring of the aromatics. None of them has the stability or the chemical properties of the aromatics.

Table 5. A comparison of benzene and some of its derivatives.

Compound	Formula	Melting Point (^{O}F)	Boiling Point (^{O}F)	Flash Point (^{O}F)	Ignition Temperature (^{O}F)	Molecular Weight
Benzene	C_6H_6	41.9	176.2	12	1,044	78
Toluene	C_7H_8	-138.1	231.3	40	997	92
o-xylene	C_8H_{10}	-13.0	291.2	90	867	106
m-xylene	C_8H_{10}	-53.3	281.9	81	982	106
p-xylene	C_8H_{10}	-55.8	281.3	81	984	106

The aromatic hydrocarbons are used mainly as solvents and as feedstock chemicals for chemical processes that produce other valuable chemicals. With regard to cyclical hydrocarbons, the aromatic hydrocarbons are the only compounds discussed. These compounds all have the six-carbon benzene ring as a base, but there are also three-, four-, five-, and seven-carbon rings. These materials will be considered as we examine their occurrence as hazardous materials. After the alkanes, the aromatics are the next most common chemicals shipped and used in commerce. The short-chain olefins (alkenes) such as ethylene and propylene may be shipped in larger quantities because of their use as monomers, but for sheer numbers of different compounds, the aromatics will surpass even the alkanes in number, although not in volume.

Hydrocarbon Derivatives

A hydrocarbon derivative is a compound with a hydrocarbon backbone and a functional group attached to it chemically. A hydrocarbon backbone is defined as a molecular fragment that began as a hydrocarbon compound and has had at least one hydrogen atom removed from the molecule. Such a fragment is also known as a radical. A functional group is defined as an atom or a group of atoms, bound together, which impart specific chemical properties to a molecule; also referred to as radicals. A hydrocarbon derivative then is essentially a compound made up of two specific parts; the first part comes from a hydrocarbon, and the second may have many different origins (which includes coming from a hydrocarbon), depending on the chemical makeup of the functional group. The hydrocarbon backbone may come from an alkane, an alkene, an alkyne (indeed, any saturated or unsaturated hydrocarbon), or from an aromatic hydrocarbon or other cyclical hydrocarbon. Any hydrocarbon compound may form the hydrocarbon backbone portion of the hydrocarbon derivative, as long as it has been converted to a radical, by removal of one or more hydrogens, in preparation for the reaction. The functional group may have many origins, with chemists using as reactants any chemical compound that will produce the desired functional group. The functional groups include the halogens (fluorine, chlorine, bromine, and iodine), the hydroxyl radical, the carbonyl group, oxygen, the carboxyl group, the peroxide radical, the amine radical, and even other hydrocarbon radicals. When these functional groups are chemically attached to hydrocarbon backbones, they form compounds called hydrocarbon derivatives, and each functional group imparts a separate set of chemical and physical properties to the molecule formed by this chemical attachment.

Just as the alkanes and alkenes had general formulas, the carbon derivatives all have general formulas. The hydrocarbon backbone provides a portion of the general formula, and the functional group provides the other part. In each case, the hydrocarbon derivative is represented by the formula R-, and the hydrocarbon backbone has its own specific formula. The term "substituted hydrocarbon" is another name for hydrocarbon derivative, because the functional group is substituted for one or more hydrogen atoms in the chemical reaction.

Halogenated Hydrocarbons

A halogenated hydrocarbon is defined as a derivative of a hydrocarbon in which a hydrogen atom is replaced by a halogen atom. Since all of the halogens react similarly, and the number of hydrocarbons (including all saturated hydrocarbons, unsaturated hydrocarbons, aromatic hydrocarbons, other cyclical hydrocarbons, and all the isomers of these hydrocarbons) is large, the number of halogenated hydrocarbons can also be very large. The most common hydrocarbon derivatives are those of the first four alkanes and the first three alkenes (and, of course, the isomers of these hydrocarbons).

There are some aromatic hydrocarbon derivatives, but, again, they are of the simplest structure. Whatever the hydrocarbon backbone is, it is represented in the general formula by its formula, which is R-. Therefore, the halogenated hydrocarbons will have formulas such as R-F, R-Cl, R-Br, and R-I for the respective substitution of fluorine, chlorine, bromine, and iodine on to the hydrocarbon backbone. As a rule, the general formula can be written R-X, with the R as the hydrocarbon backbone, the X standing for the halide (any of the halogens), and the "-" the covalent bond between the hydrocarbon backbone and the halogen. R-X is read as "alkyl halide".

Radicals of the alkanes are referred to as alkyl radicals. There are two other important radicals; they are the vinyl radical, which is produced when a hydrogen atom is removed from ethylene, and the phenyl radical, which results when a hydrogen atom is removed from benzene. The term halogenated means that a halogen atom has been substituted for a hydrogen atom in a hydrocarbon molecule. The most common halogenated hydrocarbons are the chlorinated hydrocarbons. The simplest chlorinated hydrocarbon is methyl chloride, whose molecular formula is CH_3Cl. The structural formula for methyl chloride shows that one chlorine atom is substituted for one hydrogen atom. Methyl chloride has many uses, such as a herbicide, as a topical anesthetic, extractant, and low-temperature solvent, and as a catalyst carrier in low-temperature polymerization. It is a colorless gas that is easily liquified and is flammable; it is also toxic in high concentrations. Methyl chloride is the common name for this compound, while its proper name is chloromethane. Proper names are determined by the longest carbon chain in the molecule, and the corresponding hydrocarbon's name is used as the last name of the compound. Any substituted groups are named first, and a number is used to designate the carbon atom that the functional group is attached to, if applicable.

It is possible to substitute more than one chlorine atom for a hydrogen atom on a hydrocarbon molecule; such substitution is done only when the resulting compound is commercially valuable or is valuable in another chemical process. An example is methylene chloride (the common name for dichloromethane), which is made by substituting two chlorine atoms for two hydrogen atoms on the methane molecule. Its molecular formula is CH_2Cl_2. Methylene chloride is a colorless, volatile liquid with a sharp, ether-like odor. It is listed as a non-flammable liquid, but it will ignite at 1,224°F; it is narcotic at high concentrations. It is most commonly used as a stripper of paints and other finishes. It is also a good degreaser and solvent extractor and is used in some plastics processing applications.

Substituting a third chlorine on the methane molecule results in the compound whose proper name is trichloromethane (tri- for three; chloro- for chlorine; and methane, the hydrocarbon's name for the one-carbon chain). It is more commonly known as chloroform. Its molecular formula is $CHCl_3$. Chloroform is a heavy, colorless, volatile liquid with a sweet taste and characteristic odor. It is classified as non-flammable, but it will burn if

exposed to high temperatures for long periods of time. It is narcotic by inhalation and toxic in high concentrations. It is an insecticide and a fumigant and is very useful in the manufacture of refrigerants.

The total chlorination of methane results in a compound whose proper name is tetrachloromethane (tetra- for four), but its common name is carbon tetrachloride (or carbon tet). This is a fire-extinguishing agent that is no longer used since it has been classified as a carcinogen. It is still present, though, and its uses include refrigerants, metal degreasing, and chlorination of organic compounds. Its molecular formula is CCl_4. It is possible to form analogues of methyl chloride, (methyl fluoride, methyl bromide, methyl iodide), methylene chloride (substitute fluoride, bromide, and iodide in this name also), chloroform (fluoroform, bromoform, and iodoform), and carbon tetrachloride (tetrafluoride, tetrabromide, and tetraiodide). Each of these halogenated hydrocarbons has some commercial value.

What was true for one hydrocarbon compound is true for most hydrocarbon compounds, particularly straight-chain hydrocarbons; that is, you may substitute a functional group at each of the bonds where a hydrogen atom is now connected to the carbon atom. Where four hydrogen atoms exist in methane, there are six hydrogen atoms in ethane; you recall that the difference in make-up from one compound to the next in an analogous series is the "unit" made up of one carbon and two hydrogens. Therefore, it is possible to substitute six functional groups on to the ethane molecule. You should also be aware that the functional groups that would be substituted for the hydrogens need not be the same, that is, you may substitute chlorine at one bond, fluorine at another, the hydroxyl radical at a third, an amine radical at a fourth, and so on.

Substituting one chlorine atom for a hydrogen atom in ethane produces ethyl chloride, a colorless, easily liquifiable gas with an ether-like odor and a burning taste, which is highly flammable and moderately toxic in high concentrations. It is used to make tetraethyl lead and other organic chemicals. Ethyl chloride is an excellent solvent and analytical reagent, as well as an anesthetic. Its molecular formula is C_2H_5Cl.

Although we are using chlorine as the functional group, it may be any of the other halogens. In addition, we are giving the common names, while the proper names may be used on the labels and shipping papers. Ethyl chloride's proper name is chloroethane.

Substituting another chlorine produces ethylene dichloride (proper name 1,2-dichloroethane). In this case, an isomer is possible, which would be the chlorinated hydrocarbon where both chlorines attached themselves to the same carbon atom, whereby 1,1-dichloroethane is formed. These compounds have slightly different properties and different demands in the marketplace. As further chlorination of ethane occurs, we would have to use the proper name to designate which compound is being made. One of the

analogues of ethylene dichloride is ethylene dibromide, a toxic material that is most efficient and popular as a grain fumigant, but it is known to be a carcinogen in test animals.

There are many uses for the halogenated hydrocarbons. Many of them are flammable; most are combustible. Some halogenated hydrocarbons are classified as neither, and a few are excellent fire-extinguishing agents (the Halons ®), but they will all decompose into smaller, more harmful molecular fragments when exposed to high temperatures for long periods of time.

ALCOHOLS

The compounds formed when a hydroxyl group (-OH) is substituted for a hydrogen are called alcohols. They have the general formula R-OH. The hydroxyl radical looks exactly like the hydroxide ion, but it is not an ion. Where the hydroxide ion fits the definition of a complex ion - a chemical combination of two or more atoms that have collectively lost or (as in this case) gained one or more electrons - the hydroxide radical is a molecular fragment produced by separating the -OH from another compound, and it has no electrical charge. It does have an unpaired electron waiting to pair up with another particle having its own unpaired electron. The alcohols, as a group, are flammable liquids in the short-chain range, combustible liquids as the chain grows longer, and finally solids that will burn if exposed to high temperatures, as the chain continues to become longer. As in the case of the halogenated hydrocarbons, the most useful alcohol compounds are of the short-carbon-chain variety. Just as in the case of the halogenated hydrocarbons, the simplest alcohol is made from the simplest hydrocarbon, methane. Its name is methyl alcohol and its molecular formula is CH_3OH.

Nature produces a tremendous amount of methyl alcohol, simply by the fermentation of wood, grass, and other materials made to some degree of cellulose. In fact, methyl alcohol is known as wood alcohol, along with names such as wood spirits and methanol (its proper name; the proper names of all alcohols end in -ol). Methyl alcohol is a colorless liquid with a characteristic alcohol odor. It has a flash point of 54°F, and is highly toxic. It has too many commercial uses to list here, but among them are as a denaturant for ethyl alcohol (the addition of the toxic chemical methyl alcohol to ethyl alcohol in order to form denatured alcohol), antifreezes, gasoline additives, and solvents. No further substitution of hydroxyl radicals is performed on methyl alcohol.

The most widely known alcohol is ethyl alcohol, simply because it is the alcohol in alcoholic drinks. It is also known as grain alcohol, or by its proper name, ethanol. Ethyl alcohol is a colorless, volatile liquid with a characteristic odor and a pungent taste. It has a flash point of 55°F, is classified as a depressant drug, and is toxic when ingested in large quantities. Its molecular formula is C_2H_5OH. In addition to its presence in alcoholic

beverages, ethyl alcohol has many industrial and medical uses, such as a solvent in many manufacturing processes, as antifreeze, antiseptics, and cosmetics.

The substitution of one hydroxyl radical for a hydrogen atom in propane produces propyl alcohol, or propanol, which has several uses. Its molecular formula is C_3H_7OH. Propyl alcohol has a flash point of 77°F and, like all the alcohols, burns with a pale blue flame. More commonly known is the isomer of propyl alcohol, isopropyl alcohol. Since it is an isomer, it has the same molecular formula as propyl alcohol but a different structural formula. Isopropyl alcohol has a flash point of 53°F. Its ignition temperature is 850°F, while propyl alcohol's ignition temperature is 700°F, another effect of the different structure. Isopropyl alcohol, or 2-propanol (its proper name) is used in the manufacture of many different chemicals, but is best known as rubbing alcohol.

The above-mentioned alcohols are by far the most common. Butyl alcohol is not as commonly used as the first four in the series, but it is used. Secondary butyl alcohol and tertiary butyl alcohol, so named because of the type of carbon atom in the molecule to which the hydroxyl radical is attached, must be mentioned because they are flammable liquids, while isobutyl alcohol has a flash point of 100°F. All of the alcohols of the first four carbon atoms in the alkanes, therefore, are extremely hazardous because of their combustion characteristics.

Whenever a hydrocarbon backbone has two hydroxyl radicals attached to it, it becomes a special type of alcohol known as a glycol. The simplest of the glycols, and the most important, is ethylene glycol, whose molecular formula $C_2H_4(OH)_2$. The molecular formula can also be written CH_2OHCH_2OH and may be printed as such on some labels. Ethylene glycol is a colorless, thick liquid with a sweet taste, is toxic by ingestion and by inhalation, and among its many uses is a permanent antifreeze and coolant for automobiles. It is a combustible liquid with a flash point of 240°F.

The only other glycol that is fairly common is propylene glycol which has a molecular formula of $C_3H_6(OH)_2$. It is a combustible liquid with a flash point of 210°F, and its major use is in organic synthesis, particularly of polyester resins and cellophane.

The last group of substituted hydrocarbons produced by adding hydroxyl radicals to the hydrocarbon backbone are the compounds made when three hydroxyl radicals are substituted; these are known as glycerols. The name of the simplest of this type of compound is just glycerol. Its molecular formula is $C_3H_5(OH)_3$. Glycerol is a colorless, thick, syrupy liquid with a sweet taste, and has a flash point of 320°F, and is used to make such diverse products as candy and explosives, plus many more. Other glycerols are made, but most of them are not classified as hazardous materials.

ETHERS

The ethers are a group of compounds with the general formula R-O-R'. The R, of course, stands for any hydrocarbon backbone, and the R' also stands for any hydrocarbon backbone, but the designation R' is used to indicate that the second hydrocarbon backbone may be different from the first. In other words, both the hydrocarbon backbones in the formula may be the same, but the "'" is used to indicate that it may also be different. R-O-R as the general formula for the ethers is also correct. The fact that there are two hydrocarbon backbones on either side of an oxygen atom means that there will be two hydrocarbon names used.

The simplest of the ethers would be ether that has the simplest hydrocarbon backbones attached; those backbones are the radicals of the simplest hydrocarbon, methane. Therefore, the simplest of the ethers is dimethyl ether, whose formula is CH_3OCH_3. Dimethyl is used because there are two methyl radicals, and "di-" is the prefix for two. This compound could also be called methyl methyl ether, or just plain methyl ether, but it is better known as dimethyl ether. It is an easily liquified gas that is extremely flammable, has a relatively low ignition temperature of 66°F, and is used as a solvent, a refrigerant, a propellant for sprays, and a polymerization stabilizer.

The next simplest ether is the ether with the simplest alkane as one of the hydrocarbon backbones and the next alkane, which is methyl ethyl ether. Its molecular formula is $CH_3OC_2H_5$. It is a colorless gas with the characteristic ether odor. It has a flash point of 31°F, and an ignition temperature of only 374° F. This property, of course, makes it an extreme fire and explosion hazard.

The next simplest ether is actually the one most commonly referred to as "ether". It is diethyl ether, whose molecular formula is $C_2H_5OC_2H_5$, sometimes written as $(C_2H_5)_2O$. This ether is the compound that was widely used as an anesthetic in many hospitals. One of the hazards of all ethers, and particularly diethyl ether because of its widespread use, is that once ethers have been exposed to air, they possess the unique capability of adding an oxygen atom to their structure and converting to a dangerously unstable and explosive organic peroxide. The peroxide-forming hazard aside, diethyl ether has a flash point of -56°F and ignition temperature of 356 °F; it is a colorless, volatile liquid with the characteristic ether odor. In addition to its use as an anesthetic, it is useful in the synthesis of many other chemicals, but it is an extremely hazardous material.

Another important ether is vinyl ether, a colorless liquid with the characteristic ether odor. Its molecular formula is $C_2H_3OC_2H_3$. Vinyl ether has a flash point of -22° F and an ignition temperature of 680° F. It is highly toxic by inhalation and is used in medicine and in the polymerization of certain plastics.

KETONES

The ketones are a group of compounds with the general formula R-C-R'. The -C- functional group is known as the carbonyl group or carbonyl radical; it appears in many different classes of hydrocarbon derivatives. There are only a few important ketones, and they are all extremely hazardous.

The first is the simplest, again with two methyl radicals, one on either side of the carbonyl group. Its molecular formula is CH_3COCH_3. Its proper name is propanone (propa- because of the relationship to the three-carbon alkane, propane, and -one because it is a ketone); it could logically be called dimethyl ketone, but it is universally known by its common name, acetone. Acetone is a colorless, volatile liquid with a sweet odor, has a flash point of 15° F and an ignition temperature of 1,000° F, is narcotic in high concentrations, and could be fatal by inhalation or ingestion. It is widely used in manufacturing many chemicals and is extremely popular as a solvent.

The next most common ketone is methyl ethyl ketone, commonly referred to as MEK. Its molecular formula is $CH_3COC_2H_5$. MEK has a flash point of 24°F and an ignition temperature of 960° F. It is a colorless liquid with a characteristic ketone odor. It is as widely used as acetone and is almost as hazardous.

ALDEHYDES

The aldehydes are a group of compounds with the general formula R-CHO. The aldehyde functional group is always written -CHO, even though this does not represent the aldehyde's structural formula. It is written in this way so that the aldehydes will not be confused with R-OH, the general formula of the alcohols.

The simplest of the aldehydes is formaldehyde, whose molecular formula is HCHO. The second hydrocarbon backbone of the ketone is replaced by a hydrogen atom. Formaldehyde is a gas that is extremely soluble in water; it is often sold commercially as a 50 percent solution of the gas in water. The gas itself is flammable, has an ignition temperature of 806°F and a strong, pungent odor, and is toxic by inhalation. Inhalation at low concentrations over long periods of time has produced illness in many people. Beside its use as an embalming fluid, formaldehyde is used in the production of many plastics and in the production of numerous other chemicals.

The next aldehyde is acetaldehyde, a colorless liquid with a pungent taste and a fruity odor. Its molecular formula is CH_3CHO. It has a flash point of -40°F, an ignition temperature of 340°F, and is toxic by inhalation. Acetaldehyde is used in the manufacture of many other chemicals. Other important aldehydes are propionaldehyde, butyraldehyde, and acrolein.

PEROXIDES

The peroxides are a group of compounds with the general formula R-O-O-R'. All peroxides are hazardous materials, but the organic peroxides may be the most hazardous of all.

ESTERS

The esters are a group of compounds with the general formula R-C-O-O-R'. They are not generally classified as hazardous materials, except for the acrylates, which are monomers and highly flammable. Few of the rest of the class are flammable. There are some esters that are hazardous.

AMINES

The amines are a group of compounds with the general formula $R\text{-}NH_2$, and all the common amines are hazardous. As a class the amines pose more than one hazard, being flammable, toxic, and, in some cases, corrosive. The amines are an analogous series of compounds and follow the naming pattern of the alkyl halides and the alcohols; that is, the simplest amine is methyl amine, with the molecular formula of CH_3NH_2. Methyl amine is a colorless gas with an ammonia-like odor and an ignition temperature of 806°F. It is a tissue irritant and toxic, and it is used as an intermediate in the manufacture of many chemicals.

Ethyl amine is next in the series, followed by propyl amine, isopropyl amine, butyl amine and its isomers, and so on.

FLAMMABILITY AND PYROLYSIS

Fire, or combustion is a chemical reaction, and specifically it is an oxidation reaction. Oxidation is defined as the chemical combination of oxygen with any substance. In other words, whenever oxygen (and some other materials) combines chemically with a substance, that substance is said to have been oxidized. Rust is an example of oxidized iron. In this case, the chemical reaction is very slow. The very rapid oxidation of a substance is called combustion, or fire.

There are three basic theories that are used to describe the reaction known as fire. They are: the fire triangle, the tetrahedron of fire, and the life cycle of fire. Of the three, the first is the oldest and best known, the second is accepted as more fully explaining the chemistry of fire, while the third is a more detailed version of the fire triangle. Each is briefly described below.

The first of these theories, the fire triangle, is quite simplistic and provides a basic understanding of the three entities that are necessary for a fire. This theory states that there are three things necessary to have a fire: fuel, oxygen (or an oxidizer), and heat (or energy). It likens these three things to the three sides of a triangle, stating that as long as the triangle is not complete, that is, the legs are not touching each other to form the closed or completed triangle, combustion cannot take place. Figure 4 illustrates the fire triangle.

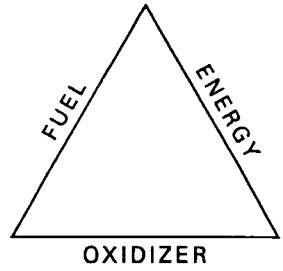


Figure 4. Illustrates the fire triangle theory.

The theory, as stated, is still correct. Without fuel to burn, there can be no fire. If there is no oxygen present, there can be no fire (technically, this is not correct, but we can make the fire triangle theory technically correct by changing the oxygen leg to an oxidizer leg). Finally, without heat, there can be no fire. This last statement must also be brought up to date. The fact is that heat is just one form of energy; it is really energy that is necessary to start a fire. This difference is mentioned because there are some instances where light or some other form of energy may be what is needed to start the combustion reaction. It is best to change the "heat" leg of the fire triangle to the "energy" leg. Therefore, our "updated" fire triangle now has three sides representing fuel, oxidizer, and energy.

A fuel may be defined as anything that will burn. It is important for you to grasp this definition, because most firefighters consider only flammable gases and liquids as fuels. Many others include wood, and coal as fuels, because we all recognize that they will burn, but we also tend to forget the metals, which under many circumstances are more hazardous than almost any other type of fuel. Fuels may be categorized into the following classes:

1. Elements (which include the metals, and some non-metals such as carbon, sulphur, and phosphorus)

2. Hydrocarbons

3. Carbohydrates (including mixtures that are made up partially of cellulose, like wood and paper)

4. Many covalently bonded gases (including carbon monoxide, ammonia, and hydrogen cyanide)

5. All other organic compounds

This list of materials that burn is quite long, and one must not forget that the list includes not only the pure substances such as the elements and compounds that make up the list, but mixtures of those elements and compounds. Examples of mixtures would include natural gas, which is a mixture of methane (principally), ethane, and a few other compounds, and gasoline, which is a mixture of the first six liquid alkanes (pentane, hexane, heptane, octane, nonane, and decane), plus a few other compounds. Wood (another mixture), and wood-related products, like paper, are excellent fuels, as are many polymers such as rubber, plastics, wool, silk, and the above-mentioned cellulose, which makes wood and paper the excellent fuels that they are.

The second leg of the fire triangle is oxygen, or the oxidizer leg. We changed this because oxygen, although it is the most common oxidizing agent encountered, is not the only oxidizer. Another problem with calling this second leg the oxygen leg is that most firefighters consider only oxygen from the atmosphere when they think of oxygen, and do not consider other sources. Since the greatest source of oxygen is the atmosphere, however, this has to be considered the source that must be eliminated as one of the ways to control a fire. Whatever the source, note that oxygen does not burn.

The third leg of the fire triangle is what was once called the heat leg but we have updated to call it the energy leg, so as to consider all forms capable of providing the source of energy needed to start the combustion process. This energy can be provided in one or more of several ways. The energy can be generated chemically by the combustion of some other fuel, or it can be generated by some other exothermic chemical reaction. Exothermic is defined as the emission or liberation of heat (or energy). This is the opposite of endothermic, which is defined as the taking-in or absorption of heat (or energy).

Energy may also be generated by mechanical action; that is, the application of physical force by one body upon another. Examples of this are the energy created by the friction of one matter upon another or the compression of a gas.The force of friction in one case may produce energy that manifests itself as heat, while friction in the other case may result in a discharge of static electricity. Static electricity is created whenever molecules move over and past other molecules. This happens whether the moving molecules are in the form of a gas, a liquid, or a solid. (This is the reason why leaking natural gas under high pressure will ignite. This is also the reason why two containers must be bonded - connected by an electrical conductor - when you are pouring flammable liquids from one container to another. In any case, the amount of energy present and/or released could be

more than enough to start the combustion reaction.)

A third method of generation of energy is electrical - much like the discharge of static electricity. This method may manifest itself as heat, as produced in an electrical heater, as arcing in an electrical motor or in a "short" circuit, or as the tremendous amount of energy released as lightning.

The fourth method of generation of energy is nuclear. Nuclear energy may be generated by the fission (splitting) of the atoms of certain elements and by the fusion (or joining together) of the nuclei of certain elements.

Once the energy - in many cases, heat - is generated, it must be transmitted to the fuel (the "touching" of the fuel and energy legs). This process is accomplished in three ways: conduction (the transfer of heat through a medium, such as a pan on a stove's heating element), convection (the transfer of heat with a medium, such as the heated air in a hot-air furnace), and radiation (the transfer of heat which is not dependent on any medium).

These three entities (fuel, oxidizer, an energy) make up the three legs of the fire triangle. It is a physical fact, a law of nature that cannot be repealed, that when fuel, oxidizers, and energy are brought together in the proper amounts, a fire will occur. If the three are brought together slowly, and over a long period of time, the oxidation will occur slowly, as in the rusting of iron. If the three are of a particular combination, the resulting oxidation reaction might even be an explosion. Whatever form the final release of energy takes, the thing that cannot be changed is that the chemical reaction will occur.

The second popular explanation of fire is the tetrahedron theory which is illustrated in Figure 5. This theory encompasses the three concepts in the fire triangle theory but adds a fourth "side" to the triangle, making it a pyramid, or tetrahedron; this fourth side is called the "chain reaction of burning". This theory states that when energy is applied to a fuel like a hydrocarbon, some of the carbon-to-carbon bonds break, leaving an unpaired electron attached to one of the molecular fragments caused by the cleavage of the bond, thus creating a free radical. This molecular fragment with the unpaired electron, or "dangling" bond, is highly reactive and will therefore seek out some other material to react with in order to satisfy the octet rule. The same energy source that provided the necessary energy to break the carbon-to-carbon bond may have also broken some carbon-to- hydrogen bonds, creating more free radicals, and also broken some oxygen-to-oxygen bonds, creating oxide radicals. This mass breaking of bonds creates the free radicals in a particular space, and in a number large enough to be near each other, so as to facilitate the recombining of these free radicals with whatever other radicals or functional groups may be nearby. The breaking of these bonds releases the energy stored in them, so that this subsequent release of energy becomes the energy source for still more bond breakage, which in

turn releases more energy. Thus the fire "feeds" upon itself by continuously creating and releasing more and more energy (the chain reaction), until one of several things happens: either the fuel is consumed, the oxygen is depleted, the energy is absorbed by something other than the fuel, or this chain reaction is broken. Thus a fire usually begins as a very small amount of bond breakage by a relatively small energy (ignition) source and builds itself up higher and higher, until it becomes a raging inferno, limited only by the fuel present (a fuel-regulated fire) or the influx of oxygen (an oxygen-regulated fire). The earlier in the process that the reaction can be interrupted, the easier the extinguishment of the fire will be. This theory claims that the propagation of all hydrocarbon fires (or fires involving hydrocarbon derivatives) depends upon the formation of the hydroxyl (-OH) radical, which is found in great quantities in all such fires.

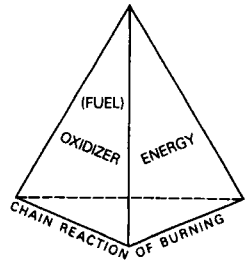


Figure 5. Illustrates the theory of the fire tetrahedron.

The third theory of fire is the life cycle theory, which is illustrated in Figure 6. According to this theory, the combustion process can be categorized by six steps, rather than the three of the fire triangle or the four of the tetrahedron of fire theory. Three of the steps in this theory are the same as the only three steps in the fire triangle theory.

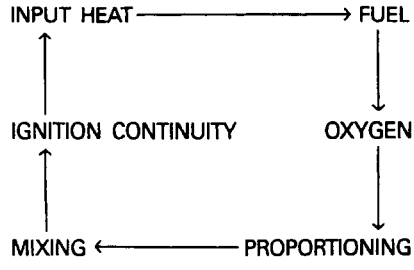


Figure 6. Illustrates the life cycle theory of fire.

In the life cycle of fire theory, the first step is the input heat, which is defined as the amount of heat required to produce the evolution of vapors from the solid or liquid. The input heat will also be the ignition source and

must be high enough to reach the ignition temperature of the fuel; it must be continuing and self-generating and must heat enough of the fuel to produce the vapors necessary to form an ignitable mixture with the air near the source of the fuel. The second part of the life cycle of fire theory is the fuel, essentially the same as the fuel in the tetrahedron of fire and the fire triangle. It was assumed without so stating in the fire triangle theory, and is true in all three theories, that the fuel must be in the proper form to burn; that is, it must have vaporized, or, in the case of a metal, almost the entire piece must be raised to the proper temperature before it will begin to burn. The third part is oxygen in which the classical explanation of this theory only concerns itself with atmospheric oxygen, because the theory centers around the diffusion flame, which is the flame produced by a spontaneous mixture (as opposed to a pre-mixed mixture) of fuel gases or vapors and air. This theory concerns itself with air-regulated fires, so airflow is crucial to the theory; this is why only atmospheric oxygen is discussed. Ignoring oxygen and the halogens that are generated from oxidizing agents should be viewed as a flaw in this theory. The fourth part of the theory is proportioning, or the occurrence of intermolecular collisions between oxygen and the hydrocarbon molecule (the "touching" together of the oxidizer leg and the fuel leg of the fire triangle). The speed of the molecules and the number of collisions depend on the heat of the mixture of oxygen and fuel; the hotter the mixture, the higher the speed. A rule of thumb is used in chemistry that states the speed of any chemical reaction doubles for roughly every 18°F (10°C.) rise in temperature. The fifth step is mixing; that is, the ratio of fuel to oxygen must be right before ignition can occur (flammable range). Proper mixing after heat has been applied to the fuel to produce the vapors needed to burn is the reason for the "backdraft" explosion that occurs when a fresh supply of air is admitted to a room where a fire has been smoldering. The sixth step is ignition continuity, which is provided by the heat being radiated from the flame back to the surface of the fuel; this heat must be high enough to act as the input heat for the continuing cycle of fire. In a fire, chemical energy is converted to heat; if this heat is converted at a rate faster than the rate of heat loss from the fire, the heat of the fire increases; therefore, the reaction will proceed faster, producing more heat faster than it can be carried away from the fire, thus increasing the rate of reaction even more. When the rate of conversion of chemical energy falls below the rate of dissipation, the fire goes out. That is to say, the sixth step, ignition continuity, is also the first step of the next cycle, the input heat. If the rate of generation of heat is such that there is not enough energy to raise or maintain the heat of the reaction, the cycle will be broken, and the fire will go out. The life cycle of fire theory adds the concepts of flash point and ignition point (heat input) and flammable range (mixing). These terms are discussed at greater length later in this chapter.

CATEGORIES OF PETROLEUM LIQUIDS

Hydrocarbons are derivatives from petroleum or crude, but within the context of our immediate discussions, we shall use the terms petroleum liquids and hydrocarbon liquids as being interchangeable. From a fire standpoint, there are only two categories of petroleum liquids, namely *flammable liquids* and *combustible liquids*. Both categories of materials will burn; however, it is into which of these two categories that a liquid belongs that determines its relative fire hazard. Of the two categories, it is the flammables that are considered to be more hazardous, principally because they release ignitable vapors at lower temperatures (a concept consistent with the life cycle theory of fire).

Fire hazard is viewed from the standpoint of safety, to which in the United States, the Occupational Safety and Health Standard (OSH) is often used as the basis for classification of flammables versus a combustible material. Additionally, the U.S. Department of Transportation also has very specific definitions regarding classification of fire hazards based on safe transport of materials. For initial discussions we will adhere to the OSHA definitions, and later refer to distinctions in U.S. federal definitions which are legal standards.

For flammable liquids, the OSHA standard defines a flammable material based upon the liquid's flash point temperature. Any liquid having a flash point below 100°F is classified as being flammable. The definition for flammable liquids given by the National Fire protection Association (NFPA) includes the additional criteria that the liquid's vapor cannot exceed 40 psi at a liquid temperature of 100°F. From a practical standpoint, these criteria refer simply to the fact that any material with a flash point temperature of 100°F or less is capable of releasing vapors at a rate sufficient to be ignitable, and hence represents the greatest danger from a fire standpoint due to the possibility of spontaneous combustion. It is important to note that there are many materials that are capable of vaporizing at extremely low temperatures. A common example is gasoline whose flash point is -40°F.

The combustible liquid category are thus those liquids whose flash points are above 100°F. The category for petroleum liquids covers a range from the 100°F flash point of kerosene to the flash point of 450°F of some motor oils. Although these materials are less hazardous than flammable liquids, they still represent fire hazards and under certain conditions are as dangerous as flammables. Some typical examples of the two categories of fire hazards for petroleum liquids are given in Table 6.

Table 6. Common examples of flammable and combustible petroleum liquids.

Flammables	Flash Point, °F	Combustible	Flash Point, °F
Gasoline	-40	Kerosene	100
Ethers	-30	Fuel oils	100-140
Acetone	-4	Diesel oil	130
Methanol	52	Lubricating oil	300
Crude Oil and Naphtha	20-90	Asphalt	400

The term flash point is sometimes confusing and its definition should be carefully considered. The term basically refers to the temperature that a liquid must be at before it will provide the fuel in vapor form necessary for the condition of spontaneous combustion to occur. Perhaps more accurate a definition is that it refers to the lowest temperature a liquid may be and still have the ability to liberate flammable vapor at a sufficient rate that, when mixed with the proper amounts of air, the air-fuel mixture will flash in the presence of a source of energy or ignition source. This provides a more pragmatic viewpoint on how fires occur. In essence, when a material liberates vapor, this vapor represents fuel. When it combines with oxygen in air in the proper amounts, we now have a flammable mixture, and hence all that is needed to complete the fire triangle is a source of energy. In essence then, it is the vapor (air-fuel mixture) that burns, and not the material itself. It, therefore, stands to reason that, assuming sufficient amounts of air to be present, the greater the volume of released vapor, the larger and more intense will be the fire.

Another term that is often given attention to is the fire point. The fire point temperature refers to the temperature which the liquid must be at before released vapor is in sufficient quantity to continue to burn. With the flash point temperature, the amounts of vapor being released at the exact flash point temperature will not sustain the fire and, after flashing across the liquid surface, the flame extinguishes. For many materials the fire point is only a few degrees above the flash point, but regardless, the flash point is perhaps the more universally accepted basis of classifying a fire hazard largely because a flash fire will generally be sufficient to ignite combustible materials.

Both the terms flash point and fire point (or also known as the ignition point) are discussed in greater detail later in this chapter.

FIRE EXTINGUISHMENT

Fire is an exothermic (heat-liberating) reaction. There must be a continuous feedback of energy (heat) to keep the reaction going. Also, heat

is dissipated from the fire by one or more of the methods of transferring heat: conduction, convection, and radiation. Heat energy is also fed back to the fire by radiation from the flame, and this source of heat keeps the fire going. If we could devise a way to interrupt that feedback of heat to the fuel, the continuity of the fire would be broken, and the fire would go out. Hence, a fire-extinguishing agent is needed that siphons heat energy away from the fire, reduces the temperature of the material burning, and cools the surroundings below the ignition temperature of the fuel, so that there would not be a re-ignition of flammable vapors once the fire was extinguished.

Water is the most common extinguishing agent that performs this task. Water has many disadvantages, however. Some of the drawbacks to the use of water as an extinguishing agent include its propensity to conduct electricity (which, of course, is deadly if the water is applied incorrectly), its low viscosity (which allows it to run off a wall instead of sticking there), and a high surface tension (which prevents it from penetrating tightly arranged materials). Water also allows heat to be radiated through it, freezes at a relatively high temperature, splashes about, and displaces many flammable liquids, causing them to spread rapidly, while burning all the time. This list of problems also includes the fact that water itself will violently react with many of the hazardous materials it is supposed to control.

In addition to the fact that water is relatively inexpensive and is usually available in large quantities, there are two specific properties of water that make it invaluable. Those properties are its latent heat of vaporization and its specific heat. The latent heat of vaporization of a substance is defined as the amount of heat a material must absorb when it changes from a liquid to a vapor or gas. The specific heat of a substance is defined as the ratio between the amount of heat necessary to raise the temperature of a substance and the amount of heat necessary to raise the same weight of water by the same number of degrees.

The specific heat of water is important because it is so high in relation to the specific heat of other materials; this fact means that it takes more energy to raise the temperature of water than just about any other material. Therefore, the temperature of the materials to which water has been applied will drop faster than the temperature of water will rise. The specific heat may be reported as the number of calories needed to raise the temperature of one gram of the material 1°C, or the number of British Thermal Units (BTUs) needed to raise one pound of the material, 1°F. Therefore, when water is applied to a fire, it begins absorbing heat from the fire, thereby cooling the fire down while the water heats up. For every BTU absorbed, the temperature of the water will rise 1°F per pound of water involved. The important thing to remember here is that the rise in temperature of the water is caused by heat energy absorbed from the fire. The water is siphoning the heat away from the burning material. The temperature of the water will continue to rise, as long as the fire is producing heat, until it reaches its

boiling point of 212°F. At this time the latent heat of vaporization of water comes into play. At 212°F the water is still a liquid and will remain a liquid unless more energy is received from the fire. At this time, there is a phase change from liquid to vapor, with no increase in temperature; that is, water as a liquid at 212°F converts to water vapor at 212°F. It is at this phase change that the latent heat of vaporization of water does its work, for while water will absorb 1 BTU per pound for every increase of 1°F, up to 212°F, at 212°F when the phase change occurs, 970 BTUs are absorbed per pound. That sudden, rapid, and massive withdrawal of heat energy from the fire at this time is what gives water its tremendous fire-extinguishing capabilities, which are so valuable as to overcome the previously mentioned disadvantages. Heat is withdrawn from the burning material so rapidly, and in such large quantities, that the temperature of the burning fuel drops dramatically, usually well below its ignition temperature. When this happens, of course, the fire goes out. The latent heat of vaporization also explains why steam at 212°F is hotter than boiling water at 212°F. The live steam has 970 BTU's of energy more than the boiling water.

This latent heat of vaporization also explains why materials wet with water are difficult, and sometimes impossible, to ignite. If a combustible substance has absorbed enough water to be considered wet, or just damp, this water will act as a barrier to ignition by its evaporation as it is heated. As heat is applied to the wet substance, the water begins to evaporate (go through the phase change from a liquid to a vapor). To make this phase change, the water must absorb 1 BTU for every pound of water present for every 1°F it rises until it reaches 212°F, whereupon it must absorb 970 BTUs for every pound of water present. Before any combustible material that has been wet with water can burn, the water (which has preferentially been absorbing the applied heat and thus keeping the combustible material itself from heating to its ignition temperature) must be driven off. If in the process of driving off the water enough heat energy from the potential ignition source has been used up so that there is not enough left (for example a burnt-out match) to raise the combustible to its ignition temperature, there will be no fire.

Water, of course, does not work with all materials. There is a special class of materials that are water reactive, and hence water becomes an unacceptable extinguishing agent. For these class of materials another approach to eliminating the fire is taken. Specifically, we must remove the oxidizer leg from the fire triangle; i.e. cut off the supply of oxygen which fuels the air to fuel mixture.

FLAMMABILITY OF PETROLEUM PRODUCTS

The following discussions are limited to petroleum liquids. From a fire standpoint, the two main categories of petroleum liquids are flammable and combustible, and are determined mainly by the liquid's flash point. Both

categories of liquids will burn but it is into which of these two categories the liquid belongs that determines its relative fire hazard. As already noted, flammable liquids are generally considered the more hazardous of the two categories mainly because they release ignitable vapors.

Following OSHA definitions, a flammable material is any liquid having a flash point below 100°F. The NFPA expands this definition by including the stipulation that the vapor cannot exceed 40 psi (pounds per square inch) at a liquid temperature of 100°F, with the theory being that such liquids are capable of releasing vapor at a rate sufficient to be ignitable. Since this aspect of the definition relating to vapor pressure has little fire-ground application it is often ignored. However, it is important to note that if the heat from a fire raises the liquid temperature to a temperature above the liquid's flash point, it will automatically increase the vapor pressure inside a closed container. Any other source of sufficient heat will produce the same result.

Within the combustible liquid category are those materials with a flash point above 100°F. Combustible liquids are considered less hazardous than flammable liquids because of their higher flash points. However, this statement can be misleading since there are circumstances when it is not a valid assumption. It is possible for certain combustible liquids to be at their flash point when a hot summer sun has been striking their metal container for some time. Additionally, during the transportation of some combustible products, the product is either preheated or a heat source is maintained to make the product more fluid than it would be at atmospheric temperatures. One reason this is done is to facilitate transportation or pumping; i.e. to aid with the movement of a material that is very viscous, such as asphalt or tar. Also, some materials classed as combustible solids will be heated to their melting point. Naphthalene is one example of this treatment. Naphthalene might be heated to a temperature above its melting point, which is about 176°F. Despite its fairly high ignition temperature (almost 980°F), it would not be unreasonable to surmise that a spill of liquid naphthalene could present a serious fire hazard. Fortunately, with naphthalene, quick action with adequate amounts of water applied as spray streams should cool and solidify it, thus greatly minimizing the fire risk.

It is important to note that a combustible liquid at or above its flash point will behave in the same manner that a flammable liquid would in a similar emergency. As an example No.2 fuel oil when heated to a temperature of 150°F can be expected to act or react in the same way gasoline would at 50°F. In most instances, however, to reach this elevated temperature will require the introduction of an external heat source. Some common examples of combustible petroleum liquids are given in Table 7.

Table 7. Examples of petroleum liquids that are combustible.

Product	Flash Point (°F)
Kerosene	100+
Fuel Oils	100 - 140
Diesel Oil	130
Lubricating Oil	300
Asphalt	400

The categories of liquids are further subdivided into classes according to the flash point plus the boiling point of certain liquids. These divisions are summarized in Table 8, which shows that flammable liquids fall into Class 1, and combustible liquids into Classes 2 and 3. The products that are at the low end (100°F) of the Class 2 combustible-liquid group might be thought of as borderline cases. These could act very much like flammable liquids if atmospheric temperatures were in the same range. It is not a common industry practice to identify either stationary or portable (mobile) liquid containers by the class of liquid it contains. The usual practice is to label either "flammable" or "combustible" and include the required U.S. Department of Transportation placard.

Table 8. Classes of flammable and combustible liquids.

Class	Flash Point (°F)	Boiling Point (°F)
1	Below 100	—
1A	Below 73	Below 100
1B	Below 73	At or above 100
1C	73-99	—
2	100-139	—
3	140 or above	Below 100
3A	140-199	At or above 100
3B	200 or above	—

It is important to note that the extinguishing techniques, controlling actions, or fire-prevention activities implemented can differ greatly depending upon which of the two categories the liquid falls in. To have the ability to categorize a liquid correctly when it is not so identified, it is only necessary to know its flash point. By definition, the flash point of a liquid determines whether a liquid is flammable or combustible.

Basically, the flash point is the temperature a liquid must be at before it will provide the fuel vapor required for a fire to ignite. A more technical

definition for flash point is: The lowest temperature a liquid may be at and still have the capability of liberating flammable vapors at a sufficient rate that, when united with the proper amounts of air, the air-fuel mixture will flash if a source of ignition is presented. The amounts of vapor being released at the exact flash-point temperature will not sustain the fire and, after flashing across the liquid surface, the flame will go out. It must be remembered that at the flash-point temperature, the liquid is releasing vapors and, as with other ordinary burnable materials, it is the vapors that burn. The burning process for both ordinary combustible solids and liquids requires the material to be vaporized. It may also be in the form of a very fine mist, which will be instantly vaporized if a source of heat is introduced. It is not the actual solid or the liquid that is burning, but the vapors being emitted from it. For this reason, when we speak of a fuel we are referring to the liberated vapor. It is an accepted phenomenon, assuming sufficient amounts of air to be present, that the greater the volume of released vapor, the larger the fire will be.

The technical literature sometimes refers to the "fire point", which in most instances is just a few degrees above the flash point temperature, and is the temperature the liquid must be before the released vapor is in sufficient quantity to continue to burn, once ignited. However, because a flash fire will normally ignite any Class "A" combustible present in the path of the flash, it is reasonable to accept the flash point as being the critical liquid temperature in assessing a fire hazard. Any of the other combustibles ignited by the flash fire, that is, wood, paper, cloth, etc., once burning, could then provide the additional heat necessary to bring the liquid to its fire point..

A crucial objective upon arrival of the first responding fire forces is to determine if the liquid present is a product that is vaporizing at the time or, if it is not, and what condition may be present that is capable of providing the required heat to cause the liquid to reach its flash point. This information would have a direct influence on the selection of control and/or extinguishing activities. An emergency involving a petroleum liquid, which is equal to or above flash point, means that a fuel source consisting of flammable vapors will be present. This, in turn, means the responding fire-fighting forces will be faced with either a highly hazardous vapor cloud condition or with a fire if ignition has occurred before arriving at the scene. Conversely, if it is a liquid at a temperature below its flash point, then fuel would not be immediately available to burn.

As explained earlier by the theories of fire, a source of air or more specifically, oxygen must be present. A reduction in the amount of available air to below ideal quantities causes the fire to diminish. Moreover, reduce the fuel quantity available and the fire will also diminish in size. Almost all extinguishing techniques developed are methods of denying the fire one or both of these requirements. By cooling a material below its flash point, vapor production is halted, thus removing the fuel from the fire. When utilizing a smothering-type extinguishing agent, the principle involved consists of

altering the air-fuel mixture. When the vapor is no longer in its explosive range, the fire dies, either due to insufficient fuel or a lack of oxygen. The flash point tells us the conditions under which we can expect the fuel vapor to be created, but it is the explosive range which tells us that a certain mixture of fuel vapor and air is required for the vapor to become ignitable. The terms flammable limit and combustible limit are also used to describe the explosive range. These three terms have identical meanings and can be used interchangeably. In chapter 5 the reader can find a compilation of published data that lists the explosive ranges for the various flammable liquids and gases. This information is reported as the lower explosive limits (LEL) and the upper explosive limits (UEL). The values that are reported for the LEL and UEL are given as a percentage of the total volume of the air-fuel mixture. The area between the LEL and the UEL is what is known as the explosive range. The figures given for the amount of fuel vapor required to place a substance within its explosive range are shown as a percentage of the total air-fuel mixture. To compute how much air is required to achieve this mixture, subtract the listed percentage from 100 percent: the remainder will be the amount of air needed. Even though it is only the oxygen contained in the air that the fire consumes, flammable ranges are shown as air-fuel ratios because it is the air that is so readily available. Any air-fuel mixture in which the vapor is above the UEL, or any air-fuel mixture in which the vapor is below the LEL, will not burn. Using gasoline as an example, the explosive range can be computed as follows:

	LEL(%)	UEL (%)
Gasoline vapor	1.5	7.6
Air	98.5	92.4
Total volume	100	100

This example helps to illustrate that large volumes of air are required to burn gasoline vapors. The explosive ranges for the different grades of gasoline, or even those of most other petroleum liquids, are such that average explosive-range figures that are suitable for use by the fire fighter would be the LEL at 1 percent and the UEL at about 7 percent. The vapor content of a contaminated atmosphere may be determined through the use of a combustible gas-detecting instrument, referred to as an explosimeter.

If a fire involving a petroleum liquid does occur, an extinguishing technique that may be appropriate is the altering of the air-fuel mixture. One technique utilized will necessitate the use of an extinguishing agent such as a foam with the capability of restricting the air from uniting with the vapor. Another technique is to prevent the liquid from having the ability to generate vapor. Usually this is a cooling action and is accomplished with water spray streams. In both cases, extinguishment is accomplished as a result of altering the air-fuel mixture to a point below the LEL for the specific liquid.

We will now devote attention to the so-called ignition temperature. Consider the emergency situation where there is a spill of gasoline. We may immediately conclude that two of the requirements for a fire exist. First, the gasoline, which would be at a temperature above its flash point, will be releasing flammable vapors; thus a source of fuel will be present. Moreover, there is ample air available to unite with the fuel thus there is the potential for the mixture to be in its explosive range. The only remaining requirement needed to have a fire is a source of heat at or above the ignition temperature of gasoline. Technically speaking, all flammable vapors have an exact minimum temperature that has the capability of igniting the specific air-vapor mixture in question. This characteristic is referred to as the ignition temperature and could range from as low as 300°F for the vapor from certain naphthas to over 900°F for asphaltic material vapor. Gasoline vapor is about halfway between - at 600°F. A rule of thumb for the ignition temperature of petroleum-liquid vapors is 500°F. This figure may appear low for several of the hydrocarbon vapors, but it is higher than that of most ordinary combustibles, and is close enough to the actual ignition temperatures of the products most frequently present at emergency scenes to give a suitable margin of safety.

In emergency situations, it is best to take conservative approaches by assuming that all heat sources are of a temperature above the ignition temperature of whatever liquid may be present. This approach is not an overreaction when it is realized that almost all the normally encountered spark or heat sources are well above the ignition temperature of whatever petroleum liquid might be present. Among the more common sources of ignition would be smoking materials of any kind (cigarettes, cigars, etc.), motor vehicles, and equipment powered by internal combustion engines: also electrically operated tools or equipment, as well as open-flame devices such as torches and flares. The removal of any and all potential ignition sources from the area must be instituted immediately and methodically. The operation of any motor vehicle, including diesel-powered vehicles, must not be permitted within the immediate vicinity of either a leak or spill of a flammable liquid. The probability of a spark from one of the many possible sources on a motor vehicle is always present. Also, under no circumstances should motor vehicles be allowed to drive through a spill of a petroleum product.

Ignition sources are not necessarily an external source of heat; it could be the temperature of the liquid itself. Refineries and chemical plants frequently operate processing equipment that contains a liquid above its respective ignition temperature. Under normal operating conditions, when the involved liquid is totally contained within the equipment, no problems are presented because the container or piping is completely filled with either liquid or vapor. If full and totally enclosed, it means there can be no air present; thus an explosive or ignitable mixture cannot be formed. If the enclosed liquid which in certain stages of its processing may be above the required ignition temperature should be released to the atmosphere, there is

a possibility that a vapor-air mixture could be formed and hence, ignition could occur. This type of ignition is referred to as auto-ignition. Auto-ignition is defined as the self-ignition of the vapors emitted by a liquid heated above its ignition temperature and that, when escaping into the atmosphere, enter into their explosive range. Some typical ignition temperatures for various petroleum liquids are 600°F for gasoline, 550°F for naphtha and petroleum ethers, 410°F for kerosene, and 725°F for methanol.

From the above discussions, the important elements that are responsible for a fire are:

- Fuel in the form of a vapor that is emitted when a liquid is at or above its flash point temperature.
- Air that must combine with the vapor in the correct amounts to place the mixture in the explosive range.
- Heat, which must be at least as hot as the ignition temperature, must then be introduced.

In addition to fuel, oxygen, and energy, the tetrahedron of fire theory identifies the chemical chain reaction of the flame as a requirement for a fire to sustain itself. The fourth side of the tetrahedron is the chain reaction, however, from a practical standpoint it does not appear to have a significant influence on normal fire-control practices. It is known that when using a dry chemical, extinguishment is achieved by the interruption of the chain reaction propagating the flame rather than by a smothering action, however this knowledge doesn't really alter the practical application of this technique to fire fighting.

Petroleum liquids have certain characteristics that can exert an influence on the behavior of the liquid and/or vapor that is causing the problem. For this reason, these features may have a bearing on the choice of control practices or extinguishing agents under consideration. These characteristics include the weight of the vapor, the weight of the liquid, and whether the liquid will mix readily with water. The specific properties of importance are vapor density, specific gravity, and water solubility. Before discussing these important physical properties, let's first examine the data in Table 9 which lists the flammability limits of some common gases and liquids. Two general conclusions can be drawn. First, the lower the material's LEL, obviously the more hazardous. Also note that there are some materials that have wide explosive ranges. This aspect is also significant from a fire standpoint. As an example, comparing hydrogen sulfide to benzene, although the LEL for H_2S is more than 3 times greater, its explosive range is 7 times wider. This would suggest that H_2S is an extremely hazardous material even though its LEL is relatively high. In fact, H_2S fires are generally so dangerous that the usual practice is to contain and allow burning to go to completion rather than to fight the fire.

Table 9. Limits of flammability of gases and vapors, percent in air.

Gas or Vapor	Lower	Upper
Hydrogen	4.00	75.0
Carbon monoxide	12.50	74.0
Ammonia	15.50	26.60
Hydrogen sulfide	4.30	45.50
Carbon disulfide	1.25	44.0
Methane	5.30	14.0
Ethane	3.00	12.5
Propane	2.20	9.5
Butane	1.90	8.5
Iso-butane	1.80	8.4
Pentane	1.50	7.80
Iso-pentane	1.40	7.6
Hexane	1.20	7.5
Heptane	1.20	6.7
Octane	1.00	3.20
Nonane	0.83	2.90
Decane	0.67	2.60
Dodecane	0.60	...
Tetradecane	0.50	...
Ethylene	3.1	32.0
Propylene	2.4	10.3
Butadiene	2.00	11.50
Butylene	1.98	9.65
Amylene	1.65	7.70
Acetylene	2.50	81.00
Allylene	1.74	...
Benzene	1.4	7.1
Toluene	1.27	6.75
Styrene	1.10	6.10
o-Xylene	1.00	6.00
Naphthalene	0.90	...
Anthracene	0.63	...
Cyclo-propane	2.40	10.4
Cyclo-hexene	1.22	4.81
Cyclo-hexane	1.30	8.0
Methyl cyclo-hexane	1.20	...
Gasoline-regular	1.40	7.50
Gasoline-73 octane	1.50	7.40
Gasoline-92 octane	1.50	7.60
Gasoline-100 octane	1.45	7.50
Naphtha	1.10	6.00

Estimating Lower Flammable Limits

The following discussion provides a plant caculation method for lower explosion limit concentrations for flare stacks or leaking valves that could ignite.

Explosivity limits for various pure components are given in Table 9. The limits of flammability (a concentration, C) for a mixture of gases can be computed from the following expression:

$$\frac{1}{C_L} = \frac{y_1}{C_{L1}} + \frac{y_2}{C_{L2}} + \cdots + \frac{y_n}{C_n} \quad (1)$$

where: C_L = Lower explosive limit concentration of the mixture in air

y_1 = Mole fraction (or volume fraction) of component 1 in the mixture

y_n = Mole fraction of the nth component

C_{L1} = Lower explosive limit concentration of component 1 in air

C_n = Lower explosive limit of the nth component.

Equation 1 is accurate for mixtures of paraffinic gases or for mixtures of H_2, CO and CH_4. It is only approximate for mixtures of H_2 and C_2H_4, H_2 and C_2H_2, H_2S and CH_4 or CH_4 and $C_2H_2Cl_2$. It is even less accurate for mixtures of flammable gases with steam or inerts. Nevertheless, for the accuracy required here, this simple equation should be tried first in all cases. When dealing with a mixture of flammable gases and inerts, the simplest way to approximate C_L is to use the above equation with C_L taken to be equal for the inert components. This step treats the inerts as a simple diluent in an ideal mixture. It would give only a rough approximation for mixtures such as H_2 and H_2O vapor, where a component which is inert in the cold mixture nevertheless enters into the reactions taking place in the flame. In such cases, if a rough approximation of C_L is not good enough, then more accurate methods described below should be used.

Application of this procedure to inadvertently ignited safety valve discharges can involve a special problem. Certain combinations of pressure ratio and length of safety valve riser can result in choked flow, with a pressure discontinuity at the exit. The pressure of the jet then adjusts to atmospheric pressure in a system of shock waves or expansion waves over a distance of a few pipe diameters. These waves can affect the local mixing of the jet with the crosswind. Since the calculation procedure incorporates correlations for subsonic jets, it cannot be expected to be entirely accurate in this case. Nevertheless, since the wave system occupies a very small portion of the flow field influenced by the jet, the procedure can still be counted on to provide a useful approximation of the gross flame length and flame shape when the actual discharge velocity and diameter are used in the calculation.

Credit for additional height of the flame center for multiple valve

installations may be taken by clustering the safety valve discharge pipes to the atmosphere. The following procedure should be used for determining equivalent diameter and exit velocity to be used in the flame center calculation. Diameter and velocity are based on the total actual area of the clustered vents.

For Equal Diameter Vents -

$$D_{jequ.} = [4*(\text{ sum of vent areas })/\pi]^{0.50} = d * n$$

$V_{jequ.}$ = actual velocity of any one vent.

For Unequal Diameter Vents :

$$D_{jequ.} = [4*(\text{ sum of vent areas })/\pi]^{0.50} = \sqrt{d_1^2 + d_2^2 + \cdots + d_n^2}$$

$$U_{jequ} = \text{Total Gas Rate / Total Vent Area} = \frac{1.273 * 10^{\&} * Q}{(D_{jequ.})^2}$$

In the above expressions, the terms are defined as follows:

d, d_1, d_2, d_n = Diameter of individual vents, in meters

D_{jequ} = Equivalent vent diameter to be used in flame calculation, in meters

n = Number of vents in cluster (n > 3)

Q = Total gas rate of all valves, in dm^3/s at one atmosphere and the release temperature

$U_{jequ.}$ = Equivalent vent exit velocity to be used in flame calc., in m/s

Let's now turn attention back to the flammability limit itself. When small increments of a combustible gas are successively mixed with air, a concentration is finally attained in which a flame will propagate if a source of ignition is present. This is referred to as the Lower Flammable Limit (or lower explosion limit, LEL or LFL) of the gas in air. As further increments of the gas are added, a higher concentration of flammable gas in air will finally be attained in which a flame will fail to propagate. The concentration of gas and air just as this point is reached is referred to as the Upper Flammable Limit (UFL or upper explosion limit, UEL) of the gas in air.

Safety requires that only the most reliable experimentally determined flammable limit data be considered in purging calculations.

Below atmospheric pressure there is no effect on the limits of flammability of natural gas-air mixtures and most other gas-air mixtures. Below about 25 mm absolute pressure, carbon monoxide-air mixtures are not flammable.

From atmospheric pressure, up to 2170 kPa, the lower limit of flammability is not affected, but the upper limit rises as the pressure on the mixture is increased. This widens the limits of flammability as the pressure increases, as shown in Table 10. Above 2170 kPa the lower limit will be reduced.

Table 10. Effect of increase in pressure on raising the upper flammability limit.

	Gage Pressure kPa	0	500	1000	1500	2000	2500
Methane and Natural Gas	Approx.	15	17	20	25	31	42
Coke Oven Gas	Approx.	31	35	44	57	72	-
Multipliers*		1	1.2	1.5	2.0	2.6	3.7

* For estimating the upper limit of gases other then those given when the limits at 0 gage pressure are known, apply the multipliers indicated in the table to the present range in flammability, adding the new range to the lower limit at 0 gage pressure to find the new upper limit.

It is necessary, in approaching most problems to obtain the limits of flammability of the particular gas mixture in question. Few industrial fuel gases are composed of pure gases or vapors, but are mixtures in most cases of many different gases. If the equipment and time are available, a number of mixtures of the fuel gas-air mixtures may be prepared and their flammabilities tested by ignition but it is much easier to determine the flammability limits of complex gas mixtures by calculation. Experience has shown that the results obtained are sufficiently dependable.

A calculation of the flammability limits of complex gas mixtures is carried out by the application of the mixture rule. Stated simply, the mixture rule is that if two limit mixtures of different gases are added together, the resulting mixture also will be a limit mixture. The mathematical statement of this law is as follows:

$$C_L = \frac{1}{\sum (y_1 / C_{L2} + y_2 / C_{L2} + y_3 / C_{L3} + \cdots + y_n / C_n)} \qquad (2)$$

where y_1, y_2, y_3, etc. , are the proportions of each combustible gas present in the original mixture, free from air and inerts so that $y_1 + y_2 + y_3, + \ldots y_n = 100$, and C_{L1}, C_{L2}, $C_{L3} \ldots C_{ln}$, etc., are the lower limits of flammability of the mixture. A similar procedure would be applied to determine the upper limit of flammability.

An example of the application of this law is given for natural gas having the following composition:

Gas	% By Volume	%Gas in Air Lower Limit
Methane	80.0	5.00
Ethane	15.0	3.10
Propane	4.0	2.10
Butane	1.0	1.86

$$\text{Lower Limit} = \frac{100}{\frac{80.0}{5.00} + \frac{15.0}{3.10} + \frac{1.0}{1.86}} = 4.30\% \text{ Gas in Air}$$

Any oxygen contained in a mixture may be considered as though it were a part of the air required for the combustion, and the analysis of the flammable mixture should be converted to an air-free basis before the flammable limits are calculated.

When mixtures contain appreciable amounts of nitrogen and carbon dioxide, calculation of the flammability limits becomes more complicated and requires the use of an extension of the mixture rule. In this modified method, the inert gases are taken into consideration by assuming that the original mixture is composed of a number of submixtures of inert gas-combustible gas, the flammability limits of which have been experimentally determined in a similar manner as have the limits for the pure gases as given in Table 9. Figures 7, 8, and 9 provide the flammability limits of mixtures of some common gases present in fuels with CO_2, N_2 and H_2O.

An illustration of the application of this modified mixture rule is given in Table 10. In this example, a producer gas has the composition shown at the top of the table. The CO_2 and N_2 may be apportioned with the different combustibles in any of several ways, two of which are represented by calculations A and B in Table 10.

In these examples, the inerts CO_2 and N_2 are combined with the combustibles H_2 and CO and the small amount of CH_4 is taken alone. Next, the ratio of inert to combustible is obtained for each group and the flammable limits for each such mixture are obtained from Figure 9. The mixture rule formula is now applied, using the data as just obtained, and the limits are calculated as shown in Table 10.

The summary at the bottom of Table 10 indicates the relative agreement between the calculated data and that experimentally determined for this particular producer gas. It is suggested that the difference between calculated and determined data in this case may be due more to inaccuracies in the analysis of the producer gas (particularly for methane) than to the fault of the mixture rule formula. This points up the fact that reliable gas analyses also are a necessary part of the calculated flammability limit data.

Vapor Density

Vapor density is a measure of the relative weight of vapor compared to the weight of air. Published data on the characteristics of petroleum products usually include the vapor density. The value of unity has been arbitrarily assigned as the weight of air. Hence any vapor that is reported to have a density of greater than 1 is heavier than air, and any vapor with a density of less than 1 is lighter than air. Vapors weighing more than 1 will usually flow like water, and those weighing less will drift readily off into the surrounding atmosphere. Even heavier-than-air flammable petroleum-liquid vapor can be carried along with very slight air currents. It may spread long distances before becoming so diluted with enough air as to place it below the lower explosive limit (LEL), at which time it would become incapable of being ignited. There are catastrophic incidences that have occurred whereby ignitable air-vapor mixtures have been detected as far as one-half mile from the vapor source. For this reason, while responding to a spill or leak, we must consider environmental and topographical features of the surroundings, such as wind direction, the slope of the ground, any natural or artificial barriers that may channel the liquid or vapors. It is critical in a non-fire incident such as a spill or leak to determine the type of petroleum liquid present and its source. Information about the material's vapor density enables us to make reasonable predictions as to the possible behavior of the emitting vapor. These factors may influence the route of approach, the positioning of firefighting apparatus and personnel, the need for and the route of evacuation, and the boundaries of the potential problem area. It is essential that no apparatus or other motor vehicles or personnel be located in the path that a vapor cloud will most likely follow.

As a rule of thumb one should approach a hydrocarbon spill (non-fire situation) under the assumption that the liquid is vaporizing (the vapors will be invisible) and that the liberated vapors are heavier than air unless proven otherwise. The expected conduct of a heavier-than-air vapor is for it to drop and spread at or below ground level much as a liquid would. The big difference is that a liquid will be visible and its boundaries well defined. One can expect that the invisible heavier-than-air vapor will settle and collect in low spots such as ditches, basements, sewers, etc. As the vapor travels, it will be mixing with the air, thus some portions of the cloud may be too

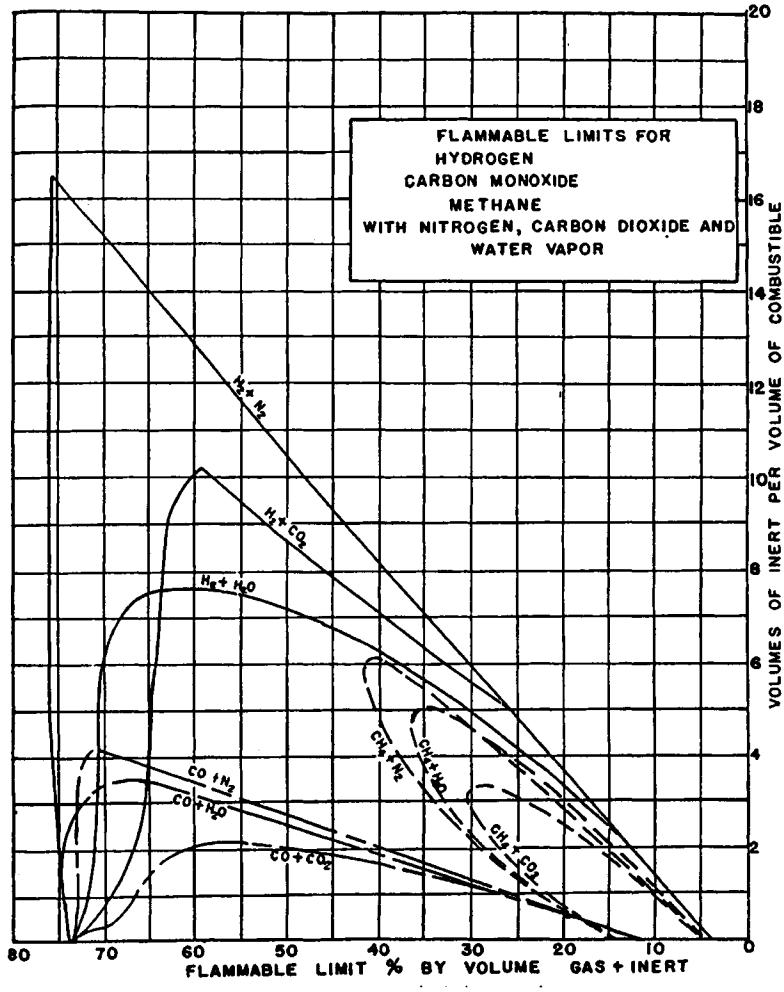


Figure 7. Flammable limits for hydrogen, carbon monoxide, methane, with nitrogen, carbon dioxide and water vapor.

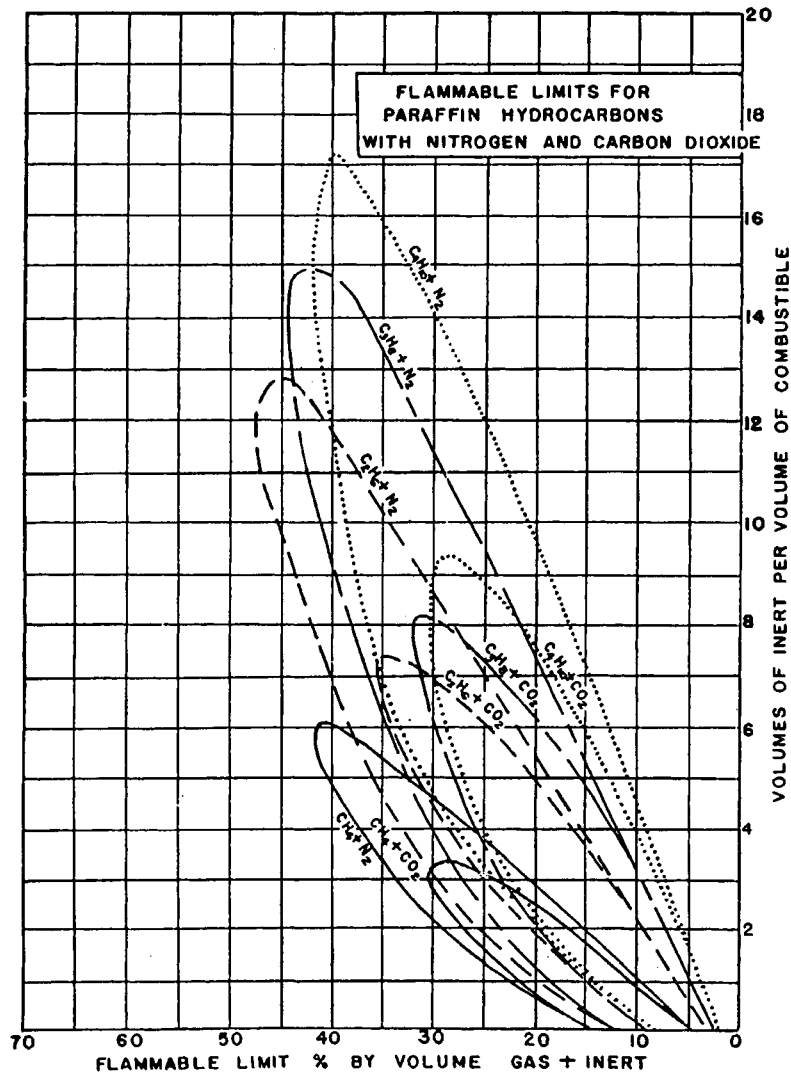


Figure 8. Flammable limits for paraffin hydrocarbons, with nitrogen and carbon dioxide.

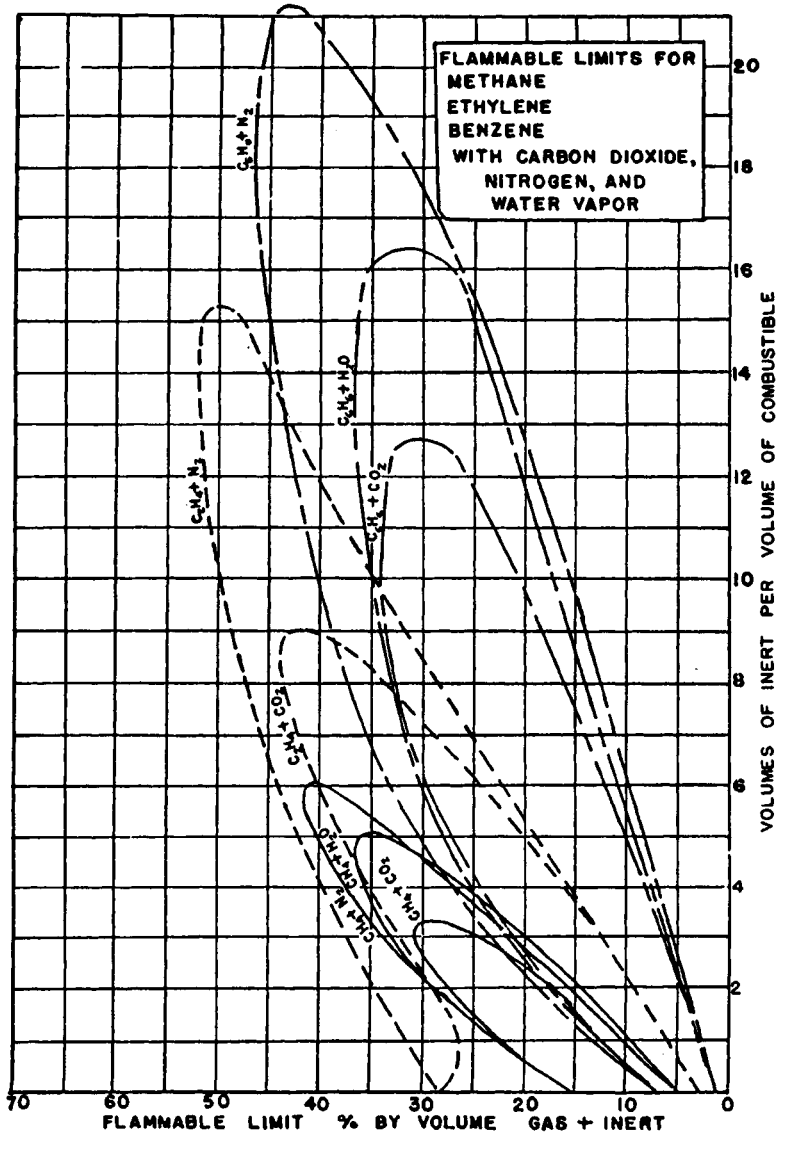


Figure 9. Flammable limits for methane, ethylene, benzene, with nitrogen, carbon dioxide and water vapor.

THE CALCULATION OF FLAMMABLE LIMITS

Gas Analysis Gas Composition		Combinations Chosen	Total	Ratio Inert/Combustible	Flammable Limits (Fig. 1) Lower	Upper
H_2	12.4%	12.4 H_2 + 6.2 CO_2	18.6%	0.50	6.0	71.5
CO	27.3	27.3 CO + 53.4 N_2	80.7%	1.96	39.8	73.0
CH_4	0.7	0.7 CH_4	0.7%	0.00	5.0	15.0
CO_2	6.2					
O_2	0.0					
N_2	53.4					

CALCULATION A

$$\text{Lower Limit} = \frac{100}{\frac{18.6}{6.0} + \frac{80.7}{39.8} + \frac{0.7}{5.0}} = 19.0$$

$$\text{Upper Limit} = \frac{100}{\frac{18.6}{71.5} + \frac{80.7}{73.0} + \frac{0.7}{15.0}} = 70.8$$

Gas Analysis	12.4 H_2 + 53.4 N_2 - 65.8	4.31	22.0	76.0
	27.3 CO + 6.2 CO_2 - 33.5	0.23	15.0	71.0
	0.7 CH_4 - 0.7	0.7	5.0	15.0

CALCULATION B

$$\text{Lower Limit} = \frac{100}{\frac{65.8}{22.0} + \frac{33.5}{15.0} + \frac{0.7}{5.0}} = 18.7$$

$$\text{Upper Limit} = \frac{100}{\frac{65.8}{76.0} + \frac{33.5}{71.0} + \frac{0.7}{15.0}} = 71.9$$

Summary	Lower Limit		Upper Limit	
Determined	20.7		73.7	
Calculation A	19.0	use 18.7	70.8	use 73.7
Calculation B	18.7		71.9	

Table 10. The calculation of flammable limits.

rich to burn, other sections too lean, and still others well within the explosive range. Some typical vapor densities for petroleum products are 3 to 4 for gasoline, 2.5 for naphtha, and 1.1 for methanol. For comparison, the vapor density for hydrogen gas is 0.1.

Specific Gravity

The property of specific gravity indicates a petroleum liquid's weight relative to the weight of an equal volume of water. The specific gravity of water is assigned the value of unity as a reference point. Hence, other liquids are evaluated relative to water; those lighter than water have a value less than unity, whereas those that are heavier have a value that is greater than unity. In general, petroleum products are lighter than water; as a result, they can be expected to float on and spread over the water's surface. The exceptions to this are thick, viscous materials such as road tars and heavy "bunker" fuel. With their low specific gravity, most petroleum liquids, if spilled onto a pool of water, have a tendency to spread quickly across the water's surface. Unless the fluid contacts an obstacle, the oil will continue to spread until it is of microscopic thickness. For this reason, a relatively small amount of oil floating on water is capable of covering a large area of the surface.

In a spill situation, knowledge of the liquid's specific gravity can help determine which one of several tactics will be implemented to mitigate the spread of contamination or to eliminate a fire hazard. Knowing the specific gravity will help determine the following:

- If it will be possible to use only water, or must we apply a different agent for purposes of smothering the fire.
- How great the probability is that the burning liquid could result in the involvement of exposures because of it floating on any water that is applied.
- Can the displacement of the fuel by water be considered an effective technique to control a leak from a container.

Some specific gravities of common petroleum liquids are 1 to 1.1 for asphalt, 0.8 for gasoline, and 0.6 for naphtha.

Water Solubility

Another important property of petroleum liquids is water solubility, which may be described as the ability of a liquid to mix with water. Since most petroleum products are lighter than water, and even if they are well mixed with water, they will separate into a layer of water and a layer of the hydrocarbon. Exceptions to this are polar solvents such as methanol and other alcohols. These types of materials will readily mix with water and can even become diluted by it.

Information on solubility is important in an emergency situation because a petroleum fire will require the application of a regular-type foam or an alcohol-resistant-type foam for extinguishment or for vapor-suppression purposes. For use on a water-soluble liquid, a good-quality alcohol-resistant foam is generally applied.

General Fire Characteristics

In an emergency situation involving a flammable petroleum liquid, the product can be expected to behave as follows:

- When accidentally released from its container it almost always results in a fire response.
- If a fire does occur, flammable liquids prove to be virtually impossible to extinguish by cooling with water.
- If the liquid is contained, the confined space will consist of a vapor-rich mixture.
- After extinguishment, there is still the strong possibility for a reflash owing to the continued production of vapor.

It is important to remember that during an emergency the escaping flammable liquids are low-flash products and, as a result, are releasing vapor at the usual atmospheric temperatures. These materials are, therefore, very susceptible to ignition. Because of this, they are generally encountered as an event requiring fire-control procedures. Also, for the same reasons, and the frequent need for large quantities of chemical extinguishing agents, they can present difficult extinguishment problems. The fact that the temperature at which many flammable liquids release vapor is well below the temperature of the water that is being used for fire-control purposes means that extinguishment by the cooling method is not feasible. This does not mean water cannot be used. In fact, the use of water serves an important function in spite of its limitations. However, to obtain extinguishment other tactics utilizing a different agent and techniques are needed. Exactly what agent and what technique will be dictated by the size of the fire, the type of storage container or processing equipment involved, and the fire-fighting resources that are available. When dealing with a low flash point flammable liquid, the probability of a reflash occurring after initial extinguishment is achieved is a high probability.

The probability of an ignitable air-fuel mixture existing inside a closed storage container of a flammable liquid is normally low. Flammable liquids have the capacity of generating vapor below the commonly encountered atmospheric temperatures; thus, the space between the tank top and the liquid surface will most usually contain a vapor-rich atmosphere (i.e., conditions will be above the UEL). As the vapor being liberated drives the air from the container, the vapor-rich mixture being above the UEL cannot be ignited; moreover, if a fire should occur outside the tank or vessel, it will not propagate a flame back into the tank. The major exceptions

would be those instances where the product had a flash point temperature about the same as the prevailing atmospheric temperature. Another example would be when a tank containing a low vapor pressure product with a flash point in the same range as the prevailing atmospheric temperature is suddenly cooled. A thunderstorm accompanied by a downpour of rain could cause the tank to breathe in air if the liquid is cooled below the temperature at which it is capable of emitting vapor (the boiling point).

In contrast to flammable liquids, an emergency situation that involves a combustible liquid will have a much different behavior. The expected behavior of a combustible product would be for:

- the liquid to present no significant vapor problem,
- a fire to be readily extinguished by cooling the liquid with water,
- the atmosphere above the liquid level to be below the LEL of any confined product.

Most combustible liquids do not present a vapor problem if accidentally released into the atmosphere. The probability of a fire, therefore, is considerably less than it would be if the spill was of a flammable material. If, however, the combustible liquid is at a temperature higher than its flash point, then it can be expected to behave in the identical manner a flammable liquid. One major difference between the two in a fire situation is that the potential exists for cooling the combustible liquid below its flash point by the proper application of water (generally applied in the form of water spray). In the event the liquid is burning, and if the fire forces are successful in achieving the required reduction in liquid temperature, then vapor production will cease and the fire will be extinguished because of a lack of vapor fuel. Unless this reduction in liquid temperature can be brought about, the fire will necessitate the same control considerations a low-flash liquid fire would.

With a fire in a storage tank containing a combustible liquid, normally the application of a foam blanket is the only practical method to achieve extinguishment. This is normally done when the entire exposed surface is burning and is necessitated by the fact that the sheer size of the fire makes it very difficult to apply water spray in the amounts and at the locations needed. Also, the volume of oil that has become heated is such that the large quantities of water needed to cool the liquid would introduce the possibility of overflowing the tank. Another problem is that the water requirements for both protecting exposures and attempting extinguishment might be far greater than what is available. These factors alone would cause the emergency forces to treat all refined product tank fires alike and, regardless of the flash point of the liquid, initiate the required steps to apply a foam blanket to the liquid surface. In addition there is always concern for any reaction the water may cause when contacting an oil or hydrocarbon heated above the boiling point of water (212°F). In general, because a spill is generally shallow, spilled or splashed combustible liquids do not present the

type of problems that a large storage tank does. It is reasonable to expect to be able to extinguish shallow pools or surface spills with water spray.

In the case of a storage tank with a combustible product, the atmosphere inside the container will normally consist of air. On occasion, there will be detectable odors such as that associated with fuel oil. These odors, which are a good indicator of the presence of a combustible product, are not considered fuel vapor. During a fire situation, flame impingement or radiant heat on a container could cause the liquid to become heated to the temperature at which it would emit vapors. Should this occur, and the vapors being generated then start to mix with the air already in the tank, at some instant the space in the container would then contain a mixture that was within the explosive range of the product; if ignition occurred, a forceful internal explosion could result.

The case of crude oil is somewhat unique compared to fires with refined petroleum products. Burning crude oil has the capability of developing a "heat wave". Crude oil has a composition of different fractions of petroleum products. In a manner similar to a refinery operation which distills, or heats crude oil to separate it into the various usable products - such as gasoline and asphalt, a fire accomplishes the same effect. As crude oil burns it releases the fractions that have lower flash points first, and these are burned. The heavier fractions sink down into the heated oil. This movement of light fractions up to the fire and heavier, heated fractions down into the crude produces the phenomenon known as a heat wave. Crude oil has the same basic characteristics as other flammable liquids. There are different grades of crude oil produced from various geographic locations throughout the world, with some crudes having more heavy-asphalt-type material than others. Some have greater quantities of sulfur (creating the problem of poisonous hydrogen sulfide gas generation during a fire) and still others more light, gaseous fractions; however, a common characteristic among them is that all will have varying amounts of impurities and some entrained water.

When liquids of this type burn, creating a heat wave which is comprised of the higher boiling point components plus whatever impurities may be present in the product, radiant heat from the flame heats the liquid surface, the light products boil-off, thus creating the vapor that is burning. The remaining hot, heavier materials transfer their heat down into the oil. As it is formed, this heat wave, or layer of heated crude oil components, can reach temperatures as high as 600°F and spread downward at a rate of from 12 to 18 inches per hour faster than the burn-off rate of the crude oil. This would mean that with a crude oil burn-off of 1 foot per hour, at the end of two hours the heat wave would be somewhere between 24 and 36 inches thick. Once this heat wave is created, the chances of extinguishing a crude-oil tank fire, unless it is of small size, are poor, and any water or foam applied could result in a "slopover" of burning oil.

As noted earlier, crude oil normal contains some entrained water and/or an emulsion layer of water and oil. In addition, crude-oil storage tanks will have some accumulations of water on the uneven tank bottoms. In a fire, when a heat wave is formed and comes in contact with any water, a steam explosion will occur, thus agitating the hot oil above it with great force. The evolution of the steam explosion can be attributed to the reaction of water to high temperatures. When water is heated to its boiling point of 212°F, water vapor or steam is generated. Steam that is produced expands approximately 1700 times in volume over the volume of the water that boils away. If a heat wave of a temperature well above 212°F contacts any water entrained in the oil, or some of the bottom water, which is usually in larger quantities, the instantaneous generation of steam will act like a piston, causing the oil to be flung upward with considerable violence and force. This reaction is so strong that it causes the oil to overflow the tank shell. This sudden eruption is known as a boilover. When the hot oil and steam reaction takes place, the oil is made frothy, which in turn further increases its volume. The reaction resulting from the heat wave contacting entrained water can be expected to be of lesser activity than from contact with bottom water. The reason for this difference is that the quantities of water converted to steam in a given spot are usually less.

Another phenomenon associated with a crude oil fire is slopover. Basically, the same principles that are responsible for a boilover are the cause of a slopover. The fundamental difference is that in a slopover the reaction is from water that has entered the tank since the start of the fire. Usually this introduction is the result of firefighting activities. A slopover will occur at some point after the heat wave has been formed. Either the water from the hose streams or, after the bubbles collapse, the water in the foam will sink into the oil, contacting the heat wave, where it is converted to steam, and the agitation of the liquid surface spills some amount of oil over the tank rim.

Use of Extinguishing Agents

The proper extinguishing agents suitable for petroleum-liquid emergencies must be capable of performing the identical functions as those agents used in the combating of structural-type fires. There will be times when circumstances dictate the use of a cooling agent, whereas at other times it will be a smothering agent, and on some occasions, both agents will be necessary. There are a variety of agents capable of accomplishing each of these objectives, as well as being appropriate to combat Class B-type fires. Agents suitable for use on Class B-type fires include halon, carbon dioxide (CO_2), dry chemicals, foam, and aqueous film forming foam. A brief description of the major types of fire fighting agents is given below.

Water - Regardless whether it is a spill or a fire, or whether it involves a flammable or a combustible liquid, water is almost invariably required. Water can be used for the dissipation of vapors, for the cooling of

exposed equipment, for the protection of personnel, for control purposes, and, for actual extinguishment. For the cooling down of exposed equipment such as pipelines, pumps, or valves, it is recommended that water be applied at the minimum flow rate of 1 gallon per minute per 10 square feet of exposed surface area. Some general guidelines to consider when applying water are as follows:

- All areas of any piping, containers, etc., that are exposed to the fire's heat or flame should be kept wetted during the course of the fire.
- The use of water streams to push and move the burning liquid away from exposed equipment is recommended provided that it can be done safely.
- The rate of flow from any hose stream should not be less than 100 gal/min regardless of its purpose.
- The use of spray streams is recommended whenever possible.
- Back-up lines for lines in active service should be provided and they should be at least of the same capacity as the attack line.
- Any equipment being protected is cool enough if water applied to it no longer turns to steam.

With storage tanks or processing equipment exposed to fire or radiant heat, the cooling of any metal above the liquid level inside the vessel is critical. Metal surfaces that have a constant film of water flowing over them will not reach a surface temperature above the boiling point of water. This temperature is well below that which would subject the metal to loss of integrity because of softening.

Water flows employed to cool exposed vertical storage tanks can be calculated using as a requirement one hose line (flowing 200 gal/min) per 10 feet of tank diameter. Assuming an average tank height of 50 feet, this would give a water flow capability in excess of the recommended rate.

On the fire ground, wind conditions, personnel deficiencies (fatigue, lack of experience or training, etc.), stream feathering, and so forth have historically resulted in not all the water that is flowing actually doing its intended function. The rule of thumb of one line flowing a minimum of 200 gal/min for each 10 feet of tank diameter provides a suitable safety margin to overcome the loss of water not reaching its target. This flow is only required on the side or sides of the tank being heated; therefore, if a 100-foot-diameter tank is receiving heat on just one-half of its circumference, it would require five hose streams of 200 gal/min, each applied to the heated area for cooling purposes. It must be anticipated that these minimum flows will need to be maintained for a time period of at least 60 minutes. Tank truck incidents in which the fire burned for several hours are not unusual. It should be appreciated that a relatively minor fire on a tank truck or rail car could require in excess of 20,000 gallons of water for control and/or extinguishment. It is imperative that as early into the event as possible, an accurate assessment of water flow requirements should be made and flow

rates adjusted accordingly. First responders must be constantly alert for any indication of an increase in the internal pressure of a container. Such an increase or any visible outward distortion of the tank shell would be an indication that additional water flows are required. These warning signs, which would be an indication of increased internal pressures, could justify the immediate use of unmanned monitors or hoseholders, larger size nozzles, and the pulling back of all personnel to a safe location.

In preparing emergency response plans for petroleum-liquid spills or fires, it should be taken into consideration that the required water rates could be needed for long periods of time. Built into the plans must be provisions for an uninterrupted supply at a suitable volume. The rates stipulated in the foregoing do not include amounts of water that may be needed for the protection of fire-fighting personnel who are involved in activities such as rescue work or valve closing and block off operations. If these or other water-consuming activities are required, additional water must be provided. Of equal importance to the amount of water being used is that water be used in the right place. In general, the application of water should have as its objective one or more of the following goals:

- The cooling of the shell of any container that is being subjected to high heat levels. This is most effectively accomplished by applying the water to the uppermost portions of the container and allowing it to cascade down the sides.
- The cooling of any piece of closed-in equipment containing a liquid or gas and exposed to high heat levels. This is most effectively accomplished by applying the water spray over the entire area being heated.
- The protection of any part of a container, piping, or item of processing equipment receiving direct flame contact. This is most effectively accomplished with a very narrow spray pattern or even a straight stream directed at the point of flame contact.
- The cooling of steel supports of any container or pipe rack that may be subjected to high heat levels. This is most effectively accomplished by the application of narrow spray streams to the highest part of the support being heated and permitting the water to run down the vertical length of the support.

Foam - The application of a foam blanket is the only means available to the fire forces for the extinguishment of large petroleum storage tank fires. The foam blanket extinguishes by preventing vapor, rising from the liquid surface, from uniting with the surrounding air and forming a flammable mixture. Although the water in a foam does provide some incidental cooling action, this is considered of more importance for cooling heated metal parts, thus reducing the possibility of re-ignition, than as an extinguishing factor. A good-quality foam blanket of several inches in thickness has also been proved effective as a vapor suppressant on low flash-point liquids. Foam may also be used to suppress vapor, hence the layer

of foam will be instrumental both in preventing ignition and reducing the contamination of the surrounding atmosphere. Since foam is still water, even if in a different form from that usually used, it may conduct electricity: consequently, its use on live electrical equipment is not recommended.

There are basically two methods of foam application to fires. The first involves the application of chemical foam, which is generated from the reaction of a powder with water. This type of foam has been replaced largely by a technique that involves the formation of foam bubbles when a foaming agent and water are expanded by the mechanical introduction of air. This type, which is not a chemical reaction, is referred to as mechanical foam. Another name for the same material is air-foam. There are a variety of foam concentrates designed to fit different hazards. These include regular protein-based foams, fluoroprotein foams, aqueous film forming types, alcohol-resistant types, as well as foams that are compatible with dry chemical powders and those that will not freeze at below-zero temperatures. Of the many types, the most suitable for general all-around petroleum the use would be either a good-quality fluoroprotein or a good-quality aqueous film forming foam (AFFF). Foam liquids are also available in a wide range of concentrates, from 1 percent to 10 percent. The 3 percent and 6 percent protein and fluoroprotein types are usually employed as low-expansion agents with an expansion ratio of about 8 to 1. That is, for each 100 gallons of foam solution (water/concentrate mix) to which air is properly introduced, it will then develop approximately 800 gallons of finished foam. Foam concentrates of other than 3 percent or 6 percent generally are either high-expansion (as high as 1,000 to 1) or alcohol-resistant types.

In foam applications, the manufacturer will provide a percentage rating of a concentrate, which identifies the quantity of concentrate required to be added to water to achieve a correct solution mixture. For each 100 gallons of solution flowing, a concentrate rated as 3 percent would mean 3 gallons of concentrate per 97 gallons of water, whereas a 6 percent concentrate would mix with 94 gallons of water. This readily explains why only half as much space is required to store or transport the amount of 3 percent concentrate needed to generate a given quantity of foam than would be needed for a 6 percent concentrate to make the same volume of foam.

Once the application of foam is initiated, it must be applied as gently as possible in order to develop a good vapor-tight blanket on the liquid surface. Any agitation of the foam blanket or of the burning liquid surface will serve to prolong the operation and to waste foam supplies. Water streams cannot be directed into the foam blanket or across the foam streams because the water will dilute and break down the foam. To be assured that all metal surfaces are cool enough and a good, thick (4 inches or more) blanket of foam has been applied, continue application for a minimum of five minutes after all visible fire is extinguished.

As noted earlier, one of the agents considered suitable for the extinguishment of petroleum-liquid fires is aqueous film forming foam. This is a liquid concentrate that contains a fluorocarbon surfactant to help float and spread the film across the petroleum-liquid surface and is commonly referred to as "A Triple F". AFFF concentrates of 1, 3, or 6 percent are available, all with about an eight to one expansion ratio. This material is one of the mechanical-type foaming agents. The same kind of air-aspirating nozzles and proportioners that are used for protein-based foams are usable with AFFF concentrates. The primary advantage of AFFF over other foaming agents is its ability to form a thin aqueous film that travels ahead of the usual foam bubbles. This film has the ability to flow rapidly across the burning liquid surface, thus extinguishing the fire by excluding the air as it moves across the surface. The regular foam bubbles formed and flowing behind the film have good securing qualities, which serve to prevent reflashing from occurring. As with all types of foams, care must be exercised that the foam blanket, once formed, is not disturbed. Water streams should not be directed into the foam blanket or onto the same target a foam stream is aimed at. Water will dilute the foam below the needed concentration and, simultaneously, the force of the stream will destroy the foam's blanketing effect. The blanket must be maintained until all flames are extinguished, all heated metal surfaces cooled, and other sources of ignition removed from the vicinity.

Alcohol-Resistant Foams - Foams that are suitable for water-soluble polar solvents are formulated to produce a bubble that is stable in those fuels and tends to mix and unite with water. Fuels of this type dissolve the water contained in regular foam very rapidly resulting in the collapse of the bubbles. The breakdown is so fast and complete with regular protein or fluoroprotein based foams that unless the rate at which the foam is being applied is well above the recommended rate, the blanket will not form at all. Alcohol-type foam concentrates are most commonly available at strengths of 3 percent, 6 percent, or 10 percent. Because of the possibility of breakdown, regular foams are not considered suitable for polar solvent-type fires. The exception would be a fire in a container of fairly small diameter or a shallow spill, either of which would allow for the possibility of applying foam at sufficient rates to the point of overwhelming the fire.

High-Expansion Foams - High-expansion foam includes foaming agents with the expansion ratio between the solution and the foam bubbles of from 20 to 1 to as high as 1,000 to 1. This agent has been found suitable when combating certain types of Class A and Class B fires. Originally developed to help fight fires inside mines, it is most effective when used in confined areas. Extinguishment is accomplished both by the smothering action of the foam blanket and the cooling action obtained from the water as the bubbles break down. Light, fluffy bubbles break apart and are easily dispersed by even relatively moderate wind currents. Bubbles formed at ratios greater than about 400 to 1 are most likely to be adversely affected by

regular air movement as well as the thermal updrafts created by the fire. In an effort to overcome the susceptibility of the bubbles to wind currents, medium expansion foams have been introduced, which have expansion ratios ranging from about 20:1 to 200:1. High-expansion foam concentrates require special foam generators both for proportioning the liquid with water, and aspirating the mixture. Many high-expansion foam-dispensing devices have a discharge range of only a few feet; thus, they must be operated fairly close to the area being blanketed.

Other Extinguishing Agents - Other extinguishing agents that are suitable for use on fires involving petroleum liquids include dry chemical powders, carbon dioxide gas, and halon gases. Each of these agents, while being capable of extinguishing Class B fires, usually is available in either hand-held extinguishers or the larger wheeled or trailer-mounted portable units.

In some petroleum refineries or chemical plants, an on-site fire brigade that is equipped with an apparatus capable of dispensing large volumes of dry chemical, or a vehicle with a large-capacity carbon dioxide (CO_2) cylinder is common practice.

Tank Cleaning and Removal Operations

A very common operation that can pose a serious fire hazard is either the cleaning and/or removal of underground storage tanks used for flammable products such as gasoline. If these operations are not performed properly, they can lead to spontaneous combustion conditions. There are two basic procedures that must be performed before a tank used for storing a flammable product can be entered either for inspection or cleaning purposes prior to its removal or repair. The first procedure is called inerting.

A vessel that has first been pumped dry of its content will have a freeboard atmosphere that is above the UEL of the flammable liquid. However, if the tank is now opened, e.g. through a manway, oxygen or air is introduced and the resulting mixture of air-vapor could easily enter within the explosive range. To avoid this dangerous situation, the tank must first be inerted. There are two common approaches to inerting, both using the same principal. The first approach involves displacing the vapor in the tank's freeboard with another fluid. The other fluid can be an inert gas like nitrogen, or with small tanks (under 10,000 gallons in capacity) by pumping in water. The use of water is generally not practiced because it becomes contaminated with residual product and sludge in the tank and can become an added expense in disposal. The second method of inerting is to use dry ice which can be introduced to a tank through a fill port. Normally a little water is also added to help dissipate the dry ice. The dry ice will melt producing carbon monoxide which then acts in the same manner as a motive fluid like N_2 or water, displacing the tank's fuel rich atmosphere. A rough guideline

is to use 10 pounds of dry ice for every 1000 gallons of tank capacity.

In both inerting procedures, the flammable vapors are discharged though tank's vent line. Because in the case of gasoline vapors, vapor densities are greater than 1, the vent line should be sufficiently tall to enable vapors to be adequately diluted in the atmosphere. A general rule of thumb is that the vent's discharge should be at least 10 feet above the tallest neighboring structure. The professional tank cleaner will use an explosimeter to monitor the LEL at the vent's exit, and hence have an exact measure of when the tank has been purged.

Once the tank has been inerted, the second operation involves purging. Purging a tank involves introducing fresh air so that the atmosphere is within a safe limit for entry by inspectors and maintenance technicians. This is a closely monitored operation requiring the use of an oxygen meter. Following OSHA standards, the minimum safe entry condition based on oxygen concentration is 18.5%. In other words, there must be a minimum of 18.5% O_2 available in the tank in order to safely send personnel in.

CLOSURE

This chapter has provided some basic information on the fire hazards of materials with emphasis given to hydrocarbons. The basic principles outlined are applicable to all flammable products, regardless of whether they are petroleum liquids or not. The next series of chapters will provide emergency response data that first responders and emergency response personnel may apply in the mitigation of fires or emergency situations involving spills and leaks. In the United States, the organization that is best recognized in providing technical assistance to emergency situations is CHEMTREC, which is the acronym for Chemical Transportation Emergency Center. The last chapter of this book contains further information about CHEMTREC.

4

Engineering and Technical Data on Petroleum Products

INTRODUCTION

This chapter provides a compendium of physical properties and engineering data on hydrocarbons and their mixtures. The information and data provided in this chapter are useful to engineers and safety specialists that handle these products.

PHYSICAL CONSTANTS

In Tables 1 through 3 the more common physical constants are given for hydrocarbons, certain other organic series, and miscellaneous materials. While these constants, in general, are based upon reliable data, estimated values are included in some instances.

The physical constants of hydrocarbons given in Table 1 include molecular weight, boiling and melting points, density and specific gravity, heats of vaporization, and heats of combustion. In addition, critical constants (temperature T, pressure P, and density D) are included. Table 2 provides the same basic properties data for various organic compounds. Table 3 provides similar data for miscellaneous materials consumed/produced in refinery and light-ends processing operations.

Table 1. PHYSICAL CONSTANTS OF HYDROCARBONS

	FORMULA	MOLEC. WT.	BOILING POINT °F	MELTING POINT °F	DENSITY °API	DENSITY Sp Gr 60/60	DENSITY Lb/Gal[a]	CRITICAL CONSTANTS t °F	CRITICAL CONSTANTS P Atm	CRITICAL CONSTANTS D g/ml	ACENTRIC FACTOR	HEAT OF VAPORIZ. @ B.P. Btu/lb	HEAT OF COMBUSTION @ 60°F Btu/lb GROSS	HEAT OF COMBUSTION @ 60°F Btu/lb NET
PARAFFINS														
Methane	CH_4	16.0	-258.7	-296.5	340[b]	0.30[b]	2.50[b]	-116.7	45.4	0.162	0.001	219.2	23882[c]	21503[c]
Ethane	C_2H_6	30.1	-127.5	-297.9	247	0.374	3.11	90.1	48.2	0.203	0.101	210.4	22320[c]	20417[c]
Propane	C_3H_8	44.1	- 43.7	-305.8	147	0.508	4.23	206.0	41.9	0.217	0.157	183.1	21662[c]	19928[c]
n-Butane	C_4H_{10}	58.1	31.1	-217.0	111	0.584	4.86	305.6	37.5	0.228	0.206	165.7	21294[c]	19654[c]
2-Methylpropane (Isobutane)	C_4H_{10}	58.1	10.9	-255.3	120	0.563	4.69	275.0	36.0	0.221	0.188	157.5	21234[c]	19591[c]
n-Pentane	C_5H_{12}	72.1	96.9	-201.5	92.7	0.631	5.25	385.7	33.3	0.237	0.256	153.6	20926	19339
2-Methylbutane (Isopentane)	C_5H_{12}	72.1	82.1	-255.6	94.9	0.625	5.20	369.0	33.4	0.236	0.223	147.1	20887	19300
2,2-Dimethylpropane (Neopentane)	C_5H_{12}	72.1	49.1	2.2	106	0.597	4.97	321.1	31.6	0.238	0.202	135.6	22954[c]	19368[c]
n-Hexane	C_6H_{14}	86.2	155.7	-139.6	81.6	0.664	5.53	453.6	29.7	0.233	0.302	144.0	20784	19232
2-Methylpentane	C_6H_{14}	86.2	140.5	-244.6	83.5	0.658	5.48	435.7	29.7	0.235	0.280	138.7	20756	19205
3-Methylpentane	C_6H_{14}	86.2	145.9	-180.4	80.0	0.669	5.57	448.2	30.8	0.235	0.278	140.1	20768	19217
2,2-Dimethylbutane	C_6H_{14}	86.2	121.5	-147.8	84.9	0.654	5.45	440.0	30.4	0.240	0.236	131.2	20711	19160
2,3-Dimethylbutane	C_6H_{14}	86.2	136.4	-199.4	81.0	0.666	5.55	440.2	30.9	0.241	0.250	136.1	20743	19191
n-Heptane	C_7H_{16}	100.2	209.2	-131.1	74.2	0.688	5.73	512.6	27.0	0.232	0.352	136.0	20681	19156
2-Methylhexane	C_7H_{16}	100.2	194.1	-180.9	75.7	0.683	5.69	494.9	27.0	0.238	0.330	131.6	20658	19133
3-Methylhexane	C_7H_{16}	100.2	197.3	-182.9	73.0	0.692	5.76	504.3	28.1	0.240	0.329	132.1	20668	19144
3-Ethylpentane	C_7H_{16}	100.2	200.3	-181.5	69.8	0.703	5.85	513.4	28.5	0.241	0.314	132.8	20679	19154
2,2-Dimethylpentane	C_7H_{16}	100.2	174.6	-190.9	77.2	0.678	5.65	477.1	27.4	0.241	0.302	125.1	20620	19095
2,3-Dimethylpentane	C_7H_{16}	100.2	193.6	--	70.9	0.699	5.82	507.4	27.7	0.255	0.304	130.4	20642	19117
2,4-Dimethylpentane	C_7H_{16}	100.2	176.9	-182.6	77.5	0.677	5.64	475.7	27.0	0.240	0.307	126.6	20639	19111
3,3-Dimethylpentane	C_7H_{16}	100.2	186.9	-210.0	71.2	0.698	5.81	505.7	29.1	0.242	0.285	127.2	20638	19113
2,2,3-Trimethylbutane (Triptane)	C_7H_{16}	100.2	177.6	- 12.8	72.1	0.695	5.79	496.3	29.1	0.252	0.259	124.2	20627	19103

a. In air, @ 60°F.
b. Hypothetical (extrapolated) value.
c. Heat of combustion as a gas, otherwise as a liquid.

Table 1 Continued. PHYSICAL CONSTANTS OF HYDROCARBONS

	FORMULA	MOLEC. WT.	BOILING POINT °F	MELTING POINT °F	DENSITY °API	DENSITY Sp Gr 60/60	DENSITY Lb/Gal[a]	CRITICAL CONSTANTS t °F	CRITICAL CONSTANTS P Atm	CRITICAL CONSTANTS D g/ml	ACENTRIC FACTOR	HEAT OF VAPORIZ. @ B.P. Btu/lb	HEAT OF COMBUSTION @ 60°F Btu/lb GROSS	HEAT OF COMBUSTION @ 60°F Btu/lb NET
PARAFFINS (continued)														
n-Octane	C_8H_{18}	114.2	285.2	- 70.2	68.6	0.707	5.89	564.1	24.5	0.232	0.394	129.5	20604	19099
2-Methylheptane	C_8H_{18}	114.2	243.8	-164.3	70.1	0.702	5.85	547.6	24.5	0.234	0.373	127.2	20585	19079
3-Ethylhexane	C_8H_{18}	114.2	245.4	-	65.6	0.718	5.98	558.1	25.7	0.251	0.361	126.5	20601	19097
2,5-Dimethylhexane	C_8H_{18}	114.2	228.4	-132.2	71.2	0.698	5.81	530.3	24.5	0.237	0.360	122.8	20564	19059
2,2,4-Trimethylpentane (Isooctane)	C_8H_{18}	114.2	210.6	-161.3	71.8	0.696	5.80	519.3	25.3	0.244	0.305	116.7	20569	19064
n-Nonane	C_9H_{20}	128.3	303.4	- 64.3	64.5	0.722	6.01	610.5	22.6	0.234	0.44	123.8	20544	19056
2-Methyloctane	C_9H_{20}	128.3	289.9	-112.7	65.7	0.717	5.98	596.2	22.6	0.237	0.42	122.9	20525	19036
3-Methyloctane	C_9H_{20}	128.3	291.5	-161.7	63.7	0.725	6.04	602.3	23.1	0.243	0.41	123.3	20532	19044
2,2-Dimethylheptane	C_9H_{20}	128.3	270.8	-171.4	66.5	0.715	5.95	580.0	22.9	0.244	0.38	116.6	20499	19011
2,6-Dimethylheptane	C_9H_{20}	128.3	275.4	-153.2	66.9	0.713	5.94	580.5	22.7	0.240	0.40	119.1	20507	19019
3,3-Diethylpentane	C_9H_{20}	128.3	295.1	- 27.6	55.3	0.757	6.31	599.5	24.0	0.253	0.47	118.4	20514	19026
n-Decane	$C_{10}H_{22}$	142.3	345.4	- 21.4	61.3	0.734	6.11	651.9	20.8	0.236	0.48	118.7	20493	19017
3-Methylnonane	$C_{10}H_{22}$	142.3	334.0	-120.6	60.4	0.737	6.14	644.5	21.1	0.244	0.45	118.2	20483	19007
5-Methylnonane	$C_{10}H_{22}$	142.3	329.2	-125.9	60.6	0.737	6.14	637.7	21.1	0.248	0.45	116.9	20485	19009
2,2-Dimethyloctane	$C_{10}H_{22}$	142.3	311.0	-	62.7	0.728	6.07	624.0	21.0	0.245	0.40	113.9	20451	18974
2,3-Dimethyloctane	$C_{10}H_{22}$	142.3	326.8	-	59.3	0.742	6.18	644.1	21.6	0.251	0.42	115.4	20479	19004
2,4-Dimethyloctane	$C_{10}H_{22}$	142.3	307.0	-	62.1	0.731	6.09	619.2	21.1	0.251	0.40	114.3	20469	18993
2,5-Dimethyloctane	$C_{10}H_{22}$	142.3	316.0	-	59.7	0.740	6.16	625.7	21.2	0.250	0.42	114.3	20468	18994
2,7-Dimethyloctane	$C_{10}H_{22}$	142.3	319.8	- 65.0	62.7	0.728	6.07	625.6	20.7	0.241	0.41	115.6	20460	18986
n-Undecane	$C_{11}H_{24}$	156.3	384.6	- 14.1	58.7	0.744	6.20	690.0	19.4	0.240	0.51	114.2	20443	18990
n-Dodecane	$C_{12}H_{26}$	170.3	421.3	14.7	56.4	0.753	6.27	725.2	18.0	0.240	0.55	110.2	20410	18966

a. In air, @ 60°F.

Table 1 Continued. PHYSICAL CONSTANTS OF HYDROCARBONS

	FORMULA	MOLEC. WT.	BOILING POINT °F	MELTING POINT °F	DENSITY °API	DENSITY Sp Gr 60/60	DENSITY Lb/Gal[a]	CRITICAL CONSTANTS t °F	CRITICAL CONSTANTS P Atm	CRITICAL CONSTANTS D g/ml	ACENTRIC FACTOR	HEAT OF VAPORIZ. @ B.P. Btu/lb	HEAT OF COMBUSTION @ 60°F Btu/lb GROSS	HEAT OF COMBUSTION @ 60°F Btu/lb NET
OLEFINS														
Ethylene	C_2H_4	28.1	-154.7	-272.5	273[b]	0.35[b]	2.91[b]	48.6	50.0	0.227	0.085	207.6	21637[c]	20276[c]
Propylene	C_3H_6	42.1	- 53.9	-301.5	140	0.522	4.35	197.2	45.6	0.233	0.147	188.2	21043[c]	19681[c]
1-Butene	C_4H_8	56.1	20.7	-301.6	104	0.601	5.01	295.6	39.7	0.233	0.197	167.9	20834[c]	19473[c]
cis-2-Butene	C_4H_8	56.1	38.7	-218.1	94.2	0.627	5.22	324.3	41.5	0.240	0.208	178.9	20782[c]	19420[c]
trans-2-Butene	C_4H_8	56.1	33.6	-158.0	100	0.610	5.08	311.8	40.5	0.236	0.212	174.4	20748[c]	19387[c]
2-Methylpropene (Isobutylene)	C_4H_8	56.1	19.6	-220.6	104	0.600	5.00	292.5	39.5	0.234	0.202	169.5	20705[c]	19344[c]
1-Pentene	C_5H_{10}	70.1	85.9	-265.4	87.5	0.646	5.38	376.9	35	0.240	0.236	154.5	20546	19185
cis-2-Pentene	C_5H_{10}	70.1	98.5	-240.5	82.6	0.661	5.50	397.	35	0.23	0.27	160.1	20499	19138
trans-2-Pentene	C_5H_{10}	70.1	97.4	-220.5	85.2	0.653	5.44	396.	35	0.23	0.26	159.8	20472	19090
2-Methyl-1-butene	C_5H_{10}	70.1	88.1	-215.6	84.2	0.656	5.46	378.	35	0.23	0.25	156.3	20451	19090
3-Methyl-1-butene	C_5H_{10}	70.1	68.1	-271.3	92.0	0.633	5.27	351.	34	0.24	0.21	147.5	20505	19144
2-Methyl-2-butene	C_5H_{10}	70.1	101.4	-208.8	80.3	0.668	5.56	387.	34	0.22	0.28	161.3	20404	19043
1-Hexene	C_6H_{12}	84.2	146.3	-219.7	77.2	0.678	5.65	447.5	31.0	0.23	0.28	144.4	20465	19104
cis-2-Hexene	C_6H_{12}	84.2	156.0	-222.1	73.0	0.692	5.76	458[d]	32[d]	0.24[d]	0.32	148.8	20406	19045
trans-2-Hexene	C_6H_{12}	84.2	154.2	-207.4	75.7	0.683	5.69	456[d]	32[d]	0.24[d]	0.31	147.7	20397	19036
cis-3-Hexene	C_6H_{12}	84.2	151.6	-216.1	75.1	0.685	5.70	453[d]	32[d]	0.24[d]	0.31	146.6	20431	19070
trans-3-Hexene	C_6H_{12}	84.2	152.8	-172.2	76.0	0.682	5.68	454[d]	32[d]	0.24[d]	0.31	147.9	20395	19034
1-Heptene	C_7H_{14}	98.2	200.6	-182.0	70.1	0.702	5.85	507.3	28.0	0.22	0.332	136.2	20408	19047
1-Octene	C_8H_{16}	112.2	250.3	-151.1	65.3	0.719	5.99	560.1	26.0	0.22	0.381	129.3	20366	19005
DIOLEFINS														
Propadiene	C_3H_4	40.1	- 30.1	-213.3	106	0.585	4.96	248	54[d]	0.25[d]	0.15	218.0	20872[c]	19922[c]
1,2-Butadiene	C_4H_6	54.1	51.5	-213.2	83.5	0.658	5.48	339[d]	44[d]	0.25[d]	0.25	181.0	20621[c]	19568[c]

a. In air, @ 60°F.
b. Hypothetical (extrapolated) value.
c. Heat of combustion as a gas, otherwise as a liquid.
d. Estimated.

Table 1 Continued. PHYSICAL CONSTANTS OF HYDROCARBONS

	FORMULA	MOLEC. WT.	BOILING POINT °F	MELTING POINT °F	DENSITY °API	DENSITY Sp Gr 60/60	DENSITY Lb/Gal[a]	CRITICAL CONSTANTS c °F	CRITICAL CONSTANTS P Atm	CRITICAL CONSTANTS D g/ml	ACENTRIC FACTOR	HEAT OF VAPORIZ. @ B.P. Btu/lb	HEAT OF COMBUSTION @ 60°F Btu/lb GROSS	HEAT OF COMBUSTION @ 60°F Btu/lb NET
DIOLEFINS (continued)														
1,3-Butadiene	C_4H_6	54.1	24.1	-164.0	94.2	0.627	5.22	306	42.7	0.245	0.199	174.0	20208[c]	19152[c]
1,2-Pentadiene	C_5H_8	68.1	112.7	-215.1	71.2	0.698	5.81	446[d]	40[d]	0.25[d]	0.18	160.0	20347	19227
1,cis-3-Pentadiene	C_5H_8	68.1	111.3	-221.5	71.8	0.696	5.80	438[d]	40[d]	0.25[d]	0.20	160.0	19984	18864
1,trans-3-Pentadiene	C_5H_8	68.1	107.7	-125.4	76.3	0.681	5.67	434[d]	39[d]	0.25[d]	0.19	158.0	19944	18823
1,4-Pentadiene	C_5H_8	68.1	78.7	-234.9	81.0	0.666	5.55	400[d]	37[d]	0.25[d]	0.13	146.0	20151	19031
3-Methyl-1,2-butadiene	C_5H_8	68.1	105.5	-172.5	75.1	0.685	5.70	434[d]	39[d]	0.25[d]	0.17	156.0	20280	19158
2-Methyl-1,3-butadiene (Isoprene)	C_5H_8	68.1	93.3	-230.7	74.8	0.686	5.71	412[d]	38[d]	0.25[d]	0.18	153.0	19951	18830
1,5-Hexadiene	C_6H_{10}	82.1	139.0	-221.3	71.5	0.697	5.80	478[d]	34[d]	0.25[d]	0.16	134.0	20138	18960
2,3-Dimethyl-1,3-butadiene	C_6H_{10}	82.1	155.8	-104.9	62.1	0.731	6.09	489[d]	35[d]	0.25[d]	0.22	141.0	19890	18706
ACETYLENES														
Acetylene	C_2H_2	26.0	-119[e]	-114.0	209	0.416	3.46	95.3	60.6	0.231	0.207	-	21463[c]	20730[c]
Propyne (Methylacetylene)	C_3H_4	40.1	- 9.8	-152.9	94.9	0.625	5.20	264.6	55.5	0.245	0.226	175.0	20801[c]	19848[c]
1-Butyne (Ethylacetylene)	C_4H_6	54.1	46.5	-194.3	86.2	0.650	5.41	375.0	47[d]	0.24[d]	0.10	179.0	20643[c]	19587[c]
2-Butyne (Dimethylacetylene)	C_4H_6	54.1	80.6	- 26.0	71.5	0.697	5.80	419.	50[d]	0.24[d]	0.16	197.0	20281	19223
1-Pentyne (Propylacetylene)	C_5H_8	68.1	104.3	-158.3	72.1	0.695	5.79	428.	40[d]	0.25[d]	0.20	157.0	20374	19251
2-Pentyne	C_5H_8	68.1	132.9	-164.7	66.1	0.716	5.96	482[d]	42[d]	0.25[d]	0.18	167.0	20263	19140
3-Methyl-1-butyne	C_5H_8	68.1	79.4	-130.5	79.1	0.672	5.60	403[d]	40[d]	0.25[d]	0.14	-	20340	19217
1-Hexyne	C_6H_{10}	82.1	160.4	-205.4	64.8	0.721	6.00	506[d]	35[d]	0.25[d]	0.19	140.0	20351	19178
2-Hexyne	C_6H_{10}	82.1	184.1	-129.1	60.8	0.736	6.13	534[d]	34[d]	0.25[d]	0.21	-	-	-
3-Hexyne	C_6H_{10}	82.1	178.6	-153.6	63.1	0.727	6.05	538[d]	35[d]	0.25[d]	0.18	144.0	20259	19099

a. In air, @ 60°F.
c. Heat of combustion as a gas, otherwise as a liquid.
d. Estimated.
e. Sublimes.

Table 1 Continued. PHYSICAL CONSTANTS OF HYDROCARBONS

	FORMULA	MOLEC. WT.	BOILING POINT °F	MELTING POINT °F	DENSITY °API	DENSITY Sp Gr 60/60	DENSITY Lb/Gal[a]	CRITICAL CONSTANTS t °F	CRITICAL CONSTANTS P Atm	CRITICAL CONSTANTS D g/ml	ACENTRIC FACTOR	HEAT OF VAPORIZ. @ B.P. Btu/lb	HEAT OF COMBUSTION @ 60°F Btu/lb GROSS	HEAT OF COMBUSTION @ 60°F Btu/lb NET
OLEFIN-ACETYLENES														
3-Butene-1-yne (Vinylacetylene)	C_4H_4	52.1	42.0	-	73.9	0.689	5.74	361[d]	48[d]	0.26[d]	0.13	-	-	-
1-Pentene-3-yne	C_5H_6	66.1	138.6	-	58.7	0.744	6.20	492[d]	41[d]	0.26[d]	0.17	-	-	-
1-Pentene-4-yne (Allylacetylene)	C_5H_6	66.1	107.0	-	49.4	0.782	6.51	441[d]	41[d]	0.26[d]	0.17	-	-	-
2-Methyl-1-butene-3-yne	C_5H_6	66.1	90.0	-	78.1	0.675	5.62	414[d]	41[d]	0.26[d]	0.17	-	-	-
AROMATICS														
Benzene	C_6H_6	78.1	176.2	42.0	28.4	0.885	7.37	552.1	48.3	0.302	0.220	169.3	17991	17258
Toluene	C_7H_8	92.1	231.1	-138.9	30.8	0.872	7.26	605.4	40.5	0.292	0.267	154.8	18251	17422
o-Xylene	C_8H_{10}	106.2	291.9	- 13.3	28.4	0.885	7.37	674.8	36.8	0.288	0.297	149.1	18445	17546
m-Xylene	C_8H_{10}	106.2	282.4	- 54.1	31.3	0.869	7.24	650.9	35.0	0.282	0.318	147.2	18441	17543
p-Xylene	C_8H_{10}	106.2	281.0	55.9	31.9	0.866	7.21	649.4	34.7	0.280	0.306	144.5	18445	17547
Ethylbenzene	C_8H_{10}	106.2	277.1	-138.9	30.8	0.872	7.26	651.1	35.6	0.284	0.307	144.0	18493	17595
1,2,3-Trimethylbenzene	C_9H_{12}	120.2	349.0	- 13.7	25.9	0.899	7.49	736.3	34.1	0.313	0.315	143.2	18601	17649
1,2,4-Trimethylbenzene (Pseudocumene)	C_9H_{12}	120.2	336.8	- 46.8	29.3	0.880	7.33	708.6	31.9	0.313	0.345	140.4	18590	17637
1,3,5-Trimethylbenzene (Mesitylene)	C_9H_{12}	120.2	328.5	- 48.5	31.1	0.870	7.25	687.4	30.9	0.313	0.383	139.6	18584	17631
n-Propylbenzene	C_9H_{12}	120.2	318.6	-147.1	31.7	0.867	7.22	689.3	31.6	0.273	0.346	136.8	18674	17721
Isopropylbenzene (Cumene)	C_9H_{12}	120.2	306.3	-140.8	31.9	0.866	7.21	676.2	31.7	0.285	0.293	134.3	18665	17711
1-Methyl-2-ethylbenzene	C_9H_{12}	120.2	329.3	-113.4	28.4	0.885	7.27	712.	30.	0.26	0.31	139.0	18645	17692
1-Methyl-3-ethylbenzene	C_9H_{12}	120.2	322.4	-140.0	31.3	0.869	7.24	687.	28.	0.25	0.38	137.8	18637	17684
1-Methyl-4-ethylbenzene	C_9H_{12}	120.2	323.6	- 80.2	31.9	0.866	7.21	693.	29.	0.26	0.39	137.4	18634	17680
1,2,4,5-Tetramethylbenzene (Durene)	$C_{10}H_{14}$	134.2	386.2	174.6	27.1[g]	0.892[g]	7.43[g]	756.	29.	0.28	0.43	145.8	-	-
Naphthalene	$C_{10}H_8$	128.2	424.3	176.5	7.9[g]	1.015[g]	8.45[g]	887.5	40.0	0.31	0.30	-	17302[f]	16721[f]

a. In air, @ 60°F.
d. Estimated.
f. Heat of combustion as a solid.
g. For the supercooled liquid below normal melting point.

Table 1 Continued. PHYSICAL CONSTANTS OF HYDROCARBONS

	FORMULA	MOLEC. WT.	BOILING POINT °F	MELTING POINT °F	DENSITY °API	DENSITY Sp Gr 60/60	DENSITY Lb/Gal[a]	CRITICAL CONSTANTS t °F	CRITICAL CONSTANTS P Atm	CRITICAL CONSTANTS D g/ml	ACENTRIC FACTOR	HEAT OF VAPORIZ. @ B.P. Btu/lb	HEAT OF COMBUSTION @ 60°F Btu/lb GROSS	HEAT OF COMBUSTION @ 60°F Btu/lb NET
AROMATICS (continued)														
1,2,3,4-Tetrahydronaphthalene (Tetralin)	$C_{10}H_{12}$	132.2	405.6	- 32.4	13.6	0.975	8.12	830[d]	33[d]	0.30[d]	0.33	-	-	-
cis-Decahydronaphthalene (cis-Decalin)	$C_{10}H_{18}$	138.2	384.2	- 45.4	25.5	0.901	7.50	804.2	29[d]	0.28[d]	0.33	-	19367	18324
trans-Decahydronaphthalene (trans-Decalin)	$C_{10}H_{18}$	138.2	369.1	- 22.7	30.4	0.874	7.28	776.8	29[d]	0.28[d]	0.33	-	19532	18289
NAPHTHENES														
Cyclopropane	C_3H_6	42.1	- 27.0	-197.4	120	0.564	4.69	256.4	54.2	0.246	0.135	204.8	21378[c]	20017[c]
Cyclobutane	C_4H_8	56.1	54.5	-131.3	70.7	0.700	5.82	368.2	49.2	0.267	0.189	185.3	21038[c]	19675[c]
Cyclopentane	C_5H_{10}	70.1	120.7	-136.9	56.9	0.751	6.25	461.3	44.5	0.270	0.203	167.3	20188	18827
Methylcyclopentane	C_6H_{12}	84.1	161.3	-224.4	56.2	0.754	6.28	499.2	37.4	0.264	0.238	147.8	20130	18769
Cyclohexane	C_6H_{12}	84.1	177.3	43.8	49.2	0.783	6.52	536.5	40.2	0.273	0.213	153.0	20034	18676
Methylcyclohexane	C_7H_{14}	98.2	213.7	-195.9	51.3	0.774	6.45	570.2	34.3	0.267	0.242	136.3	20000	18639
Ethylcyclopentane	C_7H_{14}	98.2	218.2	-217.2	52.0	0.771	6.42	565.3	33.5	0.262	0.284	141.4	20120	18759
1,1-Dimethylcyclopentane	C_7H_{14}	98.2	190.1	- 93.6	54.9	0.759	6.32	530[d]	35[d]	0.28[d]	0.27	132.6	20082	18721
1,cis-2-Dimethylcyclopentane	C_7H_{14}	98.2	211.2	- 65.0	50.6	0.777	6.47	557[d]	34[d]	0.27[d]	0.27	138.8	20113	18752
1,trans-2-Dimethylcyclopentane	C_7H_{14}	98.2	197.4	-179.6	55.7	0.756	6.30	539[d]	34[d]	0.27[d]	0.26	135.1	20086	18724
1,cis-3-Dimethylcyclopentane	C_7H_{14}	98.2	195.4	-208.7	57.2	0.750	6.25	539[d]	35[d]	0.28[d]	0.26	134.3	20091	18730
1,trans-3-Dimethylcyclopentane	C_7H_{14}	98.2	197.1	-209.2	56.2	0.754	6.28	539[d]	34[d]	0.27[d]	0.26	134.9	20100	18739
Cyclopentene	C_5H_8	68.1	111.6	-211.2	45.6	0.799	6.65	451.2	47.3	0.275	0.168	-	19672	18551
Methylcyclopentadiene	C_6H_8	80.1	165.0	-	41.1	0.820	6.83	521[d]	42[d]	0.28[d]	0.22	-	-	-
1,5-Cyclooctadiene	C_8H_{12}	108.2	301.0	- 69.5	28.0	0.887	7.39	704[d]	38[d]	0.30[d]	0.28	-	-	-

a. In air, @ 60°F. c. Heat of combustion as a gas, otherwise as a liquid.
d. Estimated.

Table 2. PHYSICAL CONSTANTS OF ORGANIC COMPOUNDS

	FORMULA	MOLEC. WT.	BOILING POINT °F	MELTING POINT °F	DENSITY		CRITICAL CONSTANTS			ACENTRIC FACTOR	HEAT OF VAPORIZ. @ B.P. Btu/lb	HEAT OF COMBUSTION @ 60°F Btu/lb	
					Sp Gr 60/60	Lb/Gal[a]	t °F	P Atm	D g/ml			GROSS	NET
ALCOHOLS													
Methanol (Methyl alcohol)	CH_3OH	32.0	148.5	-143.8	0.796	6.64	463.0	79.9	0.272	0.569	464	9770	8570
Ethanol (Ethyl alcohol)	CH_3CH_2OH	46.1	172.9	-173.4	0.794	6.62	469.6	63.0	0.276	0.635	361	12750	11510
1-Propanol (n-Propyl alcohol)	$CH_3CH_2CH_2OH$	60.1	207.0	-195.2	0.808	6.74	506.4	51.0	0.275	0.621	299	14460	13190
2-Propanol (Isopropyl alcohol)	$(CH_3)_2CHOH$	60.1	180.2	-127.3	0.790	6.59	455.3	47.0	0.273	0.666	285	14350	13080
1-Butanol (n-Butyl alcohol)	$CH_3CH_2CH_2CH_2OH$	74.1	243.8	-128.7	0.814	6.78	553.6	43.6	0.270	0.590	250	15530	14250
2-Butanol (sec-Butyl alcohol)	$CH_3CH_2CH(OH)CH_3$	74.1	211.3	-174.5	0.812	6.77	505.0	41.4	0.276	0.578	237	15490	14200
2-Methyl-1-propanol (Isobutyl alcohol)	$(CH_3)_2CHCH_2OH$	74.1	225.8	-162.0	0.806	6.72	526.2	42.4	0.273	0.587	244	15450	14160
2-Methyl-2-propanol (tert-Butyl alcohol)	$(CH_3)_3COH$	74.1	180.4	78.2	0.792	6.60	451.4	39.2	0.270	0.615	226	15350	14060
1-Pentanol	$CH_3(CH_2)_3CH_2OH$	88.2	280.0	-108.8	0.819	6.83	595.0	37[d]	0.27[d]	0.58	216	16240	14940
2-Pentanol	$CH_3(CH_2)_2CH(OH)CH_3$	88.2	246.2	-	0.814	6.78	560[d]	35[d]	0.27[d]	0.48	210	16170	14870
3-Pentanol	$(CH_3CH_2)_2CHOH$	88.2	239.5	-	0.825	6.88	550[d]	35[d]	0.27[d]	0.48	206	16170	14870
2-Methyl-1-butanol	$CH_3CH_2CH(CH_3)CH_2OH$	88.2	263.7	-	0.823	6.86	593[d]	38[d]	0.27[d]	0.47	214	16220	14920
2-Methyl-2-butanol	$CH_3CH_2C(OH)(CH_3)_2$	88.2	215.6	16.2	0.814	6.79	522.	34[d]	0.27[d]	0.44	196	16110	14810
3-Methyl-1-butanol	$(CH_3)_2CHCH_2CH_2OH$	88.2	266.9	-	0.814	6.79	583.3	38[d]	0.27[d]	0.50	215	16220	14920
3-Methyl-2-butanol	$(CH_3)_2CHCH(OH)CH_3$	88.2	232.7	-	0.822	6.86	550[d]	36[d]	0.27[d]	0.44	202	16170	14870
2,2-Dimethyl-1-propanol	$(CH_3)_3CCH_2OH$	88.2	235.6	125.6	0.823	6.86	555[d]	38[d]	0.27[d]	0.46	213	-	-
1-Octanol	$CH_3(CH_2)_6CH_2OH$	130.2	383.4	4.1	0.830	6.92	725.0	29[d]	0.27[d]	0.56	155	17490	16170
2-Ethyl-1-hexanol	$CH_3(CH_2)_3CH(C_2H_5)CH_2OH$	130.2	364.3	- 94.0	0.837	6.98	700[d]	30[d]	0.27[d]	0.56	170[d]	17470	16150
1-Tridecanol	$CH_3(CH_2)_{11}CH_2OH$	200.4	525.2	87.1	0.835	6.97	875[d]	21[d]	0.26[d]	0.6[d]	130[d]	-	-
1-Hexadecanol (Cetyl alcohol)	$CH_3(CH_2)_{14}CH_2OH$	242.4	593.6	120.6	0.842	7.02	920[d]	17[d]	0.26[d]	0.7[d]	115[d]	18580	17240

a. In air, @ 60°F. d. Estimated.

Table 2 Continued. PHYSICAL CONSTANTS OF ORGANIC COMPOUNDS

	FORMULA	MOLEC. WT.	BOILING POINT °F	MELTING POINT °F	DENSITY		CRITICAL CONSTANTS			ACENTRIC FACTOR	HEAT OF VAPORIZ. @ B.P. Btu/lb	HEAT OF COMBUSTION @ 60°F Btu/lb	
					Sp Gr 60/60	Lb/Gal[a]	t °F	P Atm	D g/ml			GROSS	NET
GLYCOLS AND GLYCEROL													
1,2-Ethanediol (Ethylene glycol)	CH_2OHCH_2OH	62.1	387.1	8.6	1.118	9.32	700[d]	75[d]	0.33[d]	-	380[d]	8240	7320
1,2-Propanediol (Propylene glycol)	$CH_3CH(OH)CH_2OH$	76.1	369.7	- 76[h]	1.040	8.67	670[d]	60[d]	0.32[d]	-	300[d]	10310	9300
1,3-Propanediol (Trimethylene glycol)	$CH_2OHCH_2CH_2OH$	76.1	417.9	- 16.1	1.057	8.82	725[d]	60[d]	0.32[d]	-	320[d]	-	-
1,2,3-Propanetriol (Glycerol)	$CH_2(OH)CH(OH)CH_2OH$	92.1	554.0	65	1.265	10.53	850[d]	65[d]	0.36[d]	-	310[d]	10850	10020
ETHERS													
Dimethyl ether	CH_3OCH_3	46.1	- 12.7	-222.7	0.676	5.64	260.4	53.0	0.242	0.189	201	13630[c]	12390[c]
Diethyl ether	$CH_3CH_2OCH_2CH_3$	74.1	94.2	-177.3	0.719	6.00	380.4	35.9	0.265	0.281	155	15810	14530
Di-n-propyl ether	$CH_3(CH_2)_2O(CH_2)_2CH_3$	102.2	193.4	-189.8	0.752	6.27	490[d]	29[d]	0.26[d]	0.38	133	16050	14810
Diisopropyl ether	$(CH_3)_2CHOCH(CH_3)_2$	102.2	154.9	-121.9	0.729	6.08	440.4	28.4	0.265	0.341	123	15960	14720
Di-n-butyl ether	$CH_3(CH_2)_3O(CH_2)_3CH_3$	130.2	288.0	-144.0	0.773	6.44	585[d]	25[d]	0.27[d]	0.51	122	17650	16330
Di-sec-butyl ether	$[CH_3CH_2CH(CH_3)]_2O$	130.2	250.0	-	0.760	6.34	546[d]	25[d]	0.27[d]	0.43[d]	114[d]	17570	16260
ALDEHYDES													
Methanal (Formaldehyde)	HCHO	30.0	- 2.4	-133.6	-	-	-	-	-	-	331[d]	8180[c]	7540[c]
Ethanal (Acetaldehyde)	CH_3CHO	44.0	68.7	-189.4	0.785	6.54	370.	55[d]	0.26[d]	0.31	262[d]	11380	10510
Propanal (Propionaldehyde)	CH_3CH_2CHO	58.1	118.4	-112.0	0.803	6.69	475[d]	45[d]	0.26[d]	0.34	217[d]	13460	12470
n-Butanal (Butyraldehyde)	$CH_3CH_2CH_2CHO$	72.1	166.6	-141.5	0.807	6.73	485[d]	40[d]	0.26[d]	0.35	191[d]	14790	13730
2-Methylpropanal (Isobutyraldehyde)	$(CH_3)_2CHCHO$	72.1	147.4	- 85.0	0.795	6.63	465[d]	40[d]	0.26[d]	0.35	185[d]	14770	13660
n-Octanal (Caprylaldehyde)	$CH_3(CH_2)_5CH_2CHO$	128.2	345.2	- 16.6	0.825	6.88	655[d]	25[d]	0.26[d]	0.56	136[d]	-	-

a. In air, @ 60°F.
c. Heat of combustion as a gas, otherwise as a liquid.
d. Estimated.
h. Sets to a glass below this temperature.

Table 2 Continued. PHYSICAL CONSTANTS OF ORGANIC COMPOUNDS

	FORMULA	MOLEC. WT.	BOILING POINT °F	MELTING POINT °F	DENSITY		CRITICAL CONSTANTS			ACENTRIC FACTOR	HEAT OF VAPORIZ. @ B.P. Btu/lb	HEAT OF COMBUSTION @ 60°F Btu/lb	
					Sp Gr 60/60	Lb/Gal[a]	t °F	P Atm	D g/ml			GROSS	NET
KETONES													
2-Propanone (Acetone)	CH_3COCH_3	58.1	133.3	-138.5	0.796	6.63	455.0	46.4	0.278	0.310	220	13250	12270
2-Butanone (Methyl ethyl ketone)	$CH_3COCH_2CH_3$	72.1	175.4	-124.4	0.810	6.76	504.5	41.0	0.270	0.359	190	14580	13520
2-Pentanone (Methyl n-propyl ketone)	$CH_3COCH_2CH_2CH_3$	86.1	216.2	-106.4	0.812	6.77	555.4	38.4	0.286	0.34	171[d]	15480	14380
3-Pentanone (Diethyl ketone)	$(CH_3CH_2)_2CO$	86.1	215.6	- 38.2	0.819	6.83	550.0	36.9	0.256	0.34	171[d]	15490	14390
3-Methyl-2-butanone (Methyl isopropyl ketone)	$CH_3COCH(CH_3)_2$	86.1	201.9	-133.6	0.808	6.74	536.4	38.0	0.278	0.35	167[d]	15470	14370
4-Methyl-2-butanone (Methyl isobutyl ketone)	$CH_3COCH_2CH(CH_3)_2$	100.2	241.7	-119.2	0.806	6.72	568.	32.3	0.28[d]	0.39	153[d]	-	-
4-Methyl-3-pentene-2-one (Mesityl oxide)	$(CH_3)_2C{:}CHCOCH_3$	98.1	266.0	- 63.2	0.860	7.20	620[d]	35[d]	0.29[d]	0.36	162[d]	-	-
ACIDS													
Methanoic acid (Formic acid)	HCOOH	46.0	213.0	47.1	1.227	10.23	-	-	-	-	350[d]	2370	1960
Ethanoic acid (Acetic acid)	CH_3COOH	60.1	244.2	62.0	1.055	8.80	610.3	57.1	0.351	0.446	280[d]	6270	5630
Propanoic acid (Propionic acid)	CH_3CH_2COOH	74.1	285.5	- 5.3	0.999	8.33	642[d]	53[d]	0.32[d]	0.54	240[d]	8870	8090
n-Butanoic acid (Butyric acid)	$CH_3CH_2CH_2COOH$	88.1	325.9	22.6	0.964	8.03	671[d]	52[d]	0.30[d]	0.67	210[d]	12680	11650
2-Methylpropanoic acid (Isobutyric acid)	$(CH_3)_2CHCOOH$	88.1	310.5	- 50.8	0.954	7.95	637[d]	40[d]	0.30[d]	0.67	210[d]	-	-

a. In air, @ 60°F. d. Estimated.

Table 3. PHYSICAL CONSTANTS OF MISCELLANEOUS MATERIALS

	FORMULA	MOLEC. WT.	BOILING POINT °F	MELTING POINT °F	DENSITY		CRITICAL CONSTANTS			ACENTRIC FACTOR	HEAT OF VAPORIZ. @ B.P. Btu/lb	HEAT OF COMBUSTION @ 60°F Btu/lb	
					Sp Gr 60/60	Lb/Gal[a]	t °F	P Atm	D g/ml			GROSS	NET
Acetonitrile	CH_3CN	41.1	178.9	- 50.3	0.787	6.55	526.	47.7	0.237	0.323	329.5	-	-
Ammonia	NH_3	17.0	- 28.1	-107.9	0.617	5.15	270.5	112.5	0.235	0.257	590.9	-	-
Argon	Ar	40.0	-302.5	-308.9	1.392[i]	11.62	-188.5	48.0	0.531	0	70.0	-	-
Carbon dioxide	CO_2	44.0	-109.2[e]	- 69.9	0.820	6.84	87.8	72.8	0.468	0.225	149.6[j]	-	-
Carbon monoxide	CO	28.0	-312.7	-337.0	0.789[i]	6.58	-220.4	34.5	0.301	0.049	92.8	4345[c]	4345[c]
Carbonyl sulfide	COS	60.1	- 58.4	-217.8	1.005	8.39	216.	58.	0.44	0.13	-	-	-
Chlorine	Cl_2	70.9	- 29.3	-149.8	1.427	11.88	291.2	76.1	0.573	0.073	123.8	-	-
Diethanolamine	$HN(CH_2CH_2OH)_2$	105.1	515.1	77.2	1.098	9.14	828[d]	32[d]	0.28[d]	1.04	267.0	-	-
Dinitrogen tetroxide	N_2O_4	92.0	69.8	11.8	1.457	12.16	316.8	100.	0.55	0.852	178.2	-	-
Ethyl chloride	CH_3CH_2Cl	64.5	54.3	-216.9	0.903	7.54	369.0	52.	0.33	0.192	164.7	-	-
Ethyl mercaptan	CH_3CH_2SH	62.1	95.0	-234.2	0.845	7.05	439.	54.2	0.300	0.187	185.5	-	-
Helium	He	4.0	-452.1	-455.8	0.125[i]	1.04	-450.3	2.3	0.069	-0.387	8.7	-	-
Hydrogen	H_2	2.0	-423.0	-434.6	0.0711[i]	0.59	-399.8	12.8	0.031	-0.223	194.4	61100[c]	51600[c]
Hydrogen chloride	HCl	36.5	-121.0	-173.5	0.827	6.90	124.7	82.0	0.45	0.125	190.6	-	-
Hydrogen fluoride	HF	20.0	67.1	-118.1	0.986	8.23	370.0	64.0	0.29	0.374	175.5	-	-
Hydrogen sulfide	H_2S	34.1	- 76.6	-122.0	0.786	6.55	212.0	88.2	0.346	0.100	235.6	-	-
Methyl chloride	CH_3Cl	50.5	- 11.6	-143.5	0.929	7.75	289.6	65.9	0.363	0.155	182.3	-	-
Methyl mercaptan	CH_3SH	48.0	42.7	-189.3	0.873	7.28	386.2	71.4	0.332	0.151	220.2	-	-
Monoethanolamine	$H_2NCH_2CH_2OH$	61.1	338.6	50.5	1.015	8.45	646[d]	44[d]	0.28[d]	0.84	357.9	-	-
Nitric oxide	NO	30.0	-241.1	-262.5	1.27[i]	10.60	- 135.2	64.6	0.52	0.489	197.6	-	-
Nitrogen	N_2	28.0	-320.4	-346.0	0.808[i]	6.74	-232.6	33.5	0.311	0.040	85.7	-	-
Nitrous oxide	N_2O	44.0	-127.2	-131.5	0.788	6.58	97.6	71.5	0.452	0.162	161.8	-	-

a. In air, @ 60°F.
c. Heat of combustion as a gas, otherwise as a liquid.
d. Estimated.
e. Sublimes.
i. At normal boiling point.
j. At triple point.

Table 3 Continued. PHYSICAL CONSTANTS OF MISCELLANEOUS MATERIALS

	FORMULA	MOLEC. WT.	BOILING POINT °F	MELTING POINT °F	DENSITY		CRITICAL CONSTANTS			ACENTRIC FACTOR	HEAT OF VAPORIZ. @ B.P. Btu/lb	HEAT OF COMBUSTION @ 60°F Btu/lb	
					Sp Gr 60/60	Lb/Gal[a]	t °F	P Atm	D g/ml			GROSS	NET
Oxygen	O_2	32.0	-297.4	-361.9	1.142[i]	9.53	-181.5	49.8	0.436	0.021	91.7	-	-
Phenol	C_6H_5OH	93.1	359.3	105.6	1.08[g]	9.00	790	60.5	0.356	0.443	211.1	-	-
Sulfur dioxide	SO_2	64.1	14.0	-103.9	1.394	11.63	315.7	77.8	0.525	0.256	170.8	-	-
Sulfur trioxide	SO_3	80.1	112.6	62.3	1.925	16.06	423.9	81.	0.633	0.392	233.5	-	-
Vinyl chloride	CH_2:CHCl	62.5	7.9	-244.8	0.969[i]	8.07	315[d]	55[d]	0.37[d]	0.098	143.0	-	-
Water	H_2O	18.0	212.0	32.0	1.000	8.328	705.5	218.3	0.315	0.344	970.6	-	-

a. In air, @ 60°F.
d. estimated
g. For the supercooled liquid below normal melting point.
i. At normal boiling point.

DENSITY OF HYDROCARBONS

Low-Boiling Hydrocarbons

The specific gravity of the saturated liquid, from low temperatures to the critical point, is given for a number of low-boiling hydrocarbons in Table 4. A hydrocarbon mixture is assumed to be an ideal solution, and its specific gravity can be calculated by adding the products of the specific gravities of individual components times their volume fractions. This assumption is essentially true for members of a homologous series and is a good approximation for mixtures composed of hydrocarbons from different series as long as no component is in the region of its critical temperature. Figures 1 trough 3 provide specific gravity data for paraffins, olefins and diolefins, and aromatics, respectively.

Thermal Expansion of Liquid Petroleum Fractions

Figures 4 through 8 provide thermal expansions of liquid petroleum fractions at pressures up to 1500 psig. As in the case of many physical properties of petroleum fractions, thermal expansion is more sensitive to average boiling point than it is to gravity, although both independent variables are necessary to correlate the data properly. Up to 1.25 multiples of the volume at 60 °F and 1 atm, gravity can be neglected and the thermal expansion can be represented by the molal average boiling point alone. Above this expansion of 1.25 volumes, gravity is introduced into the correlation in the form of a characterization factor. For each average boiling point two lines are shown, one corresponding to a characterization factor of 12.0 and the other to 11.0. Interpolation and extrapolation may be made on the basis of characterization factor.

P-V-T Relations of Hydrocarbon Vapors

A series of charts are given in Figures 9 through 15 for $\mu = PV/RT$, which is the correction factor to be applied to the ideal gas law for hydrocarbon and petroleum vapors. The correction factor is plotted as a function of reduced temperature, T/T_c, and reduced pressure, P/P_c, where T and P are the temperature and pressure of the vapor and T_c and P_c, its critical temperature and pressure. It should be noted that the pseudo-critical, not the true critical, temperature and pressure should always be used for hydrocarbon mixtures. This method of using the pseudo-critical properties of the entire hydrocarbon mixture is not only more accurate but more readily used than the application of either Amagat's Law or Dalton's Law to the individual components.

Since there is evidence of some trend in μ with increase in molecular weight for $T_r \geq 1.00$, there are three sets of charts for the region where T_r is greater than 1.0, covering different ranges of molecular weight.

Table 4.

°API GRAVITY, SPECIFIC GRAVITY (60°/60°) AND POUNDS PER GALLON

-20 TO 5°API

°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON
-20.0	1.2691	10.572	-15.0	1.2146	10.118	-10.0	1.1646	9.701	-5.0	1.1186	9.317	0.0	1.0760	8.962
-19.9	1.2679	10.562	-14.9	1.2136	10.109	-9.9	1.1637	9.693	-4.9	1.1177	9.310	0.1	1.0752	8.956
-19.8	1.2668	10.553	-14.8	1.2125	10.100	-9.8	1.1627	9.685	-4.8	1.1168	9.302	0.2	1.0744	8.949
-19.7	1.2657	10.543	-14.7	1.2115	10.092	-9.7	1.1617	9.677	-4.7	1.1159	9.295	0.3	1.0736	8.942
-19.6	1.2645	10.534	-14.6	1.2104	10.083	-9.6	1.1608	9.669	-4.6	1.1151	9.288	0.4	1.0728	8.935
-19.5	1.2634	10.524	-14.5	1.2094	10.074	-9.5	1.1598	9.661	-4.5	1.1142	9.280	0.5	1.0720	8.928
-19.4	1.2623	10.515	-14.4	1.2084	10.066	-9.4	1.1589	9.653	-4.4	1.1133	9.273	0.6	1.0712	8.922
-19.3	1.2611	10.506	-14.3	1.2073	10.057	-9.3	1.1579	9.645	-4.3	1.1124	9.266	0.7	1.0703	8.915
-19.2	1.2600	10.496	-14.2	1.2063	10.048	-9.2	1.1570	9.637	-4.2	1.1115	9.258	0.8	1.0695	8.908
-19.1	1.2589	10.487	-14.1	1.2053	10.040	-9.1	1.1560	9.629	-4.1	1.1107	9.251	0.9	1.0687	8.901
-19.0	1.2578	10.478	-14.0	1.2043	10.031	-9.0	1.1551	9.622	-4.0	1.1098	9.244	1.0	1.0679	8.895
-18.9	1.2567	10.468	-13.9	1.2032	10.023	-8.9	1.1542	9.614	-3.9	1.1089	9.237	1.1	1.0671	8.888
-18.8	1.2555	10.459	-13.8	1.2022	10.014	-8.8	1.1532	9.606	-3.8	1.1081	9.229	1.2	1.0663	8.881
-18.7	1.2544	10.450	-13.7	1.2012	10.006	-8.7	1.1523	9.598	-3.7	1.1072	9.222	1.3	1.0655	8.875
-18.6	1.2533	10.440	-13.6	1.2002	9.997	-8.6	1.1513	9.590	-3.6	1.1063	9.215	1.4	1.0647	8.868
-18.5	1.2522	10.431	-13.5	1.1992	9.989	-8.5	1.1504	9.582	-3.5	1.1055	9.208	1.5	1.0639	8.861
-18.4	1.2511	10.422	-13.4	1.1981	9.980	-8.4	1.1495	9.575	-3.4	1.1046	9.200	1.6	1.0631	8.855
-18.3	1.2500	10.413	-13.3	1.1971	9.972	-8.3	1.1485	9.567	-3.3	1.1037	9.193	1.7	1.0623	8.848
-18.2	1.2489	10.404	-13.2	1.1961	9.963	-8.2	1.1476	9.559	-3.2	1.1029	9.186	1.8	1.0615	8.841
-18.1	1.2478	10.394	-13.1	1.1951	9.955	-8.1	1.1467	9.551	-3.1	1.1020	9.179	1.9	1.0607	8.835
-18.0	1.2467	10.385	-13.0	1.1941	9.947	-8.0	1.1457	9.544	-3.0	1.1012	9.172	2.0	1.0599	8.828
-17.9	1.2456	10.376	-12.9	1.1931	9.938	-7.9	1.1448	9.536	-2.9	1.1003	9.165	2.1	1.0591	8.821
-17.8	1.2445	10.367	-12.8	1.1921	9.930	-7.8	1.1439	9.528	-2.8	1.0995	9.158	2.2	1.0583	8.815
-17.7	1.2434	10.358	-12.7	1.1911	9.921	-7.7	1.1430	9.520	-2.7	1.0986	9.150	2.3	1.0575	8.808
-17.6	1.2423	10.349	-12.6	1.1901	9.913	-7.6	1.1421	9.513	-2.6	1.0978	9.143	2.4	1.0568	8.802
-17.5	1.2412	10.340	-12.5	1.1891	9.905	-7.5	1.1411	9.505	-2.5	1.0969	9.136	2.5	1.0560	8.795
-17.4	1.2401	10.331	-12.4	1.1881	9.896	-7.4	1.1402	9.497	-2.4	1.0961	9.129	2.6	1.0552	8.788
-17.3	1.2391	10.322	-12.3	1.1871	9.888	-7.3	1.1393	9.490	-2.3	1.0952	9.122	2.7	1.0544	8.782
-17.2	1.2380	10.312	-12.2	1.1861	9.880	-7.2	1.1384	9.482	-2.2	1.0944	9.115	2.8	1.0536	8.775
-17.1	1.2369	10.303	-12.1	1.1851	9.872	-7.1	1.1375	9.474	-2.1	1.0935	9.108	2.9	1.0528	8.769
-17.0	1.2358	10.294	-12.0	1.1841	9.863	-7.0	1.1365	9.467	-2.0	1.0927	9.101	3.0	1.0520	8.762
-16.9	1.2347	10.285	-11.9	1.1831	9.855	-6.9	1.1356	9.459	-1.9	1.0918	9.094	3.1	1.0513	8.756
-16.8	1.2337	10.276	-11.8	1.1821	9.847	-6.8	1.1347	9.452	-1.8	1.0910	9.087	3.2	1.0505	8.749
-16.7	1.2326	10.268	-11.7	1.1811	9.839	-6.7	1.1338	9.444	-1.7	1.0901	9.080	3.3	1.0497	8.743
-16.6	1.2315	10.259	-11.6	1.1802	9.830	-6.6	1.1329	9.437	-1.6	1.0893	9.073	3.4	1.0489	8.736
-16.5	1.2304	10.250	-11.5	1.1792	9.822	-6.5	1.1320	9.429	-1.5	1.0885	9.066	3.5	1.0481	8.730
-16.4	1.2294	10.241	-11.4	1.1782	9.814	-6.4	1.1311	9.421	-1.4	1.0876	9.059	3.6	1.0474	8.723
-16.3	1.2283	10.232	-11.3	1.1772	9.806	-6.3	1.1302	9.414	-1.3	1.0868	9.052	3.7	1.0466	8.717
-16.2	1.2272	10.223	-11.2	1.1762	9.798	-6.2	1.1293	9.406	-1.2	1.0860	9.045	3.8	1.0458	8.710
-16.1	1.2262	10.214	-11.1	1.1752	9.790	-6.1	1.1284	9.399	-1.1	1.0851	9.038	3.9	1.0451	8.704
-16.0	1.2251	10.205	-11.0	1.1743	9.781	-6.0	1.1275	9.391	-1.0	1.0843	9.031	4.0	1.0443	8.697
-15.9	1.2240	10.196	-10.9	1.1733	9.773	-5.9	1.1266	9.384	-0.9	1.0835	9.024	4.1	1.0435	8.691
-15.8	1.2230	10.188	-10.8	1.1723	9.765	-5.8	1.1257	9.376	-0.8	1.0826	9.017	4.2	1.0427	8.685
-15.7	1.2219	10.179	-10.7	1.1714	9.757	-5.7	1.1248	9.369	-0.7	1.0818	9.010	4.3	1.0420	8.678
-15.6	1.2209	10.170	-10.6	1.1704	9.749	-5.6	1.1239	9.362	-0.6	1.0810	9.003	4.4	1.0412	8.672
-15.5	1.2198	10.161	-10.5	1.1694	9.741	-5.5	1.1230	9.354	-0.5	1.0802	8.997	4.5	1.0404	8.665
-15.4	1.2188	10.152	-10.4	1.1685	9.733	-5.4	1.1221	9.347	-0.4	1.0793	8.990	4.6	1.0397	8.659
-15.3	1.2177	10.144	-10.3	1.1675	9.725	-5.3	1.1212	9.339	-0.3	1.0785	8.983	4.7	1.0389	8.653
-15.2	1.2167	10.135	-10.2	1.1665	9.717	-5.2	1.1203	9.332	-0.2	1.0777	8.976	4.8	1.0382	8.646
-15.1	1.2156	10.126	-10.1	1.1656	9.709	-5.1	1.1195	9.324	-0.1	1.0769	8.969	4.9	1.0374	8.640
												5.0	1.0366	8.634

Table 4 Continued.

°API GRAVITY, SPECIFIC GRAVITY (60°/60°) AND POUNDS PER GALLON

5 TO 30°API

°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON
5.0	1.0366	8.634	10.0	1.0000	8.328	15.0	0.9659	8.044	20.0	0.9340	7.778	25.0	0.9042	7.529
5.1	1.0359	8.627	10.1	0.9993	8.322	15.1	0.9652	8.038	20.1	0.9334	7.773	25.1	0.9036	7.524
5.2	1.0351	8.621	10.2	0.9986	8.317	15.2	0.9646	8.033	20.2	0.9328	7.768	25.2	0.9030	7.519
5.3	1.0344	8.615	10.3	0.9979	8.311	15.3	0.9639	8.027	20.3	0.9321	7.762	25.3	0.9024	7.515
5.4	1.0336	8.608	10.4	0.9972	8.305	15.4	0.9632	8.022	20.4	0.9315	7.757	25.4	0.9018	7.510
5.5	1.0328	8.602	10.5	0.9965	8.299	15.5	0.9626	8.016	20.5	0.9309	7.752	25.5	0.9013	7.505
5.6	1.0321	8.596	10.6	0.9958	8.293	15.6	0.9619	8.011	20.6	0.9303	7.747	25.6	0.9007	7.500
5.7	1.0313	8.590	10.7	0.9951	8.287	15.7	0.9613	8.005	20.7	0.9297	7.742	25.7	0.9001	7.495
5.8	1.0306	8.583	10.8	0.9944	8.281	15.8	0.9606	8.000	20.8	0.9291	7.737	25.8	0.8996	7.491
5.9	1.0298	8.577	10.9	0.9937	8.276	15.9	0.9600	7.995	20.9	0.9285	7.732	25.9	0.8990	7.486
6.0	1.0291	8.571	11.0	0.9930	8.270	16.0	0.9593	7.989	21.0	0.9279	7.727	26.0	0.8984	7.481
6.1	1.0283	8.565	11.1	0.9923	8.264	16.1	0.9587	7.984	21.1	0.9273	7.722	26.1	0.8978	7.476
6.2	1.0276	8.558	11.2	0.9916	8.258	16.2	0.9580	7.978	21.2	0.9267	7.717	26.2	0.8973	7.472
6.3	1.0269	8.552	11.3	0.9909	8.252	16.3	0.9574	7.973	21.3	0.9260	7.712	26.3	0.8967	7.467
6.4	1.0261	8.546	11.4	0.9902	8.247	16.4	0.9567	7.967	21.4	0.9254	7.707	26.4	0.8961	7.462
6.5	1.0254	8.540	11.5	0.9895	8.241	16.5	0.9561	7.962	21.5	0.9248	7.702	26.5	0.8956	7.457
6.6	1.0246	8.534	11.6	0.9888	8.235	16.6	0.9554	7.957	21.6	0.9242	7.696	26.6	0.8950	7.453
6.7	1.0239	8.257	11.7	0.9881	8.229	16.7	0.9548	7.951	21.7	0.9236	7.691	26.7	0.8944	7.448
6.8	1.0231	8.521	11.8	0.9874	8.221	16.8	0.9541	7.946	21.8	0.9230	7.686	26.8	0.8939	7.443
6.9	1.0224	8.515	11.9	0.9868	8.218	16.9	0.9535	7.941	21.9	0.9224	7.681	26.9	0.8933	7.439
7.0	1.0217	8.509	12.0	0.9861	8.212	17.0	0.9529	7.935	22.0	0.9218	7.676	27.0	0.9927	7.434
7.1	1.0209	8.503	12.1	0.9854	8.206	17.1	0.9522	7.930	22.1	0.9212	7.671	27.1	0.8922	7.429
7.2	1.0202	8.497	12.2	0.9847	8.201	17.2	0.9516	7.925	22.2	0.9206	7.666	27.2	0.8916	7.425
7.3	1.0195	8.490	12.3	0.9840	8.195	17.3	0.9509	7.919	22.3	0.9200	7.661	27.3	0.8911	7.420
7.4	1.0187	8.484	12.4	0.9833	8.189	17.4	0.9503	7.914	22.4	0.9194	7.656	27.4	0.8905	7.415
7.5	1.0180	8.478	12.5	0.9826	8.184	17.5	0.9497	7.909	22.5	0.9188	7.651	27.5	0.8899	7.411
7.6	1.0173	8.472	12.6	0.9820	8.178	17.6	0.9490	7.903	22.6	0.9182	7.646	27.6	0.8894	7.406
7.7	1.0165	8.466	12.7	0.9813	8.172	17.7	0.9484	7.898	22.7	0.9176	7.642	27.7	0.8888	7.401
7.8	1.0158	8.460	12.8	0.9806	8.166	17.8	0.9478	7.893	22.8	0.9170	7.637	27.8	0.8883	7.397
7.9	1.0151	8.454	12.9	0.9799	8.161	17.9	0.9471	7.887	22.9	0.9165	7.632	27.9	0.8877	7.392
8.0	1.0143	8.448	13.0	0.9792	8.155	18.0	0.9465	7.882	23.0	0.9159	7.627	28.0	0.8871	7.387
8.1	1.0136	8.442	13.1	0.9786	8.150	18.1	0.9459	7.877	23.1	0.9153	7.622	28.1	0.8866	7.383
8.2	1.0129	8.436	13.2	0.9779	8.144	18.2	0.9452	7.872	23.2	0.9147	7.617	28.2	0.8860	7.378
8.3	1.0122	8.430	13.3	0.9772	8.138	18.3	0.9446	7.866	23.3	0.9141	7.612	28.3	0.8855	7.373
8.4	1.0114	8.424	13.4	0.9765	8.133	18.4	0.9440	7.861	23.4	0.9135	7.607	28.4	0.8849	7.369
8.5	1.0107	8.418	13.5	0.9759	8.127	18.5	0.9433	7.856	23.5	0.9129	7.602	28.5	0.8844	7.364
8.6	1.0100	8.412	13.6	0.9752	8.121	18.6	0.9427	7.851	23.6	0.9123	7.597	28.6	0.8838	7.360
8.7	1.0093	8.406	13.7	0.9745	8.116	18.7	0.9421	7.845	23.7	0.9117	7.592	28.7	0.8833	7.355
8.8	1.0086	8.400	13.8	0.9738	8.110	18.8	0.9415	7.840	23.8	0.9111	7.587	28.8	0.8827	7.350
8.9	1.0078	8.394	13.9	0.9732	8.105	18.9	0.9408	7.835	23.9	0.9106	7.582	28.9	0.8822	7.346
9.0	1.0071	8.388	14.0	0.9725	8.099	19.0	0.9402	7.830	24.0	0.9100	7.578	29.0	0.8816	7.341
9.1	1.0064	8.382	14.1	0.9718	8.093	19.1	0.9396	7.824	24.1	0.9094	7.573	29.1	0.8811	7.337
9.2	1.0057	8.376	14.2	0.9712	8.088	19.2	0.9390	7.819	24.2	0.9088	7.568	29.2	0.8805	7.332
9.3	1.0050	8.370	14.3	0.9705	8.082	19.3	0.9383	7.814	24.3	0.9082	7.563	29.3	0.8800	7.327
9.4	1.0043	8.364	14.4	0.9698	8.077	19.4	0.9377	7.809	24.4	0.9076	7.558	29.4	0.8794	7.323
9.5	1.0035	8.358	14.5	0.9692	8.071	19.5	0.9371	7.804	24.5	0.9071	7.553	29.5	0.8789	7.318
9.6	1.0028	8.352	14.6	0.9685	8.066	19.6	0.9365	7.798	24.6	0.9065	7.548	29.6	0.8783	7.314
9.7	1.0021	8.346	14.7	0.9679	8.060	19.7	0.9358	7.793	24.7	0.9059	7.544	29.7	0.8778	7.309
9.8	1.0014	8.340	14.8	0.9672	8.055	19.8	0.9352	7.788	24.8	0.9053	7.539	29.8	0.8772	7.305
9.9	1.0007	8.334	14.9	0.9665	8.049	19.9	0.9346	7.783	24.9	0.9047	7.534	29.9	0.8767	7.300
												30.0	0.8762	7.296

Table 4 Continued.

°API GRAVITY, SPECIFIC GRAVITY (60°/60°) AND POUNDS PER GALLON

30 TO 55°API

°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON
30.0	0.8762	7.296	35.0	0.8499	7.076	40.0	0.8251	6.870	45.0	0.8017	6.675	50.0	0.7796	6.491
30.1	0.8756	7.291	35.1	0.8493	7.072	40.1	0.8246	6.866	45.1	0.8012	6.671	50.1	0.7792	6.487
30.2	0.8751	7.287	35.2	0.8488	7.068	40.2	0.8241	6.862	45.2	0.8008	6.667	50.2	0.7788	6.483
30.3	0.8745	7.282	35.3	0.8483	7.064	40.3	0.8236	6.858	45.3	0.8003	6.663	50.3	0.7783	6.480
30.4	0.8740	7.278	35.4	0.8478	7.059	40.4	0.8232	6.854	45.4	0.7999	6.660	50.4	0.7779	6.476
30.5	0.8735	7.273	35.5	0.8473	7.055	40.5	0.8227	6.850	45.5	0.7994	6.656	50.5	0.7775	6.473
30.6	0.8729	7.269	35.6	0.8468	7.051	40.6	0.8222	6.846	45.6	0.7990	6.652	50.6	0.7770	6.469
30.7	0.8724	7.264	35.7	0.8463	7.047	40.7	0.8217	6.842	45.7	0.7985	6.648	50.7	0.7766	6.466
30.8	0.8718	7.260	35.8	0.8458	7.042	40.8	0.8212	6.838	45.8	0.7981	6.645	50.8	0.7762	6.462
30.9	0.8713	7.255	35.9	0.8453	7.038	40.9	0.8208	6.834	45.9	0.7976	6.641	50.9	0.7758	6.459
31.0	0.8708	7.251	36.0	0.8448	7.034	41.0	0.8203	6.830	46.0	0.7972	6.637	51.0	0.7753	6.455
31.1	0.8702	7.246	36.1	0.8443	7.030	41.1	0.8198	6.826	46.1	0.7967	6.633	51.1	0.7749	6.451
31.2	0.8697	7.242	36.2	0.8438	7.026	41.2	0.8193	6.822	46.2	0.7963	6.630	51.2	0.7745	6.448
31.3	0.8692	7.237	36.3	0.8433	7.021	41.3	0.8189	6.818	46.3	0.7958	6.626	51.3	0.7741	6.444
31.4	0.8686	7.233	36.4	0.8428	7.017	41.4	0.8184	6.814	46.4	0.7954	6.622	51.4	0.7736	6.441
31.5	0.8681	7.228	36.5	0.8423	7.013	41.5	0.8179	6.810	46.5	0.7949	6.618	51.5	0.7732	6.437
31.6	0.8676	7.224	36.6	0.8418	7.009	41.6	0.8174	6.806	46.6	0.7945	6.615	51.6	0.7728	6.434
31.7	0.8670	7.220	36.7	0.8413	7.005	41.7	0.8170	6.802	46.7	0.7941	6.611	51.7	0.7724	6.430
31.8	0.8665	7.215	36.8	0.8408	7.000	41.8	0.8165	6.798	46.8	0.7936	6.607	51.8	0.7720	6.427
31.9	0.8660	7.211	36.9	0.8403	6.996	41.9	0.8160	6.794	46.9	0.7932	6.604	51.9	0.7715	6.423
32.0	0.8654	7.206	37.0	0.8398	6.992	42.0	0.8156	6.790	47.0	0.7927	6.600	52.0	0.7711	6.420
32.1	0.8649	7.202	37.1	0.8393	6.988	42.1	0.8151	6.786	47.1	0.7923	6.596	52.1	0.7707	6.416
32.2	0.8644	7.197	37.2	0.8388	6.984	42.2	0.8146	6.783	47.2	0.7918	6.592	52.2	0.7703	6.413
32.3	0.8639	7.193	37.3	0.8383	6.980	42.3	0.8142	6.779	47.3	0.7914	6.589	52.3	0.7699	6.409
32.4	0.8633	7.189	37.4	0.8378	6.976	42.4	0.8137	6.775	47.4	0.7909	6.585	52.4	0.7694	6.406
32.5	0.8628	7.184	37.5	0.8373	6.971	42.5	0.8132	6.771	47.5	0.7905	6.581	52.5	0.7690	6.402
32.6	0.8623	7.180	37.6	0.8368	6.967	42.6	0.8128	6.767	47.6	0.7901	6.578	52.6	0.7686	6.399
32.7	0.8618	7.176	37.7	0.8363	6.963	42.7	0.8123	6.763	47.7	0.7896	6.574	52.7	0.7682	6.395
32.8	0.8612	7.171	37.8	0.8358	6.959	42.8	0.8118	6.759	47.8	0.7892	6.570	52.8	0.7678	6.392
32.9	0.8607	7.167	37.9	0.8353	6.955	42.9	0.8114	6.755	47.9	0.7887	6.567	52.9	0.7674	6.388
33.0	0.8602	7.162	38.0	0.8348	6.951	43.0	0.8109	6.751	48.0	0.7883	6.563	53.0	0.7669	6.385
33.1	0.8597	7.158	38.1	0.8343	6.947	43.1	0.8104	6.748	48.1	0.7879	6.559	53.1	0.7665	6.381
33.2	0.8591	7.154	38.2	0.8338	6.943	43.2	0.8100	6.744	48.2	0.7874	6.556	53.2	0.7661	6.378
33.3	0.8586	7.149	38.3	0.8333	6.939	43.3	0.8095	6.740	48.3	0.7870	6.552	53.3	0.7657	6.375
33.4	0.8581	7.145	38.4	0.8328	6.934	43.4	0.8090	6.736	48.4	0.7865	6.548	53.4	0.7563	6.371
33.5	0.8576	7.141	38.5	0.8324	6.930	43.5	0.8086	6.732	48.5	0.7861	6.545	53.5	0.7649	6.368
33.6	0.8571	7.136	38.6	0.8319	6.926	43.6	0.8081	6.728	48.6	0.7857	6.541	53.6	0.7645	6.364
33.7	0.8565	7.132	38.7	0.8314	6.922	43.7	0.8076	6.724	48.7	0.7852	6.538	53.7	0.7640	6.361
33.8	0.8560	7.128	38.8	0.8309	6.918	43.8	0.8072	6.721	48.8	0.7848	6.534	53.8	0.7636	6.357
33.9	0.8555	7.123	38.9	0.8304	6.914	43.9	0.8067	6.717	48.9	0.7844	6.530	53.9	0.7632	6.354
34.0	0.8550	7.119	39.0	0.8299	6.910	44.0	0.8063	6.713	49.0	0.7839	6.527	54.0	0.7628	6.350
34.1	0.8545	7.115	39.1	0.8294	6.906	44.1	0.8058	6.709	49.1	0.7835	6.523	54.1	0.7624	6.347
34.2	0.8540	7.110	39.2	0.8289	6.902	44.2	0.8054	6.705	49.2	0.7831	6.519	54.2	0.7620	6.344
34.3	0.8534	7.106	39.3	0.8285	6.898	44.3	0.8049	6.701	49.3	0.7826	6.516	54.3	0.7616	6.340
34.4	0.8529	7.102	39.4	0.8280	6.894	44.4	0.8044	6.698	49.4	0.7822	6.512	54.4	0.7612	6.337
34.5	0.8524	7.098	39.5	0.8275	6.890	44.5	0.8040	6.694	49.5	0.7818	6.509	54.5	0.7608	6.333
34.6	0.8519	7.093	39.6	0.8270	6.886	44.6	0.8035	6.690	49.6	0.7813	6.505	54.6	0.7603	6.330
34.7	0.8514	7.089	39.7	0.8265	6.882	44.7	0.8031	6.686	49.7	0.7809	6.501	54.7	0.7599	6.327
34.8	0.8509	7.085	39.8	0.8260	6.878	44.8	0.8026	6.682	49.8	0.7805	6.498	54.8	0.7595	6.323
34.9	0.8504	7.081	39.9	0.8256	6.874	44.9	0.8022	6.679	49.9	0.7800	6.494	54.9	0.7591	6.320
												55.0	0.7587	6.316

Table 4 Continued.

°API GRAVITY, SPECIFIC GRAVITY (60°/60°) AND POUNDS PER GALLON

55 TO 80°API

°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON
55.0	0.7587	6.316	60.0	0.7389	6.151	65.0	0.7201	5.994	70.0	0.7022	5.845	75.0	0.6852	5.704
55.1	0.7583	6.313	60.1	0.7385	6.148	65.1	0.7197	5.991	70.1	0.7019	5.842	75.1	0.6849	5.701
55.2	0.7579	6.310	60.2	0.7381	6.145	65.2	0.7194	5.988	70.2	0.7015	5.840	75.2	0.6846	5.698
55.3	0.7575	6.306	60.3	0.7377	6.141	65.3	0.7190	5.985	70.3	0.7012	5.837	75.3	0.6842	5.695
55.4	0.7571	6.303	60.4	0.7374	6.138	65.4	0.7186	5.982	70.4	0.7008	5.834	75.4	0.6839	5.693
55.5	0.7567	6.299	60.5	0.7370	6.135	65.5	0.7183	5.979	70.5	0.7005	5.831	75.5	0.6836	5.690
55.6	0.7563	6.296	60.6	0.7366	6.132	65.6	0.7179	5.976	70.6	0.7001	5.828	75.6	0.6832	5.687
55.7	0.7559	6.293	60.7	0.7362	6.129	65.7	0.7175	5.973	70.7	0.6998	5.825	75.7	0.6829	5.684
55.8	0.7555	6.289	60.8	0.7358	6.126	65.8	0.7172	5.970	70.8	0.6995	5.822	75.8	0.6826	5.682
55.9	0.7551	6.286	60.9	0.7354	6.122	65.9	0.7168	5.967	70.9	0.6991	5.819	75.9	0.6823	5.679
56.0	0.7547	6.283	61.0	0.7351	6.119	66.0	0.7165	5.964	71.0	0.6988	5.816	76.0	0.6819	5.676
56.1	0.7543	6.279	61.1	0.7347	6.116	66.1	0.7161	5.961	71.1	0.6984	5.814	76.1	0.6816	5.673
56.2	0.7539	6.276	61.2	0.7343	6.113	66.2	0.7157	5.958	71.2	0.6981	5.811	76.2	0.6813	5.671
56.3	0.7535	6.273	61.3	0.7339	6.110	66.3	0.7154	5.955	71.3	0.6977	5.808	76.3	0.6809	5.668
56.4	0.7531	6.269	61.4	0.7335	6.106	66.4	0.7150	5.952	71.4	0.6974	5.805	76.4	0.6806	5.665
56.5	0.7527	6.266	61.5	0.7332	6.103	66.5	0.7146	5.949	71.5	0.6970	5.802	76.5	0.6803	5.662
56.6	0.7523	6.263	61.6	0.7328	6.100	66.6	0.7143	5.946	71.6	0.6967	5.799	76.6	0.6800	5.660
56.7	0.7519	6.259	61.7	0.7324	6.097	66.7	0.7139	5.943	71.7	0.6964	5.796	76.7	0.6796	5.657
56.8	0.7515	6.256	61.8	0.7320	6.094	66.8	0.7136	5.940	71.8	0.6960	5.794	76.8	0.6793	5.654
56.9	0.7511	6.253	61.9	0.7316	6.091	66.9	0.7132	5.937	71.9	0.6957	5.791	76.9	0.6790	5.651
57.0	0.7507	6.249	62.0	0.7313	6.087	67.0	0.7128	5.934	72.0	0.6953	5.788	77.0	0.6787	5.649
57.1	0.7503	6.246	62.1	0.7309	6.084	67.1	0.7125	5.931	72.1	0.6950	5.785	77.1	0.6783	5.646
57.2	0.7499	6.243	62.2	0.7305	6.081	67.2	0.7121	5.928	72.2	0.6946	5.782	77.2	0.6780	5.643
57.3	0.7495	6.239	62.3	0.7301	6.078	67.3	0.7118	5.925	72.3	0.6943	5.779	77.3	0.6777	5.641
57.4	0.7491	6.236	62.4	0.7298	6.075	67.4	0.7114	5.922	72.4	0.6940	5.776	77.4	0.6774	5.638
57.5	0.7487	6.233	62.5	0.7294	6.072	67.5	0.7111	5.919	72.5	0.6936	5.774	77.5	0.6770	5.635
57.6	0.7483	6.229	62.6	0.7290	6.069	67.6	0.7107	5.916	72.6	0.6933	5.771	77.6	0.6767	5.633
57.7	0.7479	6.226	62.7	0.7286	6.065	67.7	0.7103	5.913	72.7	0.6929	5.768	77.7	0.6764	5.630
57.8	0.7475	6.223	62.8	0.7283	6.062	67.8	0.7100	5.910	72.8	0.6926	5.765	77.8	0.6761	5.627
57.9	0.7471	6.219	62.9	0.7279	6.059	67.9	0.7096	5.907	72.9	0.6923	5.762	77.9	0.6757	5.624
58.0	0.7467	6.216	63.0	0.7275	6.056	68.0	0.7093	5.904	73.0	0.6919	5.759	78.0	0.6754	5.622
58.1	0.7463	6.213	63.1	0.7271	6.053	68.1	0.7089	5.901	73.1	0.6916	5.757	78.1	0.6751	5.619
58.2	0.7459	6.210	63.2	0.7268	6.050	68.2	0.7086	5.898	73.2	0.6913	5.754	78.2	0.6748	5.616
58.3	0.7455	6.206	63.3	0.7264	6.047	68.3	0.7082	5.895	73.3	0.6909	5.751	78.3	0.6745	5.614
58.4	0.7451	6.203	63.4	0.7260	6.044	68.4	0.7079	5.892	73.4	0.6906	5.748	78.4	0.6741	5.611
58.5	0.7447	6.200	63.5	0.7256	6.041	68.5	0.7075	5.889	73.5	0.6902	5.745	78.5	0.6738	5.608
58.6	0.7443	6.197	63.6	0.7253	6.037	68.6	0.7071	5.886	73.6	0.6899	5.743	78.6	0.6735	5.606
58.7	0.7440	6.193	63.7	0.7249	6.034	68.7	0.7068	5.883	73.7	0.6896	5.740	78.7	0.6732	5.603
58.8	0.7436	6.190	63.8	0.7245	6.031	68.8	0.7064	5.880	73.8	0.6892	5.737	78.8	0.6728	5.600
58.9	0.7432	6.187	63.9	0.7242	6.028	68.9	0.7061	5.878	73.9	0.6889	5.734	78.9	0.6725	5.598
59.0	0.7428	6.183	64.0	0.7238	6.025	69.0	0.7057	5.875	74.0	0.6886	5.731	79.0	0.6722	5.595
59.1	0.7424	6.180	64.1	0.7234	6.022	69.1	0.7054	5.872	74.1	0.6882	5.729	79.1	0.6719	5.592
59.2	0.7420	6.177	64.2	0.7230	6.019	69.2	0.7050	5.869	74.2	0.6879	5.726	79.2	0.6716	5.590
59.3	0.7416	6.174	64.3	0.7227	6.016	69.3	0.7047	5.866	74.3	0.6876	5.723	79.3	0.6713	5.587
59.4	0.7412	6.171	64.4	0.7223	6.013	69.4	0.7043	5.863	74.4	0.6872	5.720	79.4	0.6709	5.584
59.5	0.7408	6.167	64.5	0.7219	6.010	69.5	0.7040	5.860	74.5	0.6869	5.717	79.5	0.6706	5.582
59.6	0.7405	6.164	64.6	0.7216	6.007	69.6	0.7036	5.857	74.6	0.6866	5.715	79.6	0.6703	5.579
59.7	0.7401	6.161	64.7	0.7212	6.004	69.7	0.7033	5.854	74.7	0.6862	5.712	79.7	0.6700	5.576
59.8	0.7397	6.158	64.8	0.7208	6.000	69.8	0.7029	5.851	74.8	0.6859	5.709	79.8	0.6697	5.574
59.9	0.7393	6.154	64.9	0.7205	5.997	69.9	0.7026	5.848	74.9	0.6856	5.706	79.9	0.6693	5.571
												80.0	0.6690	5.569

Table 4 Continued.

°API GRAVITY, SPECIFIC GRAVITY (60°/60°) AND POUNDS PER GALLON

80 TO 100°API

°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON
80.0	0.6690	5.569	85.0	0.6536	5.440	90.0	0.6388	5.317	95.0	0.6247	5.199
80.1	0.6687	5.566	85.1	0.6533	5.437	90.1	0.6385	5.314	95.1	0.6244	5.197
80.2	0.6684	5.563	85.2	0.6530	5.435	90.2	0.6383	5.312	95.2	0.6242	5.194
80.3	0.6681	5.561	85.3	0.6527	5.432	90.3	0.6380	5.309	95.3	0.6239	5.192
80.4	0.6678	5.558	85.4	0.6524	5.430	90.4	0.6377	5.307	95.4	0.6236	5.190
80.5	0.6675	5.555	85.5	0.6521	5.427	90.5	0.6374	5.305	95.5	0.6233	5.188
80.6	0.6671	5.553	85.6	0.6518	5.425	90.6	0.6371	5.302	95.6	0.6231	5.185
80.7	0.6668	5.550	85.7	0.6515	5.422	90.7	0.6368	5.300	95.7	0.6228	5.183
80.8	0.6665	5.547	85.8	0.6512	5.420	90.8	0.6365	5.297	95.8	0.6225	5.181
80.9	0.6662	5.545	85.9	0.6509	5.417	90.9	0.6362	5.295	95.9	0.6223	5.178
81.0	0.6659	5.542	86.0	0.6506	5.415	91.0	0.6360	5.293	96.0	0.6220	5.176
81.1	0.6656	5.540	86.1	0.6503	5.412	91.1	0.6357	5.290	96.1	0.6217	5.174
81.2	0.6653	5.537	86.2	0.6500	5.410	91.2	0.6354	5.288	96.2	0.6214	5.172
81.3	0.6649	5.534	86.3	0.6497	5.407	91.3	0.6351	5.286	96.3	0.6212	5.169
81.4	0.6646	5.532	86.4	0.6494	5.405	91.4	0.6348	5.283	96.4	0.6209	5.167
81.5	0.6643	5.529	86.5	0.6491	5.402	91.5	0.6345	5.281	96.5	0.6206	5.165
81.6	0.6640	5.527	86.6	0.6488	5.400	91.6	0.6342	5.278	96.6	0.6203	5.163
81.7	0.6637	5.524	86.7	0.6485	5.397	91.7	0.6340	5.276	96.8	0.6201	5.160
81.8	0.6634	5.521	86.8	0.6482	5.395	91.8	0.6337	5.274	96.8	0.6198	5.158
81.9	0.6631	5.519	86.9	0.6479	5.392	91.9	0.6334	5.271	96.9	0.6195	5.156
82.0	0.6628	5.516	87.0	0.6476	5.390	92.0	0.6331	5.269	97.0	0.6193	5.153
82.1	0.6625	5.514	87.1	0.6473	5.387	92.1	0.6328	5.267	97.1	0.6190	5.151
82.2	0.6621	5.511	87.2	0.6470	5.385	92.2	0.6325	5.264	97.2	0.6187	5.149
82.3	0.6618	5.508	87.3	0.6467	5.382	92.3	0.6323	5.262	97.3	0.6184	5.147
82.4	0.6615	5.506	87.4	0.6464	5.380	92.4	0.6320	5.260	97.4	0.6182	5.144
82.5	0.6612	5.503	87.5	0.6461	5.377	92.5	0.6317	5.257	97.5	0.6179	5.142
82.6	0.6609	5.501	87.6	0.6458	5.375	92.6	0.6314	5.255	97.6	0.6176	5.140
82.7	0.6606	5.498	87.7	0.6455	5.373	92.7	0.6311	5.252	97.7	0.6174	5.138
82.8	0.6603	5.496	87.8	0.6452	5.370	92.8	0.6309	5.250	97.8	0.6171	5.135
82.9	0.6600	5.493	87.9	0.6449	5.368	92.9	0.6306	5.248	97.9	0.6168	5.133
83.0	0.6597	5.490	88.0	0.6446	5.365	93.0	0.6303	5.245	98.0	0.6166	5.131
83.1	0.6594	5.488	88.1	0.6444	5.363	93.1	0.6300	5.243	98.1	0.6163	5.129
83.2	0.6591	5.485	88.2	0.6441	5.360	93.2	0.6297	5.241	98.2	0.6160	5.126
83.3	0.6588	5.483	88.3	0.6438	5.358	93.3	0.6294	5.238	98.3	0.6158	5.124
83.4	0.6584	5.480	88.4	0.6435	5.355	93.4	0.6292	5.236	98.4	0.6155	5.122
83.5	0.6581	5.478	88.5	0.6432	5.353	93.5	0.6289	5.234	98.5	0.6152	5.120
83.6	0.6578	5.475	88.6	0.6429	5.351	93.6	0.6286	5.231	98.6	0.6150	5.118
83.7	0.6575	5.473	88.7	0.6426	5.348	93.7	0.6283	5.229	98.7	0.6147	5.115
83.8	0.6572	5.470	88.8	0.6423	5.346	93.8	0.6281	5.227	98.8	0.6144	5.113
83.9	0.6569	5.468	88.9	0.6420	5.343	93.9	0.6278	5.224	98.9	0.6141	5.111
84.0	0.6566	5.465	89.0	0.6417	5.341	94.0	0.6275	5.222	99.0	0.6139	5.109
84.1	0.6563	5.462	89.1	0.6414	5.338	94.1	0.6272	5.220	99.1	0.6136	5.106
84.2	0.6560	5.460	89.2	0.6411	5.336	94.2	0.6269	5.218	99.2	0.6134	5.104
84.3	0.6557	5.457	89.3	0.6409	5.334	94.3	0.6267	5.215	99.3	0.6131	5.102
84.4	0.6554	5.455	89.4	0.6406	5.331	94.4	0.6264	5.213	99.4	0.6128	5.100
84.5	0.6551	5.452	89.5	0.6403	5.329	94.5	0.6261	5.211	99.5	0.6126	5.098
84.6	0.6548	5.450	89.6	0.6400	5.326	94.6	0.6258	5.208	99.6	0.6123	5.095
84.7	0.6545	5.447	89.7	0.6397	5.324	94.7	0.6256	5.206	99.7	0.6120	5.093
84.8	0.6542	5.445	89.8	0.6394	5.321	94.8	0.6253	5.204	99.8	0.6118	5.091
84.9	0.6539	5.442	89.9	0.6391	5.319	94.9	0.6250	5.201	99.9	0.6115	5.089
									100.0	0.6112	5.087

Table 4 Continued.

°API GRAVITY, SPECIFIC GRAVITY (60°/60°) AND POUNDS PER GALLON

100 TO 200°API

°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON
100.0	0.6112	5.087	120.0	0.5626	4.681	140.0	0.5212	4.336	160.0	0.4854	4.038	180.0	0.4543	3.778
100.5	0.6099	5.076	120.5	0.5615	4.672	140.5	0.5202	4.328	160.5	0.4846	4.031	180.5	0.4535	3.772
101.0	0.6086	5.065	121.0	0.5604	4.663	141.0	0.5193	4.320	161.0	0.4838	4.024	181.0	0.4528	3.766
101.5	0.6073	5.054	121.5	0.5593	4.654	141.5	0.5183	4.312	161.5	0.4829	4.017	181.5	0.4521	3.760
102.0	0.6060	5.043	122.0	0.5582	4.644	142.0	0.5174	4.304	162.0	0.4821	4.010	182.0	0.4514	3.754
102.5	0.6047	5.032	122.5	0.5571	4.635	142.5	0.5164	4.296	162.5	0.4813	4.003	182.5	0.4506	3.748
103.0	0.6034	5.022	123.0	0.5560	4.626	143.0	0.5155	4.288	163.0	0.4805	3.996	183.0	0.4499	3.742
103.5	0.6021	5.011	123.5	0.5549	4.617	143.5	0.5145	4.281	163.5	0.4797	3.990	183.5	0.4492	3.736
104.0	0.6009	5.000	124.0	0.5538	4.608	144.0	0.5136	4.273	164.0	0.4789	3.983	184.0	0.4485	3.730
104.5	0.5996	4.990	124.5	0.5527	4.599	144.5	0.5127	4.265	164.5	0.4780	3.976	184.5	0.4478	3.724
105.0	0.5983	4.979	125.0	0.5517	4.590	145.0	0.5118	4.257	165.0	0.4772	3.969	185.0	0.4471	3.718
105.5	0.5970	4.968	125.5	0.5506	4.581	145.5	0.5108	4.250	165.5	0.4764	3.963	185.5	0.4464	3.712
106.0	0.5958	4.958	126.0	0.5495	4.572	146.0	0.5099	4.242	166.0	0.4756	3.956	186.0	0.4457	3.706
106.5	0.5945	4.948	126.5	0.5485	4.563	146.5	0.5090	4.234	166.5	0.4748	3.949	186.5	0.4450	3.700
107.0	0.5933	4.937	127.0	0.5474	4.554	147.0	0.5081	4.227	167.0	0.4740	3.943	187.0	0.4443	3.695
107.5	0.5921	4.927	127.5	0.5463	4.546	147.5	0.5072	4.219	167.5	0.4732	3.936	187.5	0.4436	3.689
108.0	0.5908	4.916	128.0	0.5453	4.537	148.0	0.5063	4.211	168.0	0.4725	3.930	188.0	0.4429	3.683
108.5	0.5896	4.906	128.5	0.5442	4.528	148.5	0.5054	4.204	168.5	0.4717	3.923	188.5	0.4422	3.677
109.0	0.5884	4.896	129.0	0.5432	4.519	149.0	0.5045	4.196	169.0	0.4709	3.916	189.0	0.4415	3.671
109.5	0.5871	4.886	129.5	0.5421	4.511	149.5	0.5036	4.189	169.5	0.4701	3.910	189.5	0.4408	3.666
110.0	0.5859	4.876	130.0	0.5411	4.502	150.0	0.5027	4.181	170.0	0.4693	3.903	190.0	0.4401	3.660
110.5	0.5847	4.866	130.5	0.5401	4.493	150.5	0.5018	4.174	170.5	0.4685	3.897	190.5	0.4394	3.654
111.0	0.5835	4.856	131.0	0.5390	4.485	151.0	0.5009	4.167	171.0	0.4678	3.891	191.0	0.4388	3.649
111.5	0.5823	4.846	131.5	0.5380	4.476	151.5	0.5000	4.159	171.5	0.4670	3.884	191.5	0.4381	3.643
112.0	0.5811	4.836	132.0	0.5370	4.468	152.0	0.4991	4.152	172.0	0.4662	3.878	192.0	0.4374	3.637
112.5	0.5799	4.826	132.5	0.5360	4.459	152.5	0.4982	4.145	172.5	0.4655	3.871	192.5	0.4367	3.632
113.0	0.5787	4.816	133.0	0.5350	4.451	153.0	0.4974	4.137	173.0	0.4647	3.865	193.0	0.4361	3.626
113.5	0.5776	4.806	133.5	0.5340	4.442	153.5	0.4965	4.130	173.5	0.4639	3.859	193.5	0.4354	3.621
114.0	0.5764	4.796	134.0	0.5330	4.434	154.0	0.4956	4.123	174.0	0.4632	3.852	194.0	0.4347	3.615
114.5	0.5752	4.786	134.5	0.5320	4.426	154.5	0.4948	4.116	174.5	0.4624	3.846	194.5	0.4341	3.609
115.0	0.5740	4.777	135.0	0.5310	4.417	155.0	0.4939	4.108	175.0	0.4617	3.840	195.0	0.4334	3.604
115.5	0.5729	4.767	135.5	0.5300	4.409	155.5	0.4930	4.101	175.5	0.4609	3.833	195.5	0.4327	3.598
116.0	0.5717	4.757	136.0	0.5290	4.401	156.0	0.4922	4.094	176.0	0.4602	3.827	196.0	0.4321	3.593
116.5	0.5706	4.748	136.5	0.5280	4.393	156.5	0.4913	4.087	176.5	0.4594	3.821	196.5	0.4314	3.587
117.0	0.5694	4.738	137.0	0.5270	4.384	157.0	0.4905	4.080	177.0	0.4587	3.815	197.0	0.4307	3.582
117.5	0.5683	4.729	137.5	0.5260	4.376	157.5	0.4896	4.073	177.5	0.4579	3.808	197.5	0.4301	3.576
118.0	0.5671	4.719	138.0	0.5250	4.368	158.0	0.4888	4.066	178.0	0.4572	3.802	198.0	0.4294	3.571
118.5	0.5660	4.710	138.5	0.5241	4.360	158.5	0.4879	4.059	178.5	0.4565	3.796	198.5	0.4288	3.566
119.0	0.5649	4.700	139.0	0.5231	4.352	159.0	0.4871	4.052	179.0	0.4557	3.790	199.0	0.4281	3.560
119.5	0.5637	4.691	139.5	0.5221	4.344	159.5	0.4863	4.045	179.5	0.4550	3.784	199.5	0.4275	3.555
												200.0	0.4269	3.549

Table 4 Continued.

°API GRAVITY, SPECIFIC GRAVITY (60°/60°) AND POUNDS PER GALLON

200 TO 300°API

°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON	°API	SPECIFIC GRAVITY	POUNDS PER GALLON
200.0	0.4269	3.549	220.0	0.4026	3.347	240.0	0.3809	3.166	260.0	0.3614	3.004	280.0	0.3439	2.857
200.5	0.4262	3.544	220.5	0.4020	3.342	240.5	0.3804	3.162	260.5	0.3610	3.000	280.5	0.3434	2.854
201.0	0.4256	3.539	221.0	0.4014	3.337	241.0	0.3799	3.158	261.0	0.3605	2.996	281.0	0.3430	2.850
201.5	0.4249	3.533	221.5	0.4009	3.333	241.5	0.3794	3.153	261.5	0.3601	2.992	281.5	0.3426	2.847
202.0	0.4243	3.528	222.0	0.4003	3.328	242.0	0.3789	3.149	262.0	0.3596	2.989	282.0	0.3422	2.844
202.5	0.4237	3.523	222.5	0.3997	3.323	242.5	0.3783	3.145	262.5	0.3591	2.985	282.5	0.3418	2.840
203.0	0.4230	3.517	223.0	0.3992	3.318	243.0	0.3778	3.141	263.0	0.3587	2.981	283.0	0.3414	2.837
203.5	0.4224	3.512	223.5	0.3986	3.314	243.5	0.3773	3.136	263.5	0.3582	2.977	283.5	0.3410	2.833
204.0	0.4218	3.507	224.0	0.3980	3.308	244.0	0.3768	3.132	264.0	0.3578	2.873	284.0	0.3406	2.830
204.5	0.4211	3.502	224.5	0.3975	3.304	244.5	0.3763	3.128	264.5	0.3573	2.970	284.5	0.3401	2.826
205.0	0.4205	3.496	225.0	0.3969	3.300	245.0	0.3758	3.124	265.0	0.3569	2.966	285.0	0.3397	2.823
205.5	0.4199	3.491	225.5	0.3964	3.295	245.5	0.3753	3.120	265.5	0.3564	2.962	285.5	0.3393	2.820
206.0	0.4193	3.486	226.0	0.3958	3.290	246.0	0.3748	3.116	266.0	0.3560	2.958	286.0	0.3389	2.816
206.5	0.4186	3.481	226.5	0.3953	3.286	246.5	0.3743	3.112.	266.5	0.3555	2.955	286.5	0.3385	2.813
207.0	0.4180	3.476	227.0	0.3947	3.281	247.0	0.3738	3.107	267.0	0.3551	2.951	287.0	0.3381	2.809
207.5	0.4174	3.471	227.5	0.3942	3.277	247.5	0.3734	3.103	267.5	0.3546	2.947	287.5	0.3377	2.806
208.0	0.4168	3.465	228.0	0.3936	3.272	248.0	0.3729	3.099	268.0	0.3542	2.944	288.0	0.3373	2.803
208.5	0.4162	3.460	228.5	0.3931	3.268	248.5	0.3724	3.095	268.5	0.3538	2.940	288.5	0.3369	2.799
209.0	0.4156	3.455	229.0	0.3925	3.263	249.0	0.3719	3.091	269.0	0.3533	2.936	289.0	0.3365	2.796
209.5	0.4150	3.450	229.5	0.3920	3.259	249.5	0.3714	3.087	269.5	0.3529	2.932	289.5	0.3361	2.793
210.0	0.4144	3.445	230.0	0.3914	3.254	250.0	0.3709	3.083	270.0	0.3524	2.929	290.0	0.3357	2.789
210.5	0.4137	3.440	230.5	0.3909	3.249	250.5	0.3704	3.079	270.5	0.3520	2.925	290.5	0.3353	2.786
211.0	0.4131	3.435	231.0	0.3903	3.245	251.0	0.3699	3.075	271.0	0.3516	2.922	291.0	0.3349	2.783
211.5	0.4125	3.430	231.5	0.3898	3.240	251.5	0.3695	3.071	271.5	0.3511	2.918	291.5	0.3345	2.779
212.0	0.4119	3.425	232.0	0.3893	3.236	252.0	0.3690	3.067	272.0	0.3507	2.914	292.0	0.3341	2.776
212.5	0.4113	3.420	232.5	0.3887	3.232	252.5	0.3685	3.063	272.5	0.3503	2.911	292.5	0.3337	2.773
213.0	0.4107	3.415	233.0	0.3882	3.227	253.0	0.3680	3.059	273.0	0.3498	2.907	293.0	0.3333	2.770
213.5	0.4101	3.410	233.5	0.3877	3.223	253.5	0.3675	3.055	273.5	0.3494	2.903	293.5	0.3329	2.766
214.0	0.4096	3.405	234.0	0.3871	3.218	254.0	0.3671	3.051	274.0	0.3490	2.900	294.0	0.3326	2.763
214.5	0.4090	3.400	234.5	0.3866	3.214	254.5	0.3666	3.047	274.5	0.3485	2.896	294.5	0.3322	2.760
215.0	0.4084	3.395	235.0	0.3861	3.209	255.0	0.3661	3.043	275.0	0.3481	2.893	295.0	0.3318	2.757
215.5	0.4078	3.390	235.5	0.3856	3.205	255.5	0.3656	3.039	275.5	0.3477	2.889	295.5	0.3314	2.753
216.0	0.4072	3.385	236.0	0.3850	3.201	256.0	0.3652	3.035	276.0	0.3472	2.886	296.0	0.3310	2.750
216.5	0.4066	3.381	236.5	0.3845	3.196	256.5	0.3647	3.031	276.5	0.3468	2.882	296.5	0.3306	2.747
217.0	0.4060	3.376	237.0	0.3840	3.192	257.0	0.3642	3.027	277.0	0.3464	2.878	297.0	0.3302	2.744
217.5	0.4054	3.371	237.5	0.3835	3.188	257.5	0.3638	3.023	277.5	0.3460	2.875	297.5	0.3298	2.740
218.0	0.4049	3.366	238.0	0.3830	3.183	258.0	0.3633	3.019	278.0	0.3455	2.871	298.0	0.3295	2.737
218.5	0.4043	3.361	238.5	0.3824	3.179	258.5	0.3628	3.015	278.5	0.3451	2.868	298.5	0.3291	2.734
219.0	0.4037	3.356	239.0	0)3819	3.175	259.0	0.3624	3.012	279.0	0.3447	2.864	299.0	0.3287	2.731
219.5	0.4031	3.352	239.5	0.3814	3.170	259.5	0.3619	3.008	279.5	0.3443	2.861	299.5	0.3283	2.727
												300.0	0.3279	2.724

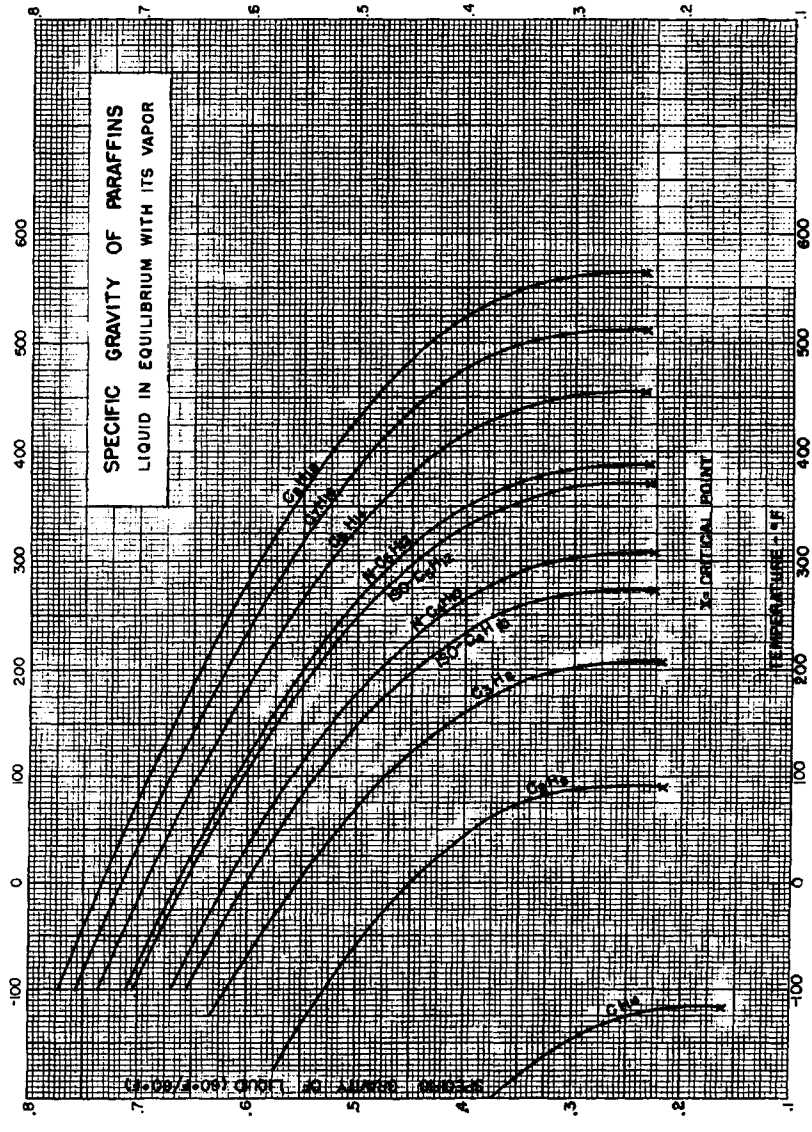


Figure 1. Chart for specific gravity of paraffins.

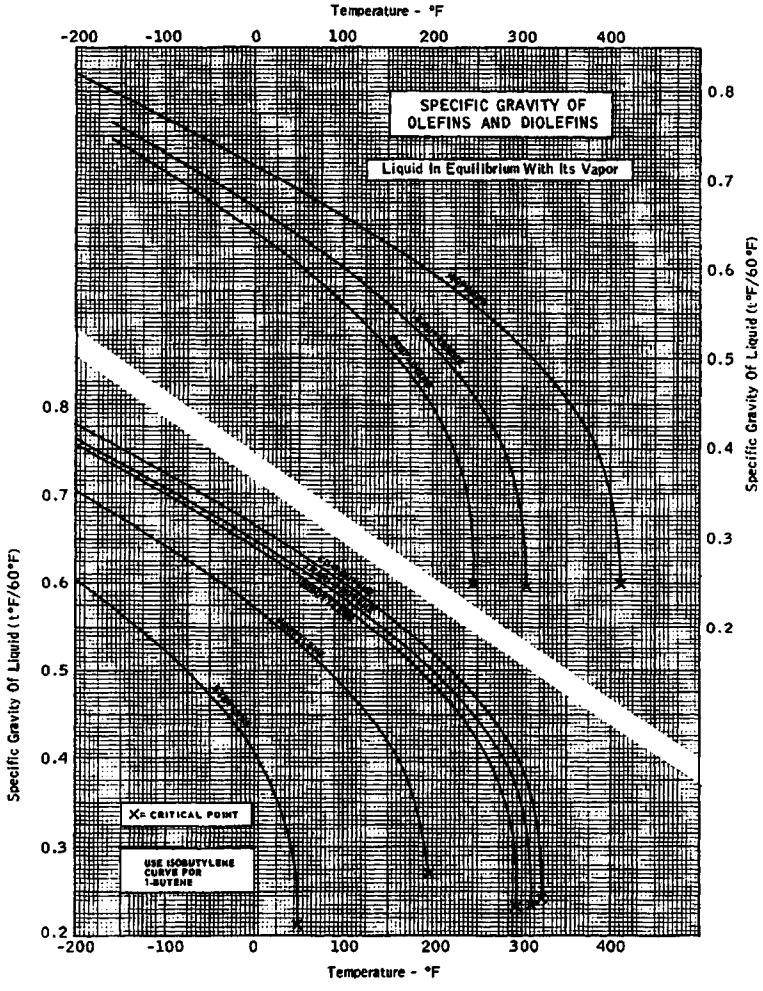


Figure 2. Chart of specific gravity of olefins and diolefins.

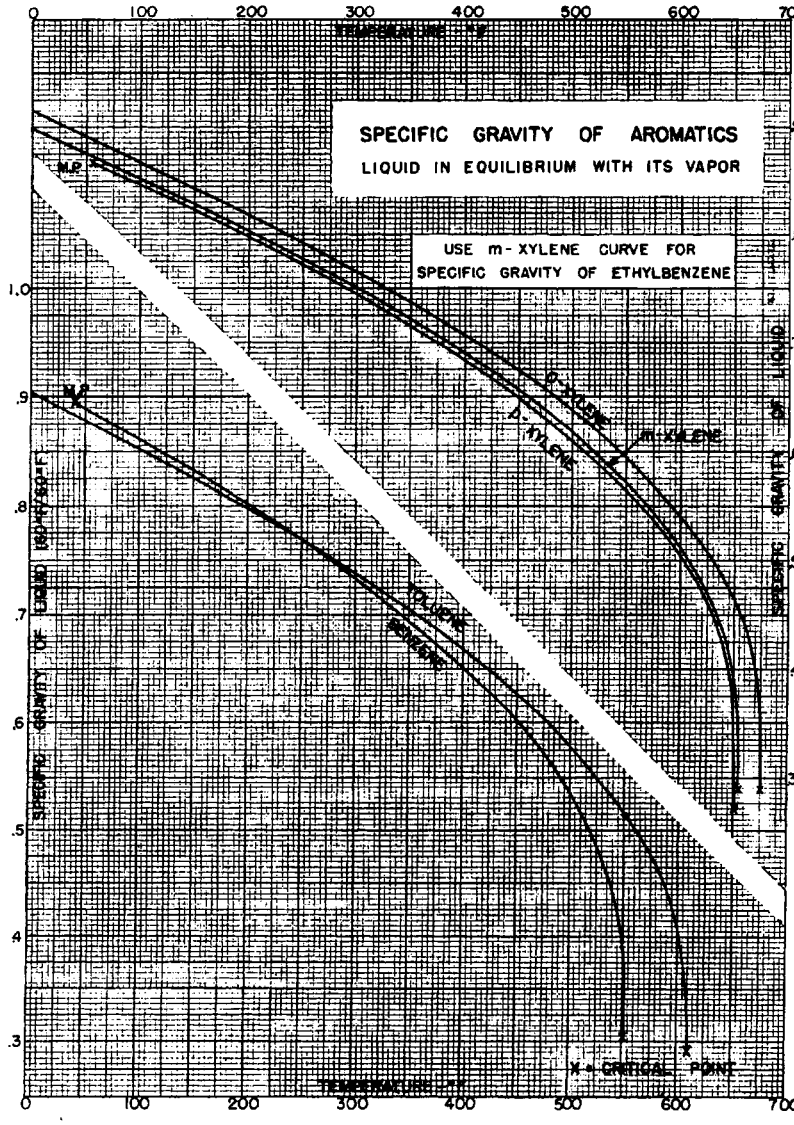


Figure 3. Chart of specific gravity of aromatics.

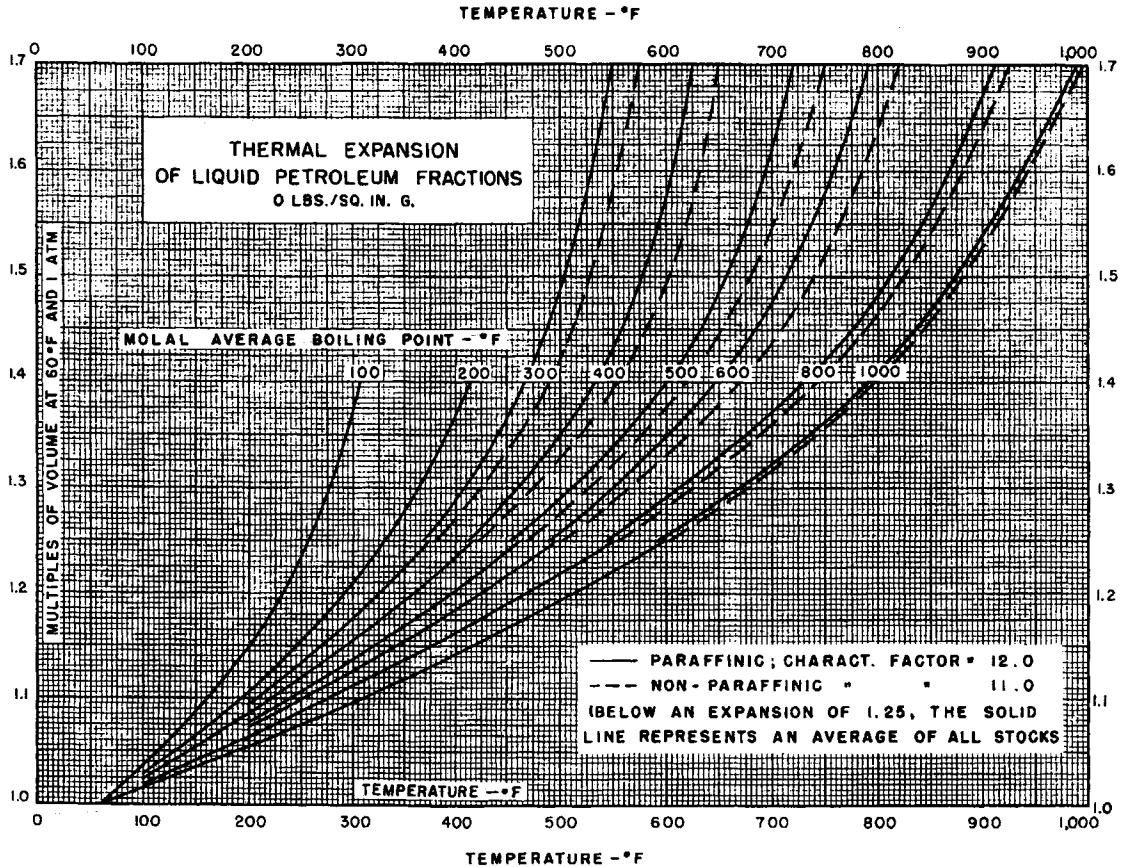


Figure 4. Chart of thermal expansion of liquid petroleum fractions (0 psig).

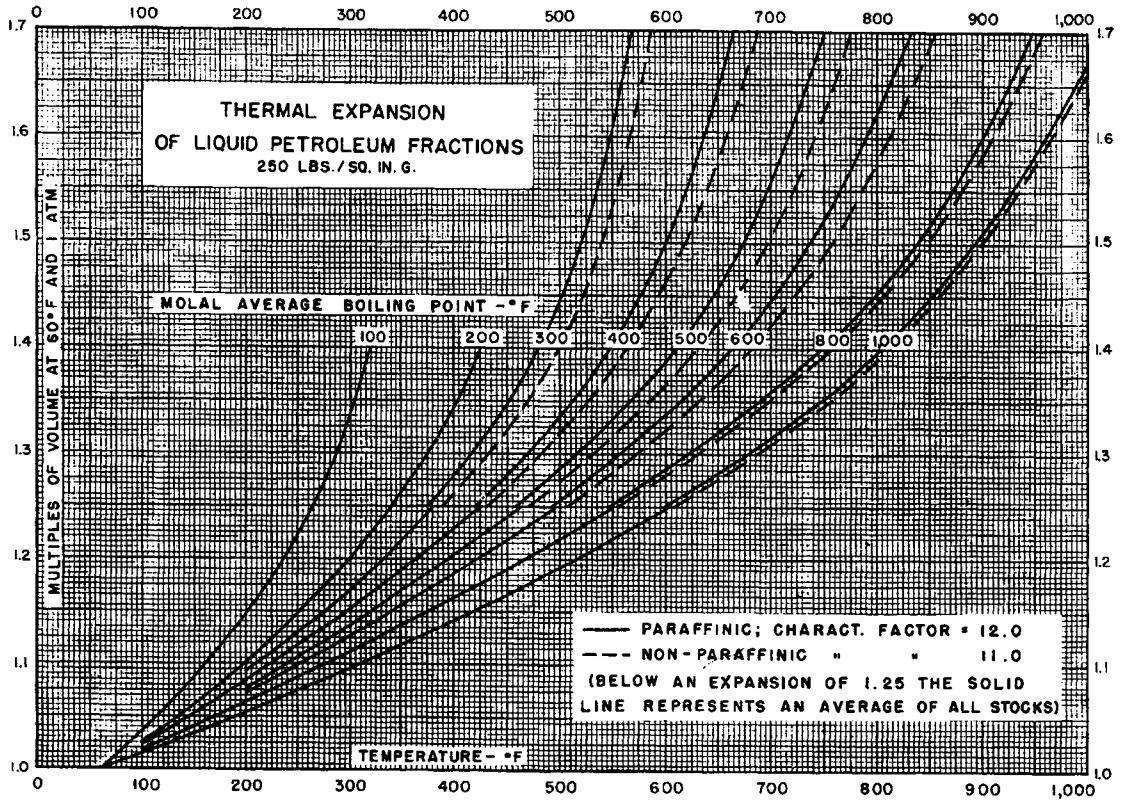


Figure 5. Chart of thermal expansion of liquid petroleum fractions (250 psig).

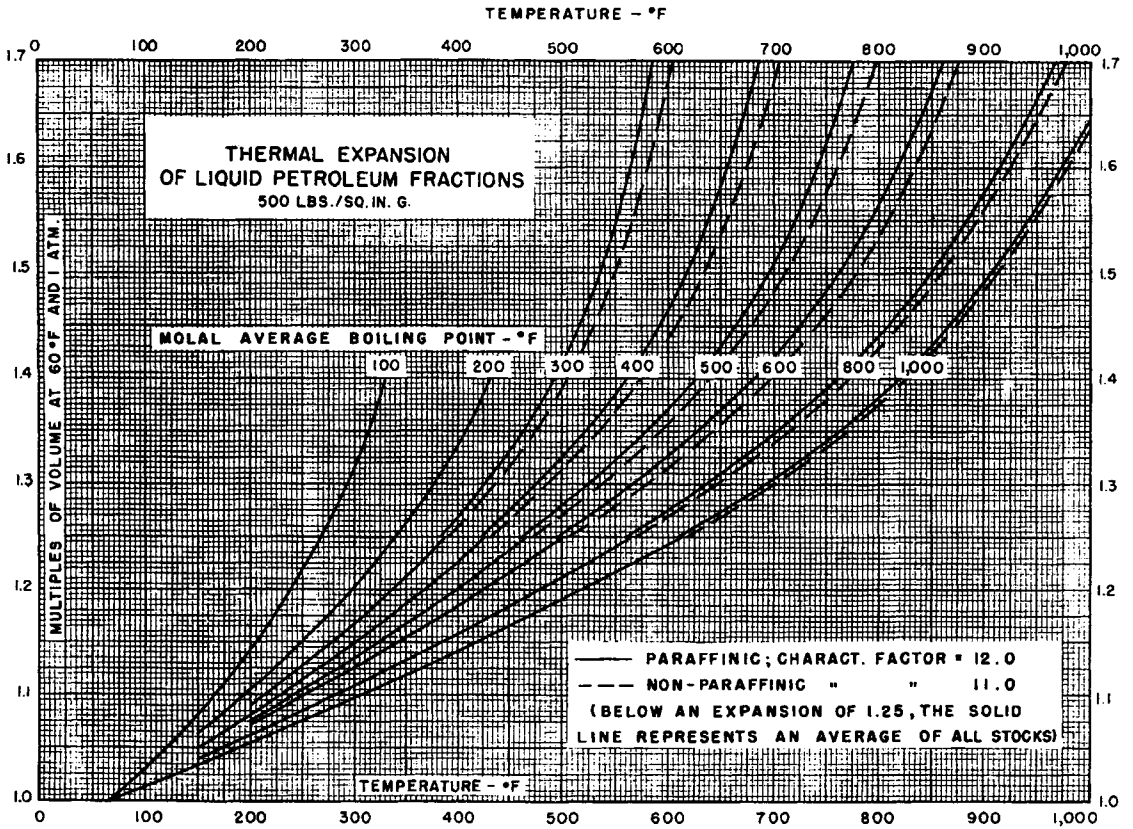


Figure 6. Chart of thermal expansion of liquid petroleum fractions (500 psig).

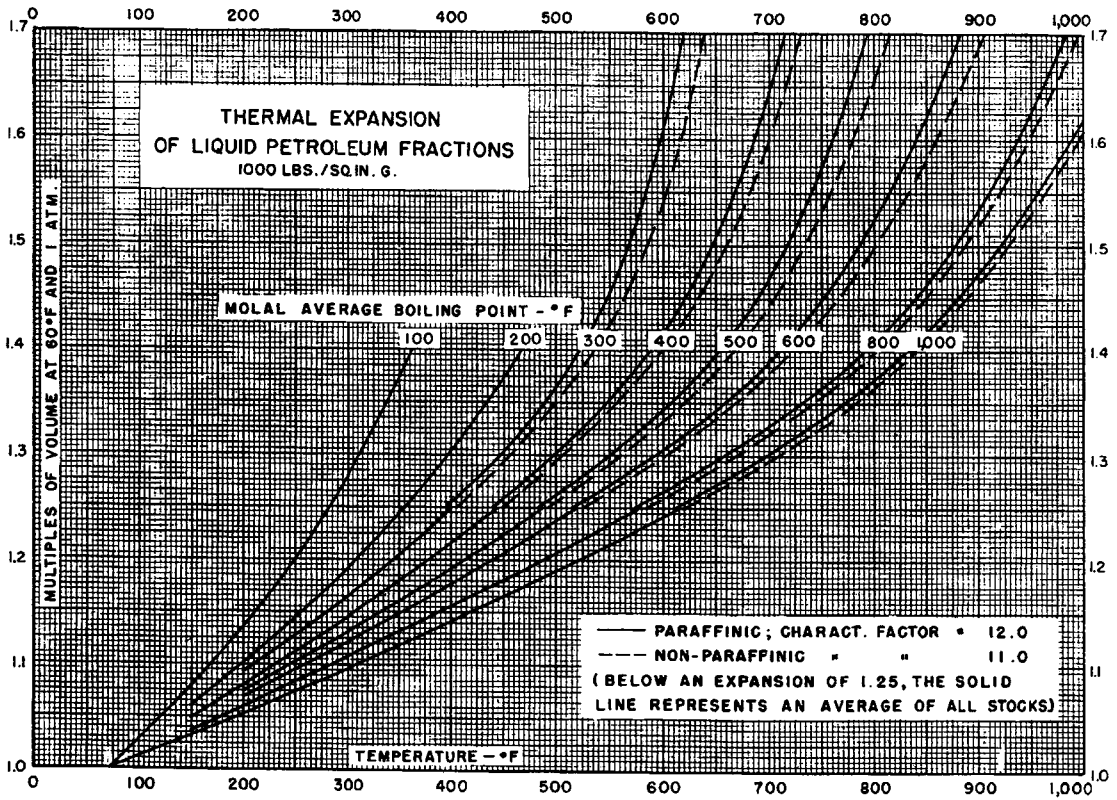


Figure 7. Chart of thermal expansion of liquid petroleum fractions (1000 psig).

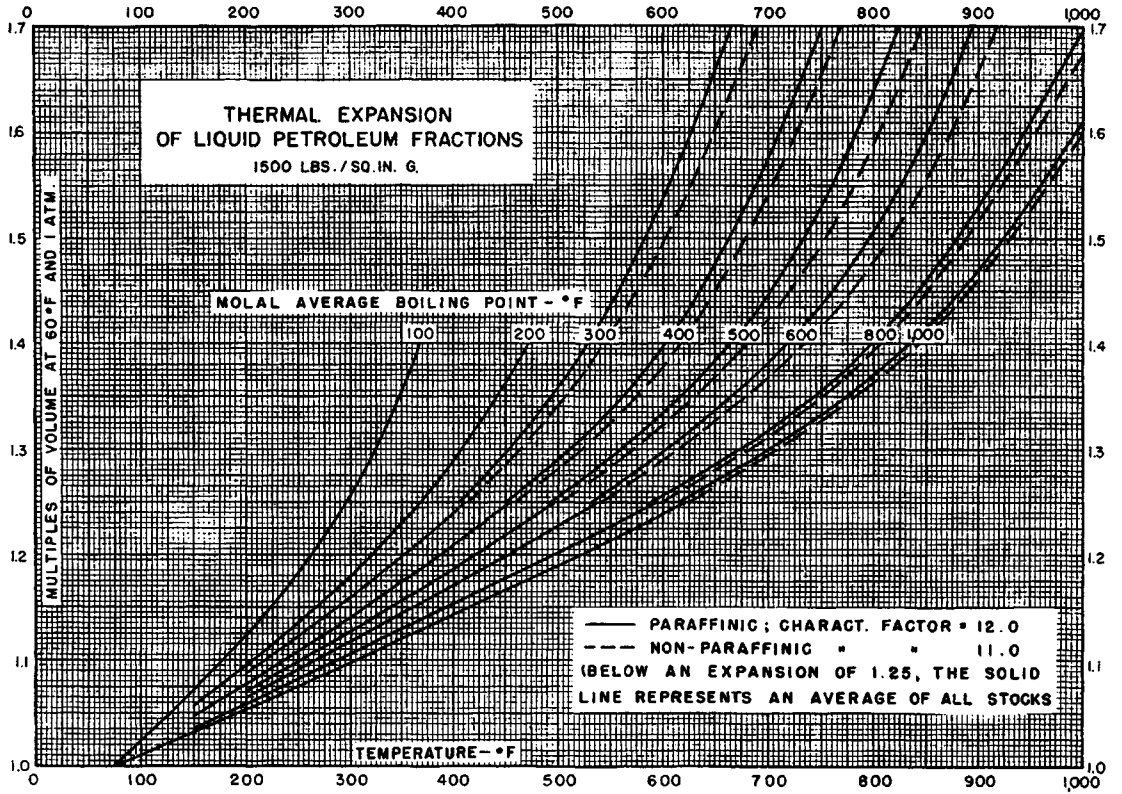


Figure 8. Chart of thermal expansion of liquid petroleum fractions (1500 psig).

Below $T_r = 1.0$, the data are insufficient to take into account a similar trend, so a single chart covers the entire molecular weight range.

If other gases or vapors (H_2, O_2, H_2O, etc.) are present in a mixture of hydrocarbon vapors, an effective pressure equal to $\pi(y_{HC})^{1/2}$ should be used to obtain the reduced pressure of the hydrocarbon portion. Likewise, if it is necessary to take into account gas law deviations for any of the other gases, μ should be determined for each of these gases at an effective pressure equal to the total pressure multiplied by the square root of its mole fraction. The molal volume is then calculated by Amagat's Law,

$$V_m = \frac{RT}{\pi}(y_{HC}\mu_{HC} + y_a\mu_a + y_b\mu_b + \ldots) \qquad (1)$$

where V_m is the molal volume of the mixture, the subscript *HC* refers to the total hydrocarbon fraction, and the subscripts *a*, *b*, etc,, refer to other gases. Usually μ_a, μ_b, etc., may be taken as 1.00 with very little error, since most of these gases approximate a perfect gas at the effective pressures encountered. In the absence of other data, the hydrocarbon charts may be used for these gases.

The following table (Table 5) provides typical values of the gas law constant.

Table 5. Values of gas law constant, R.

Pressure	Units	Temperature	R
Lb/sq in. abs	Cu ft/lb-mole	°R	10.73
Lb/sq ft abs	Cu ft/lb-mole	°R	1545
Atm	Cu ft/lb-mole	°R	0.7302
Atm	Liters/g-mole	°K	0.08205
Atm	Cu ft/lb-mole	°K	1.314
Mm of Hg	Liters/g-mole	°K	62.36
Lb/sq ft abs	Cu ft/lb-mole	°K	2781

Degrees API, Specific Gravity, and Pounds per Gallon

Hydrometer readings in degrees API are related by definition to specific gravity by the following formulas:

$$°\text{API} = (141.5/\textit{Sp. Gr.}) - 131.5 \qquad (2)$$

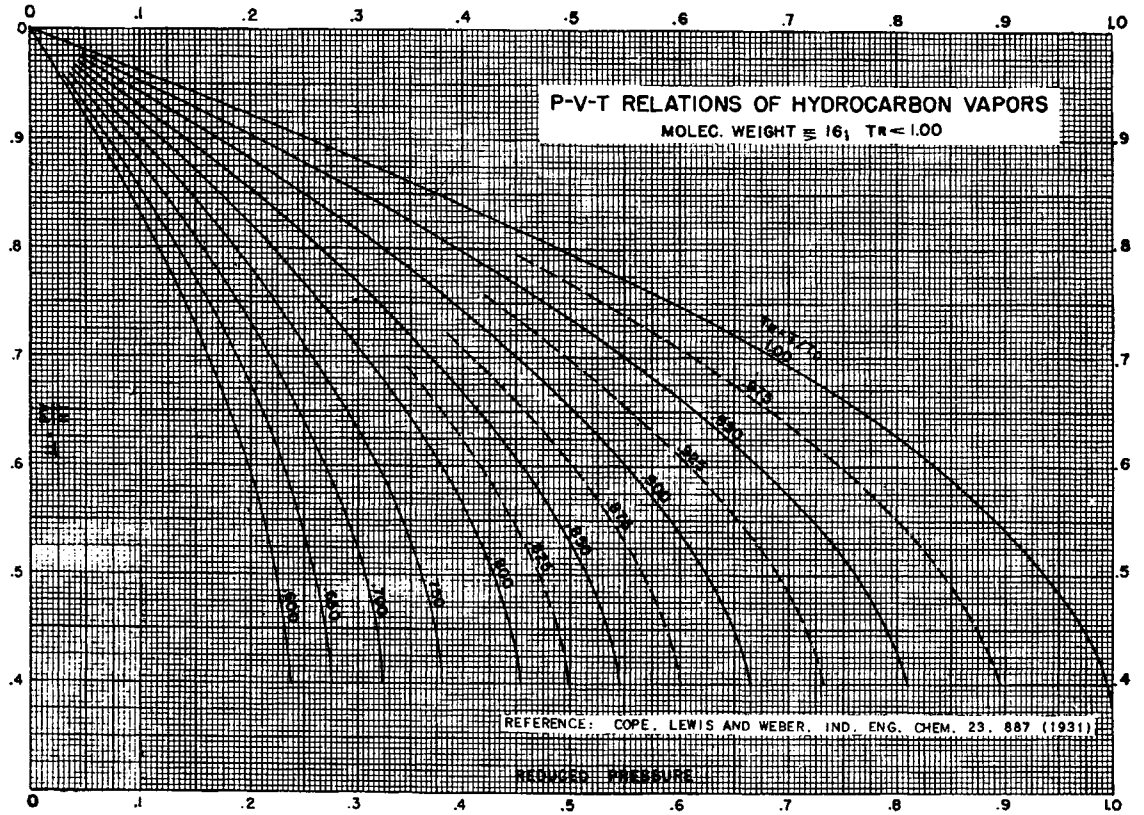


Figure 9. Chart for P-V-T relations of hydrocarbon vapors.

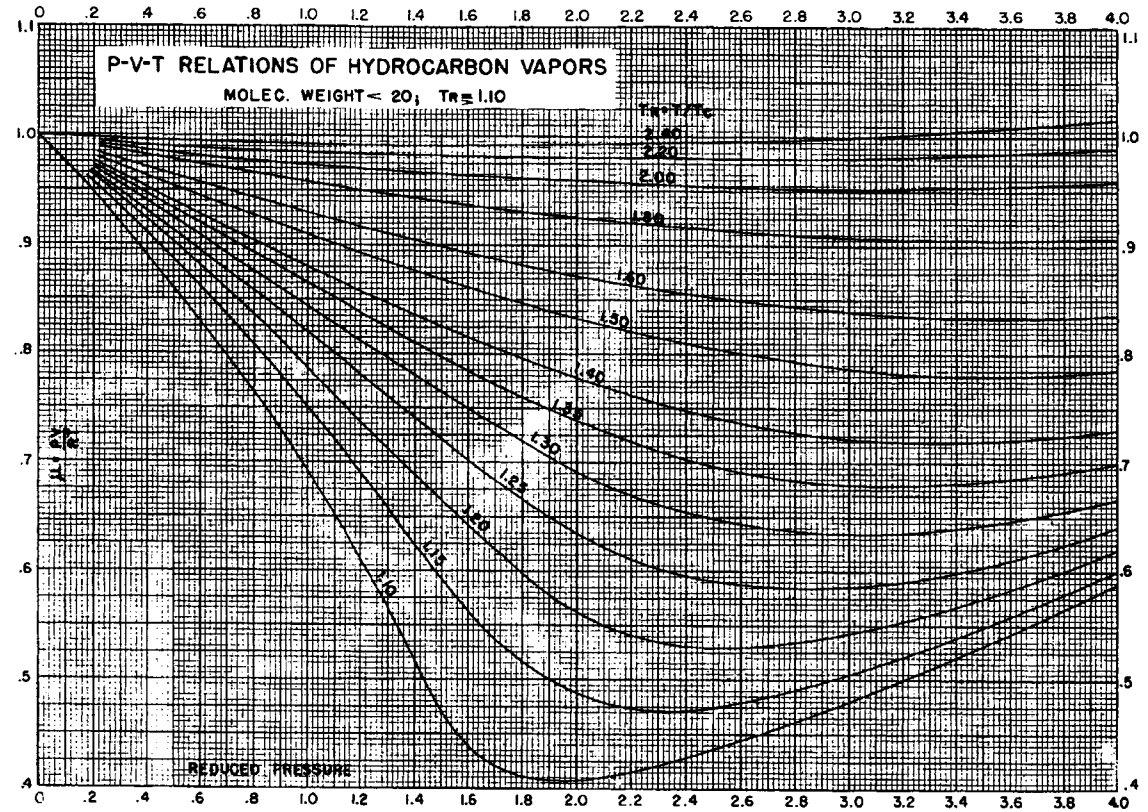


Figure 10. Chart for P-V-T relations of hydrocarbon vapors.

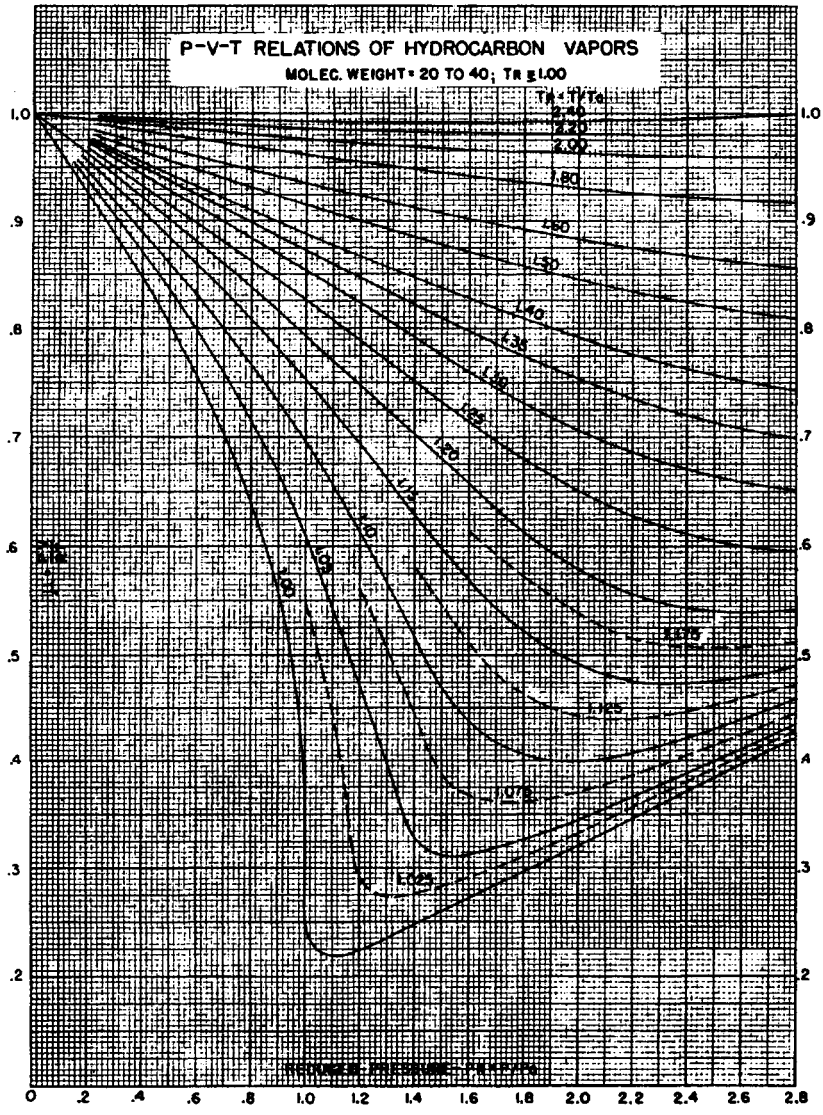


Figure 11. Chart for P-V-T relations of hydrocarbon vapors.

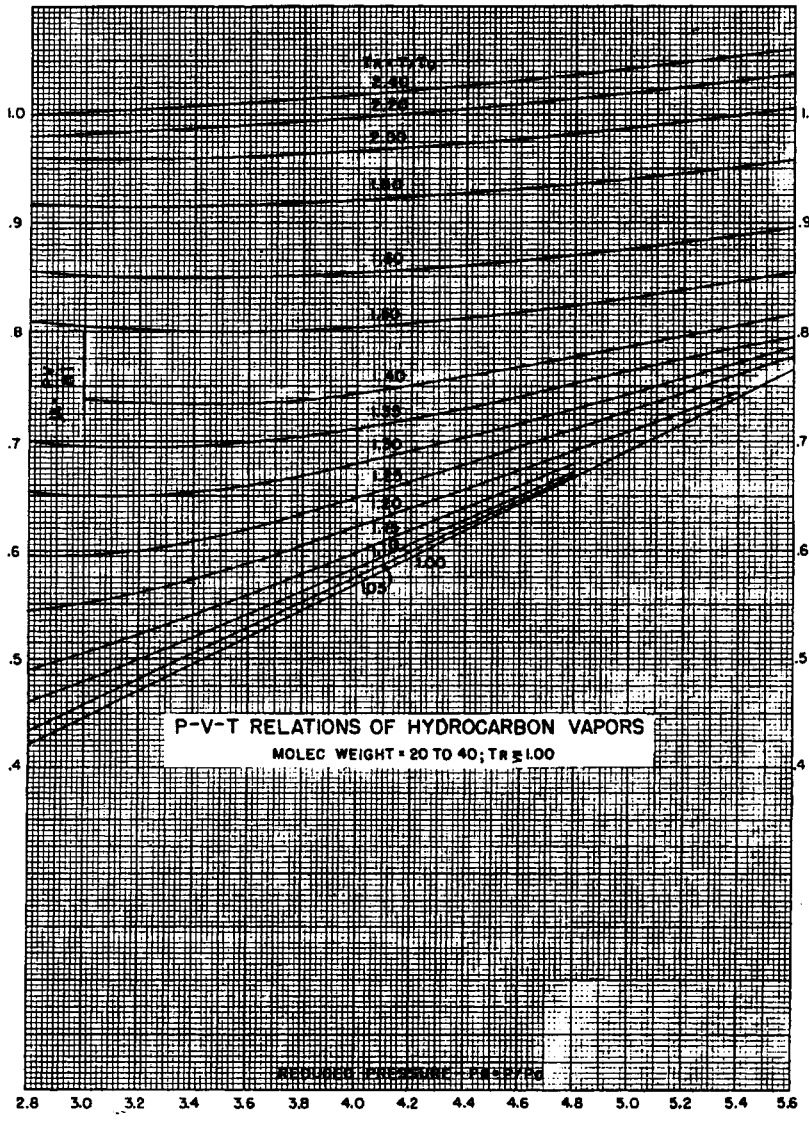


Figure 12. Chart for P-V-T relations of hydrocarbon vapors.

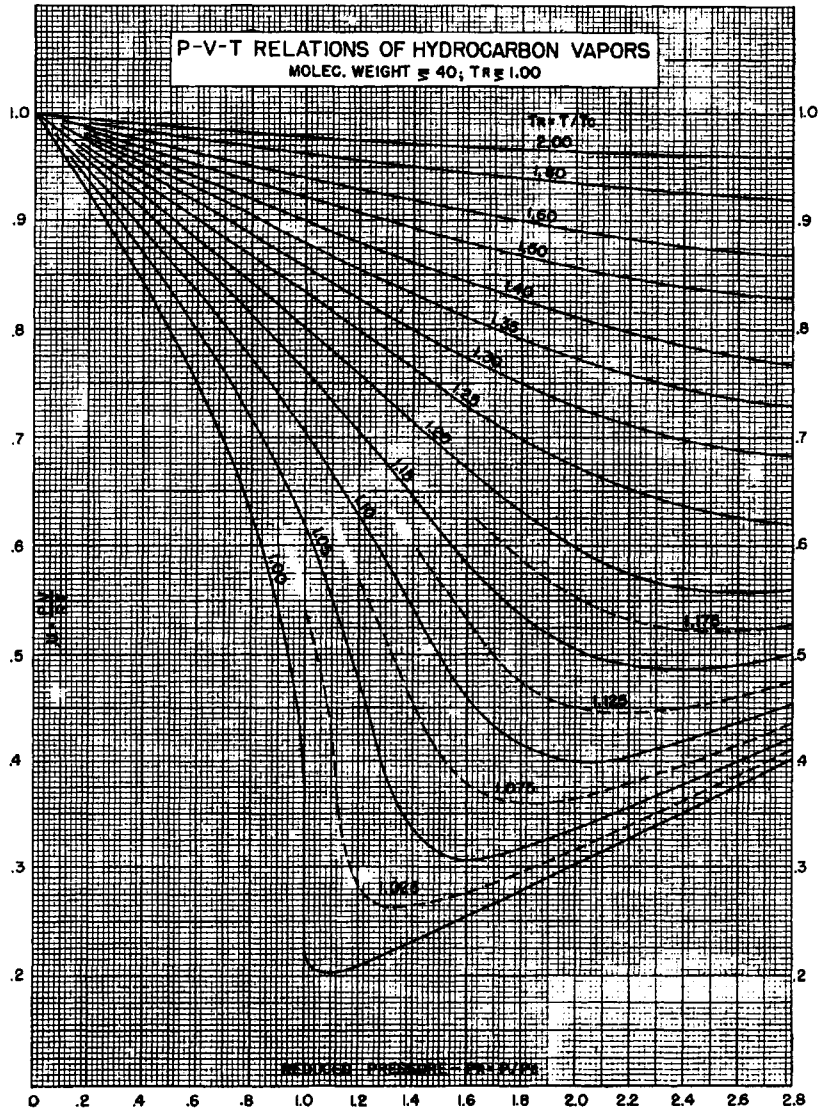


Figure 13. Chart for P-V-T relations of hydrocarbon vapors.

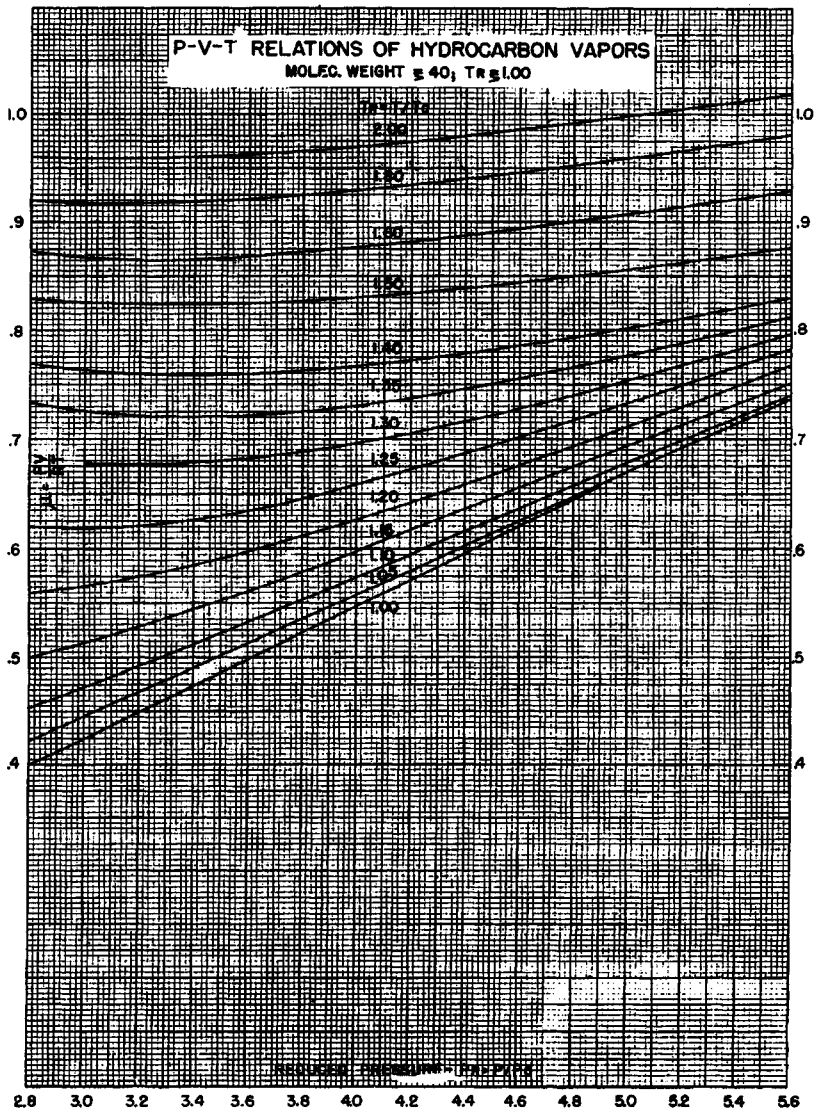


Figure 14. Chart for P-V-T relations of hydrocarbon vapors.

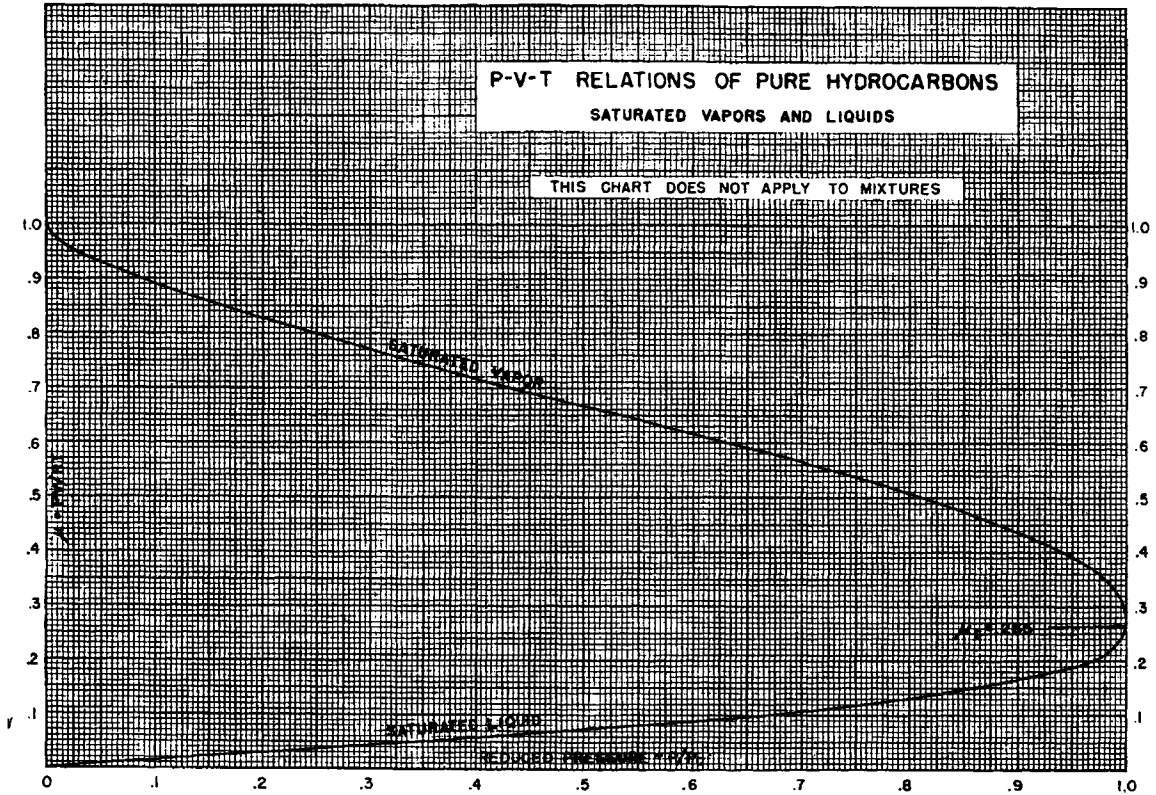


Figure 15. Chart for P-V-T relations of pure hydrocarbon.

$$Sp.\ Gr. = 141.5/(°API + 131.5) \quad (3)$$

These relationships are for hydrometer readings made at or corrected to 60 °F, and for specific gravity when defined as the ratio of the weight of a given volume of oil at 60 °F to the weight of the same volume of water at 60 °F, all weighings being reduced to weights in vacuum by correcting for the buoyancy of air.

Pounds per gallon values are given as weight in air. For engineering design purposes, the difference between weight in air and weight in vacuum will generally be trivial.

Specific Gravity Data: Miscellaneous

Figures 16 through 22 provide charts on specific gravity data for the following materials:

- C_1-C_3 alcohols (Figure 16)
- C_4-C_5 alcohols (Figure 17)
- Phenol (Figure 18)
- Ketones (Figure 19)
- Mercaptans (Figure 20)
- Aqueous HNO_3 solutions (Figure 21)
- Aqueous HSO_4 solutions (Figure 22)

CHARACTERISTICS OF PETROLEUM FRACTIONS

Average Boiling Point of Petroleum Fractions

Many physical properties of pure hydrocarbons can be correlated with specific gravity and normal boiling point as independent variables. However, for use in the petroleum industry, these correlations must also be applicable to petroleum fractions which are mixtures of a large number of components, usually having a wide variation in boiling points.

While the average specific gravity is a property of the petroleum fraction which can be measured directly, just as in the case of pure compounds, there is not an analogous average normal boiling point for a mixture. By integrating or averaging its distillation curve (temperature vs. liquid volume percent distilled), a volume average boiling point can be determined for the mixture. However, this has no special significance as a true average boiling point and many physical properties can be better correlated by the use of some other average boiling point, i.e., weight

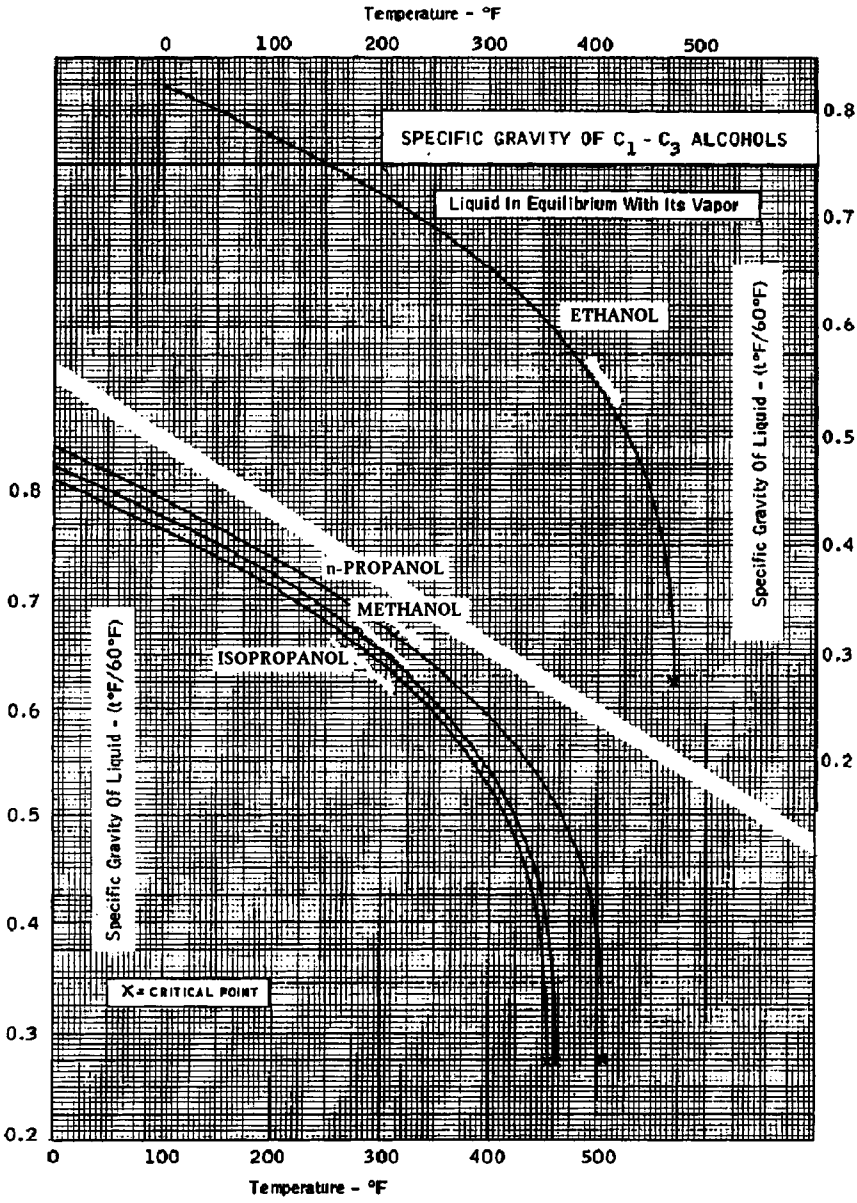


Figure 16. Chart for specific gravity of C_1-C_3 alcohols.

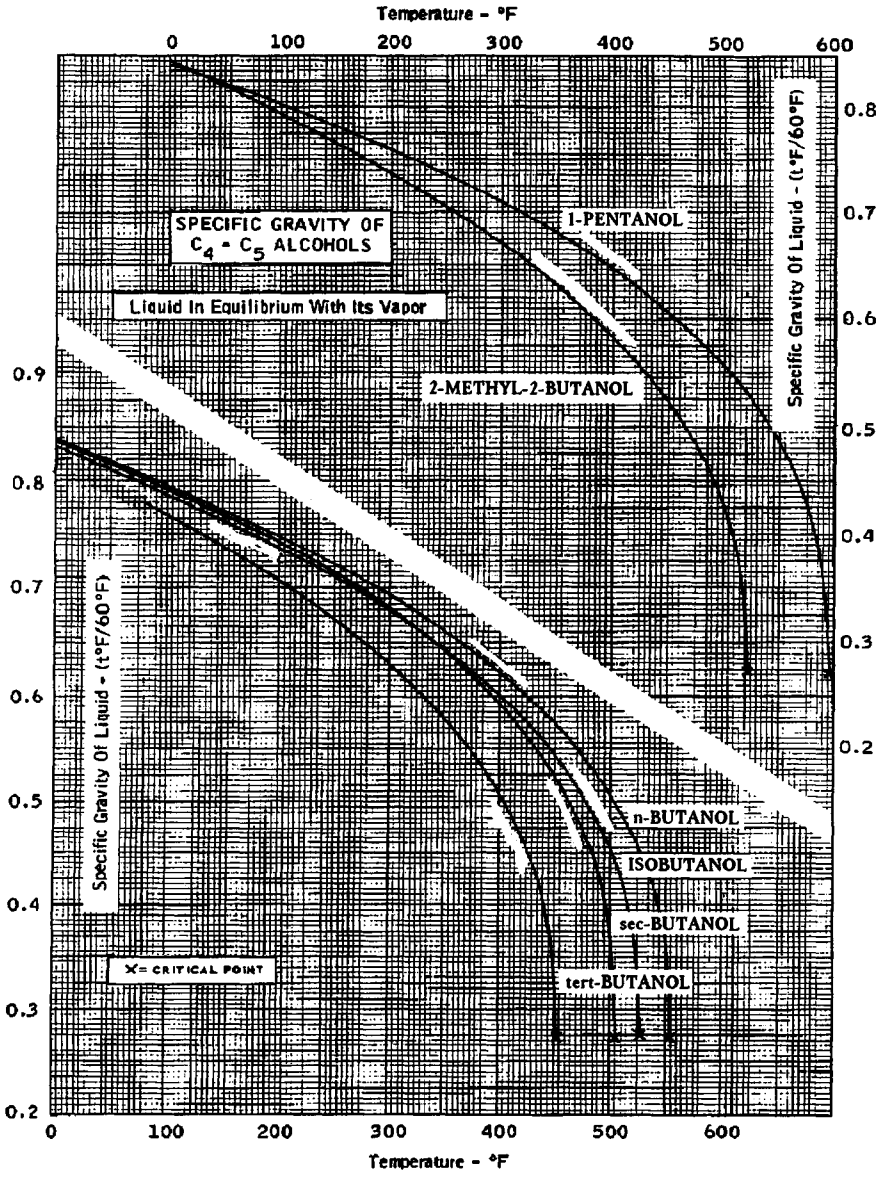


Figure 17. Chart for specific gravity of C_4-C_5 alcohols.

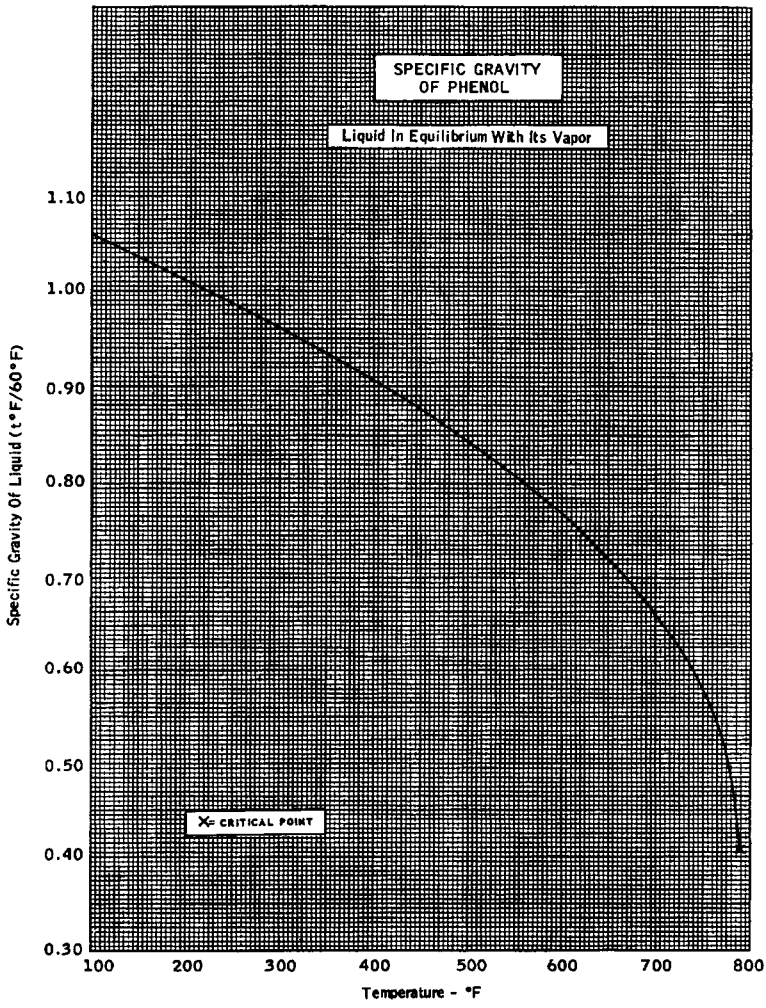


Figure 18. Chart for specific gravity of phenol.

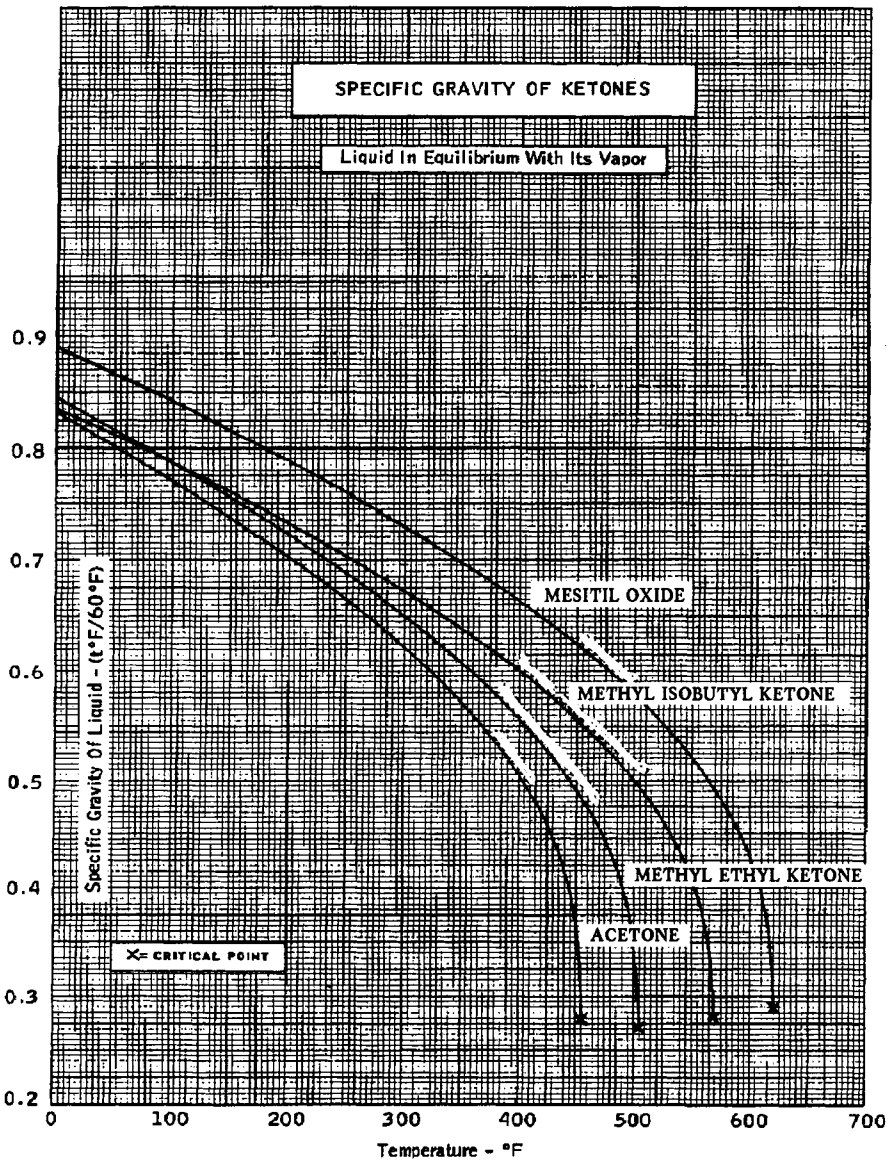


Figure 19. Chart for specific gravity of ketones.

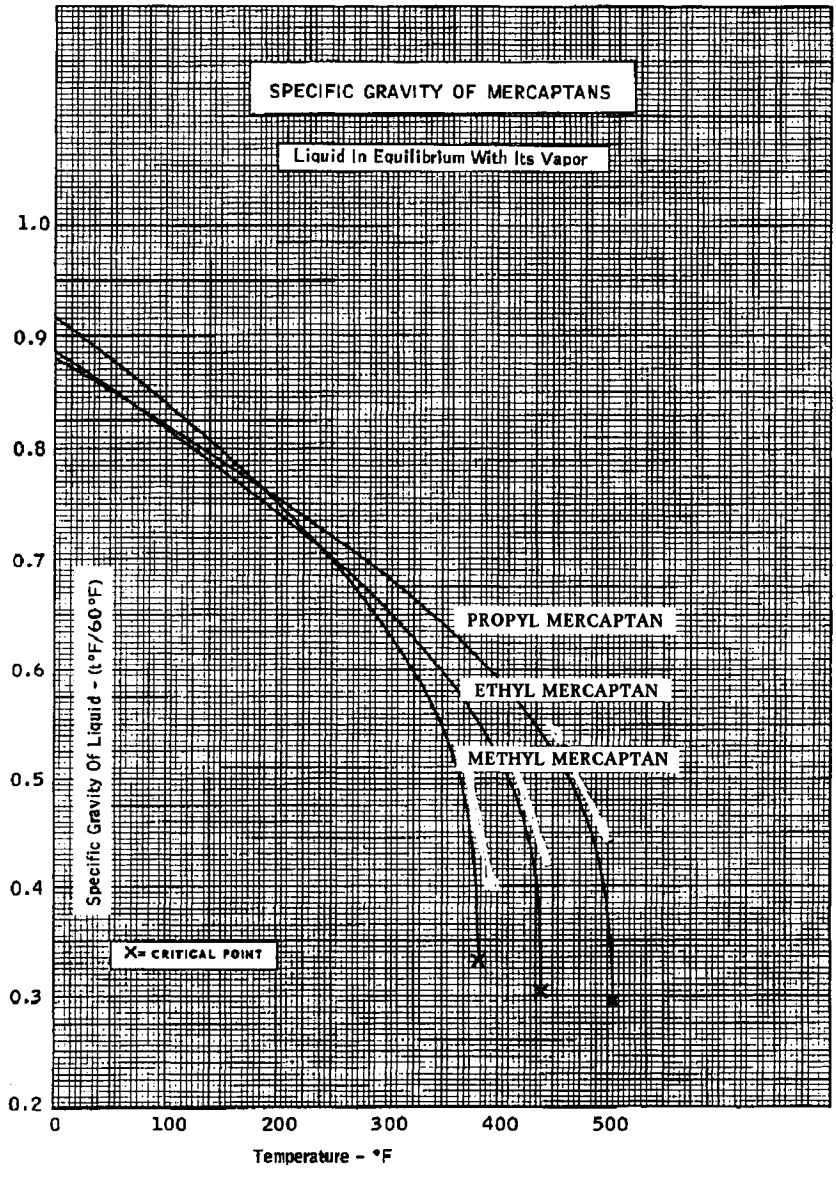


Figure 20. Chart for specific gravity of mercaptans.

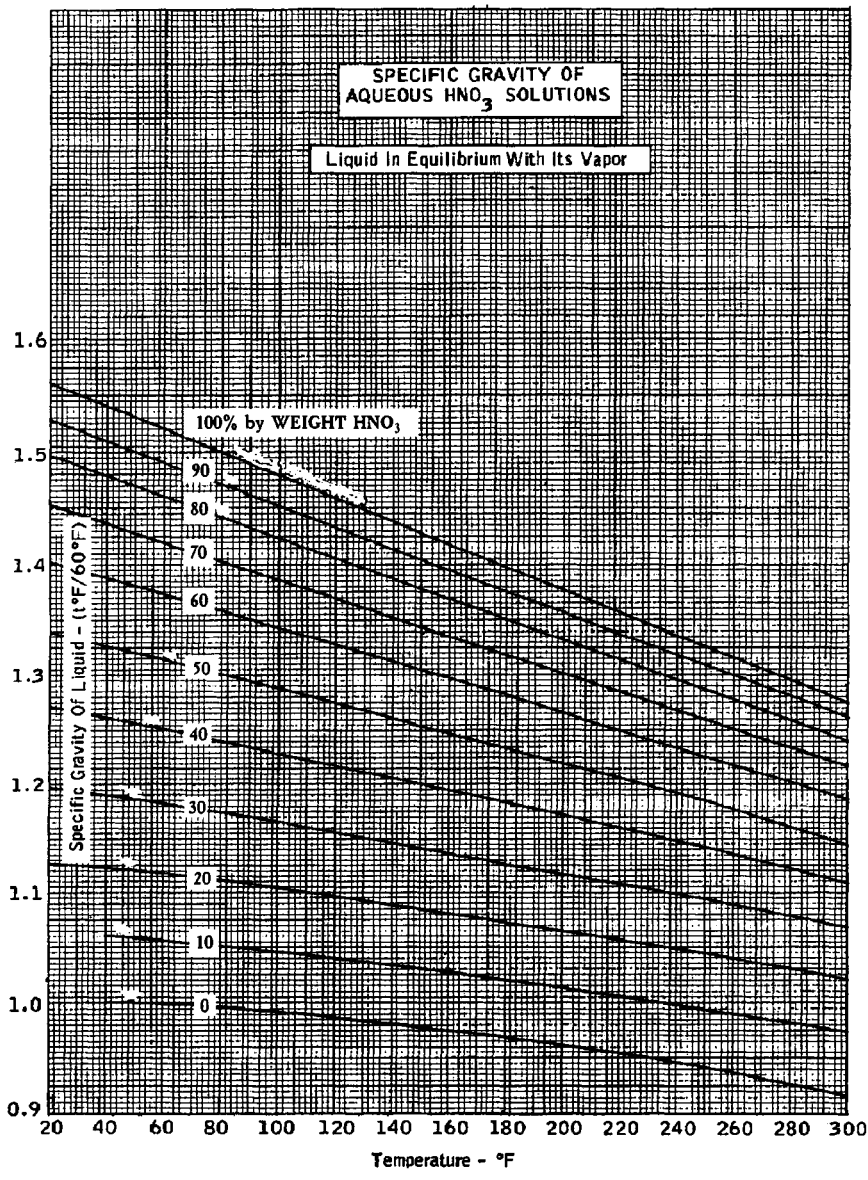


Figure 21. Chart for specific gravity of aqueous HNO_3 solutions.

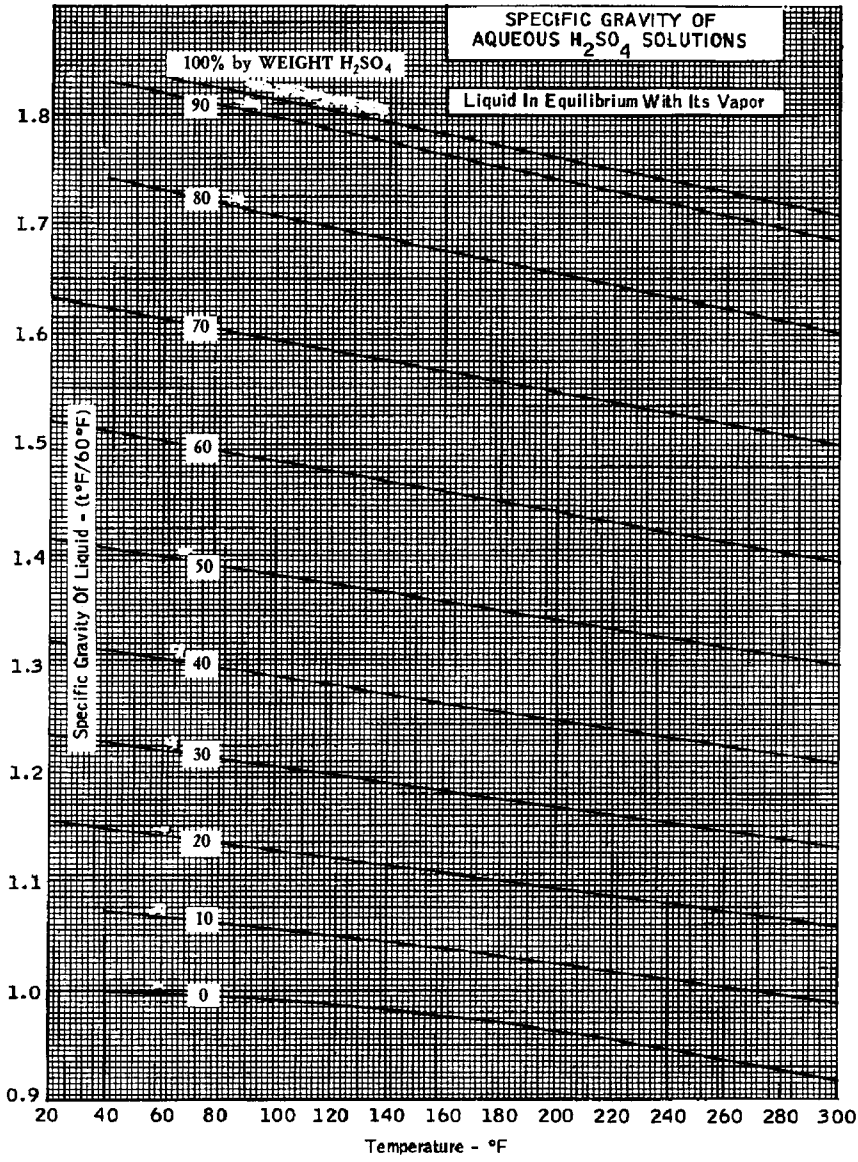


Figure 22. Chart for specific gravity of aqueous H_2SO_4 solutions.

average, molal average, etc. Consequently, in all correlations involving boiling points of petroleum fractions, the proper average should be used.

Table 6 provides a list of the average boiling point that should be correlated with the specific physical property.

Table 6. Average boiling point correlated with physical property.

Average Boiling Point	Physical Property
Volume average	Viscosity Liquid specific heat
Weight average	True critical temperature
Molal average	Pseudo-critical temperature Thermal expansion of liquids
Mean average	Molecular weight Characterization factor Specific gravity Pseudo-critical pressure Heat of combustion

Since a distillation curve is usually available and a volume average boiling point is readily obtained therefrom, the other average boiling points are given as a function of these data.

Figures 23 and 24 provide average boiling point data for petroleum fractions.

Characterization Factor

It is standard practice to use a characterization factor as an index of the chemical character of pure hydrocarbons and petroleum fractions. The characterization factor of a hydrocarbon is defined as the cube root of its absolute boiling point in °R divided by its specific gravity (60 °F/60 °F), or

$$Characterization\ Factor = \sqrt[3]{T} / Sp\ Gr \qquad (4)$$

The characterization factor is given in Figures 25 and 26 as a function of gravity in °API and boiling point in° F for hydrocarbons and petroleum fractions.

That characterization factor is only an approximate index of the chemical nature of hydrocarbons as indicated by its variation with boiling point both for members of a homologous series and for fractions from the same crude (Figure 26). However, it has considerable value in that it can be applied to the entire boiling range of a crude and it has been generally accepted by the petroleum industry.

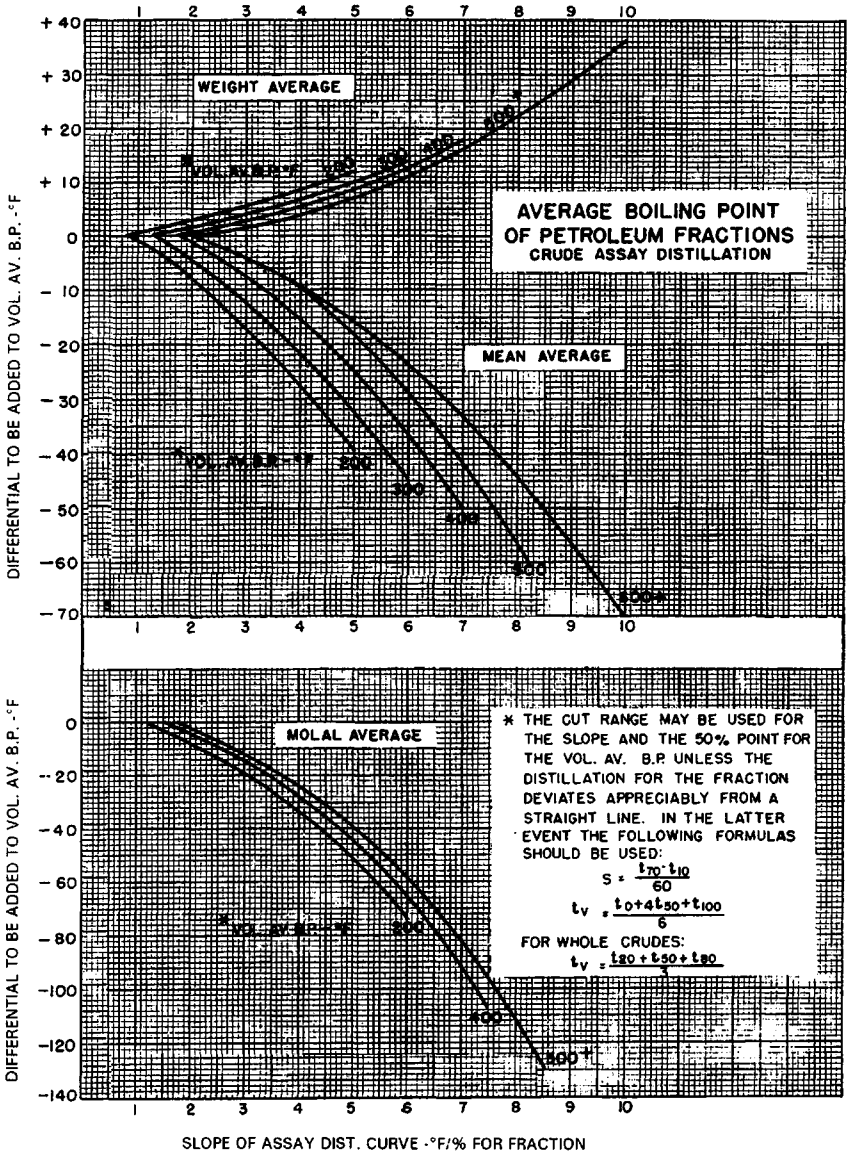


Figure 23. Chart for average boiling point of petroleum fractions (crude assay distillation).

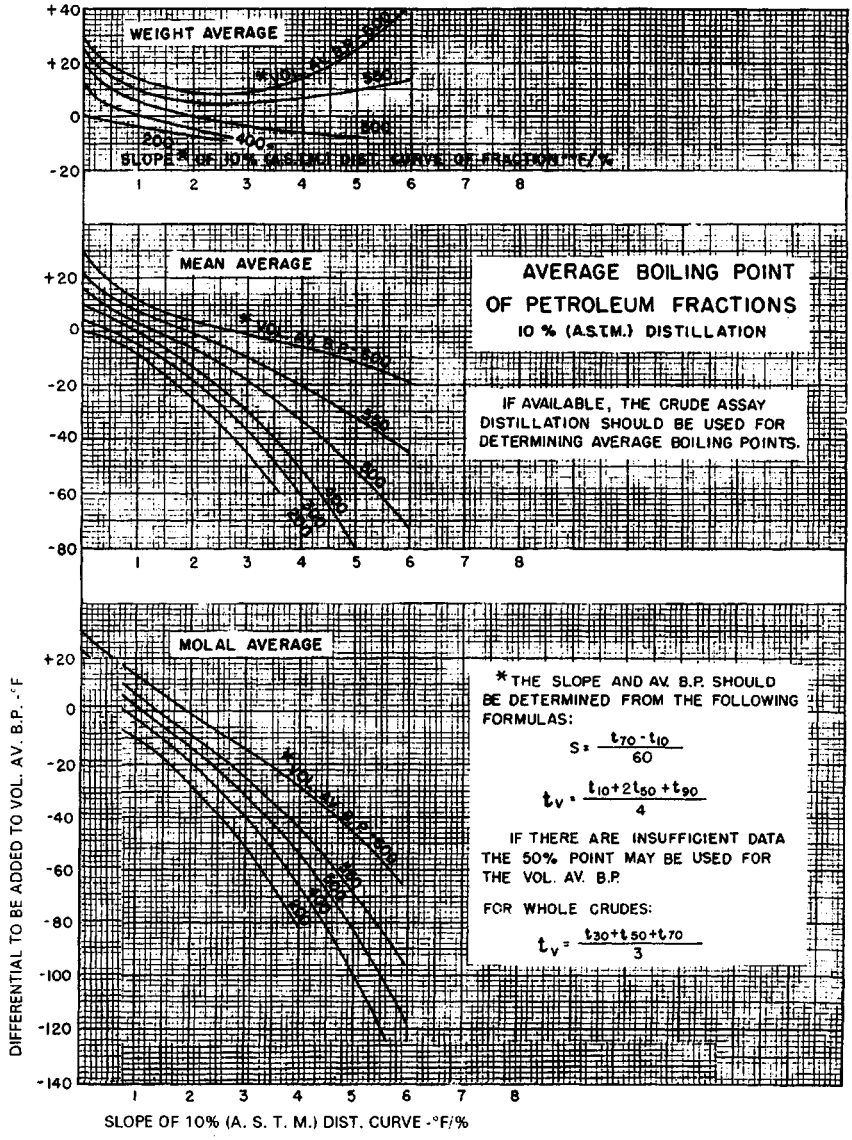


Figure 24. Chart for average boiling point of petroleum fractions (10% A.S.T.M. distillation).

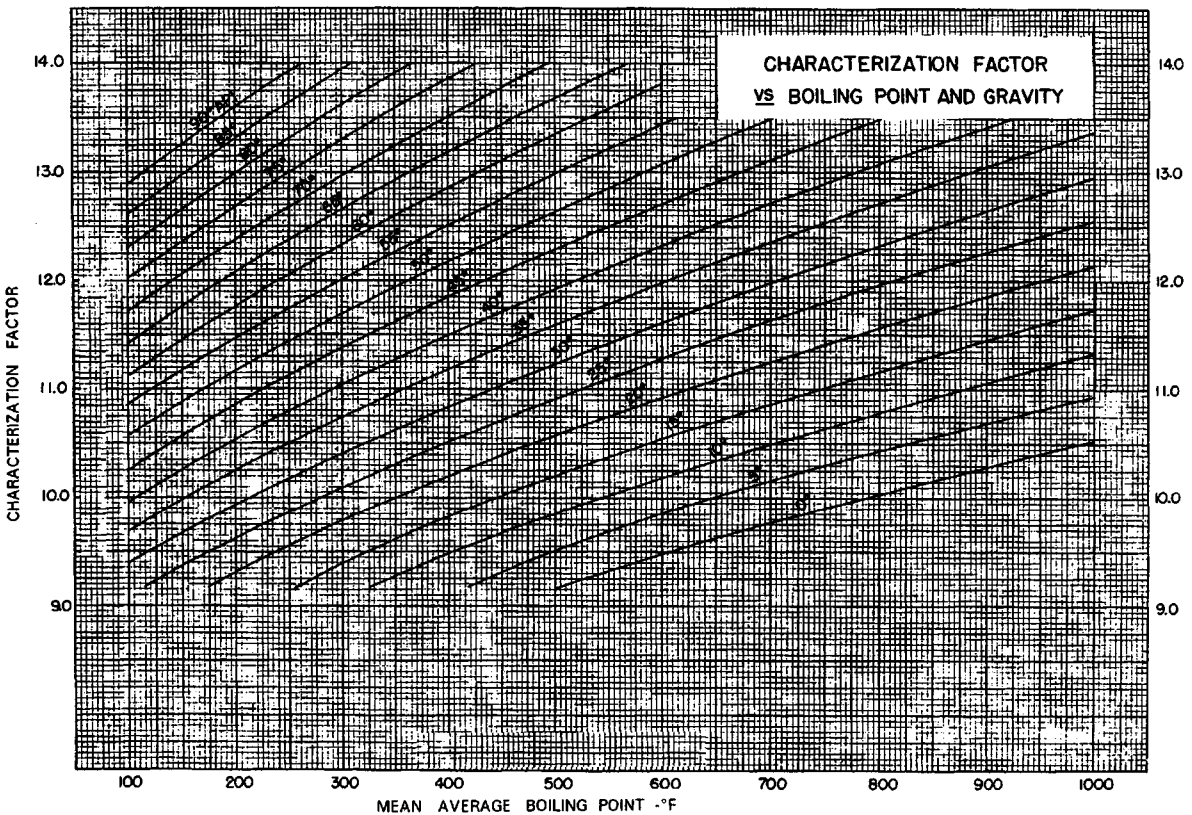


Figure 25. Chart for characterisation factor vs. boiling point and specific gravity.

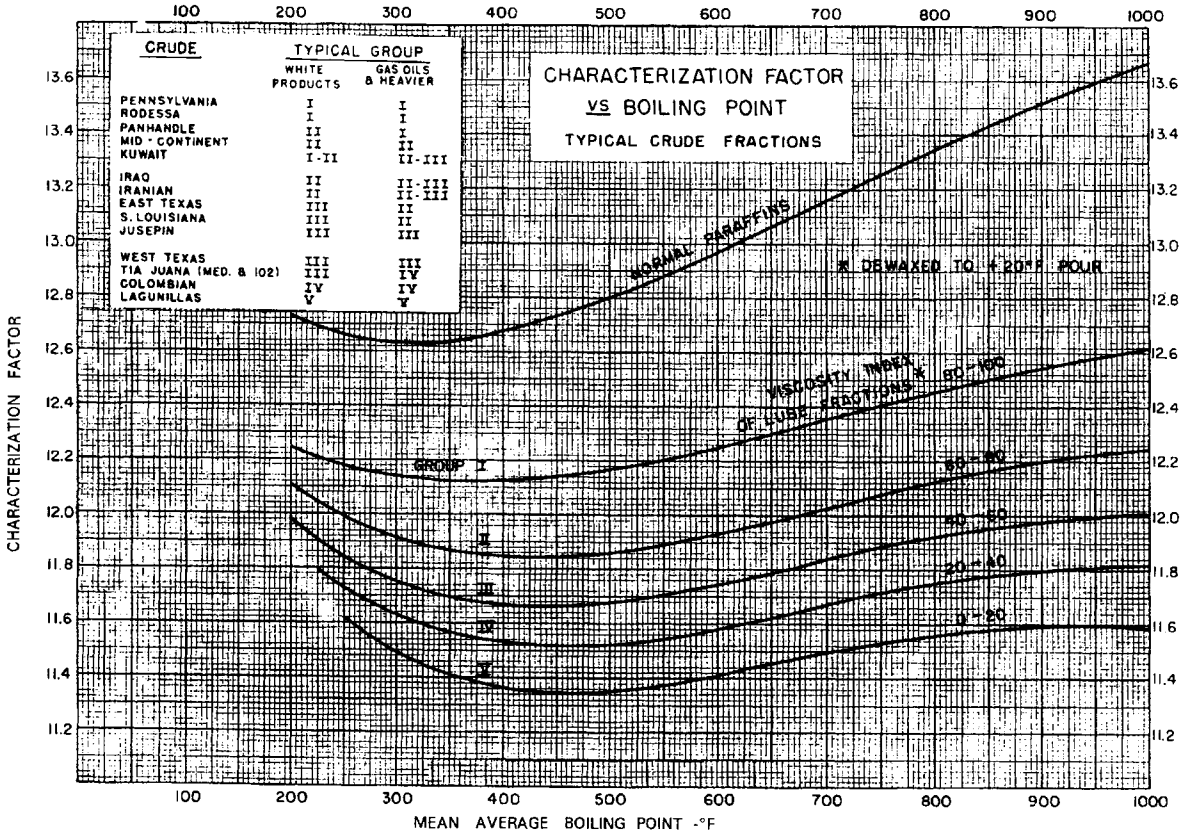


Figure 26. Chart for characterization factor vs. boiling point of crude fractions.

Typical Crude Fractions

For approximate use when there are insufficient data, several correlations have been developed for typical crude fractions grouped according to characterization factor and viscosity index. These groups are numbered in order of decreasing paraffinicity and each may be considered representative of the crude fractions within its characterization factor or viscosity index range. The five groups are summarized in Table 7.

Table 7. Classification of Crude Fractions.

Group	Characterization Factor	Viscosity Index of Lube Fractions
I	12.1-12.6	80-100
II	11.9-12.2	60-80
III	11.7-12.0	40-60
IV	11.5-11.8	20-40
V	11.5-11.8	0-20

Fractions from some of the more common crudes are classified in Table 8.

Table 8. Example of Classifying Crudes.

CRUDE	TYPICAL GROUP	
	White Products	Gas Oils and Heavier
Pennsylvania	I	I
Rodessa	I	I
Panhandle	II	I
Mid-Continent	II	II
Kuwait	I-II	II-III
Iraq	II	II-III
Iranian	II	II-III
East Texas	III	II
South Louisiana	III	II
Jusepin	III	III
West Texas	III	III
Tia Juana (Med. and 102)	III	IV
Colombian	IV	IV
Lagunillas	V	V

Since, in the case of some crudes, the lower boiling fractions

belonged in a different group than the higher boiling fractions, they were classified separately- that is, into white products having an average boiling point less than 500 °F, and gas oils and heavier having an average boiling point greater than 500 °F. Figure 27 provides a chart of gravity versus boiling point, illustrating typical crude fractions.

Inspection Properties

In addition to boiling point and specific gravity, most petroleum products require additional characterization. These other characterizing parameters, related to burning characteristics, pumpability, stability, safety hazard, etc., are loosely grouped, under the general heading of inspection properties. Usually, data measured according to ASTM test procedures are available for virgin and processed stocks. However, it is frequently necessary to estimate values for blends from the corresponding data for the components.

In general, these properties do not blend linearly by weight or volume. To correct for this non-linearity, empirical correlations have been developed which employ some type of weighting factor or index. Correlations for blending, pour, cloud, aniline, and flash points are given in Figures 28 through 30. The correlations for blending, cloud, aniline and flash points are applicable only to middle distillates, i.e., materials boiling in the range of 300-700 °F. The pour point, blending correlation can be used for fractions up to 1050 °F.

Pour Point -

$$t_M = \frac{\Sigma V_i t_i f_i}{\Sigma V_i f_i} \qquad (5)$$

where t_M is the pour point of the blend, °F
t_i is the pour point of component i, °F
V_i is the volume fraction of component i
f_i is the pour point blending factor of component i

Cloud Point -

The blend cloud point is calculated in an analogous manner, using the cloud point blending factor.

An alternative procedure for blend cloud points, where an experimental pour point is available is:

$$t_{M(Cloud)} = t_{M(Pour)} + 13 \qquad (6)$$

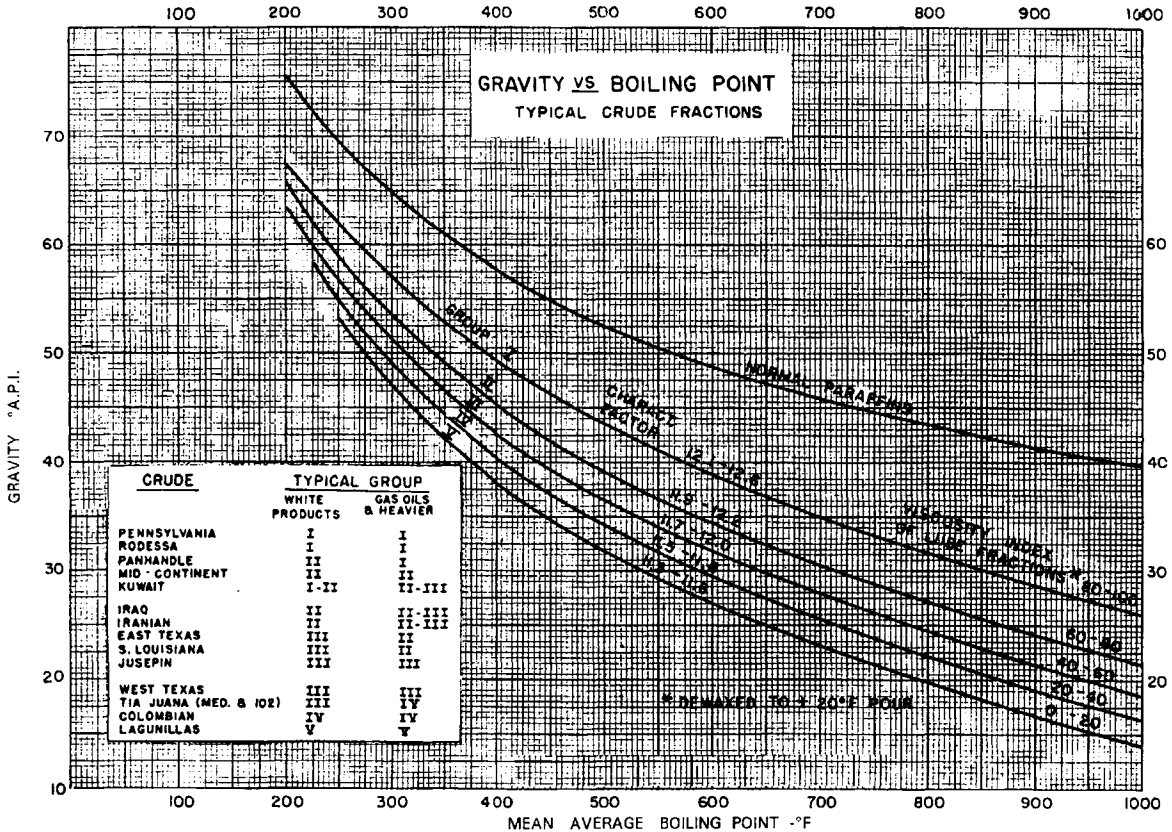


Figure 27. Chart for gravity vs. boiling point for some typical crude fractions.

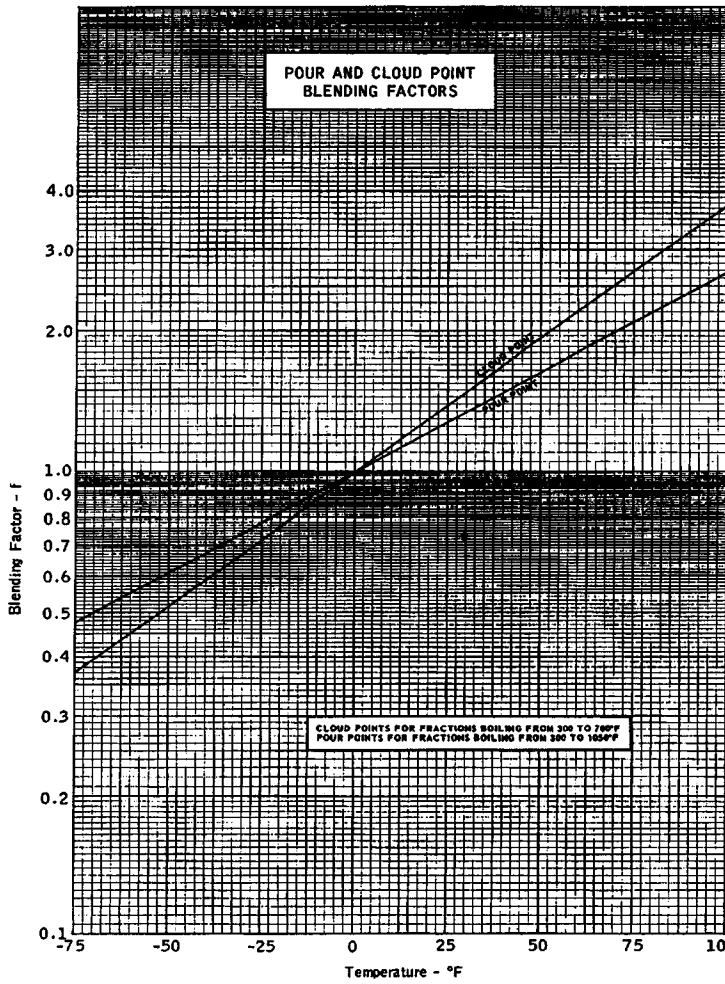


Figure 28. Chart for pour and cloud point blending factors.

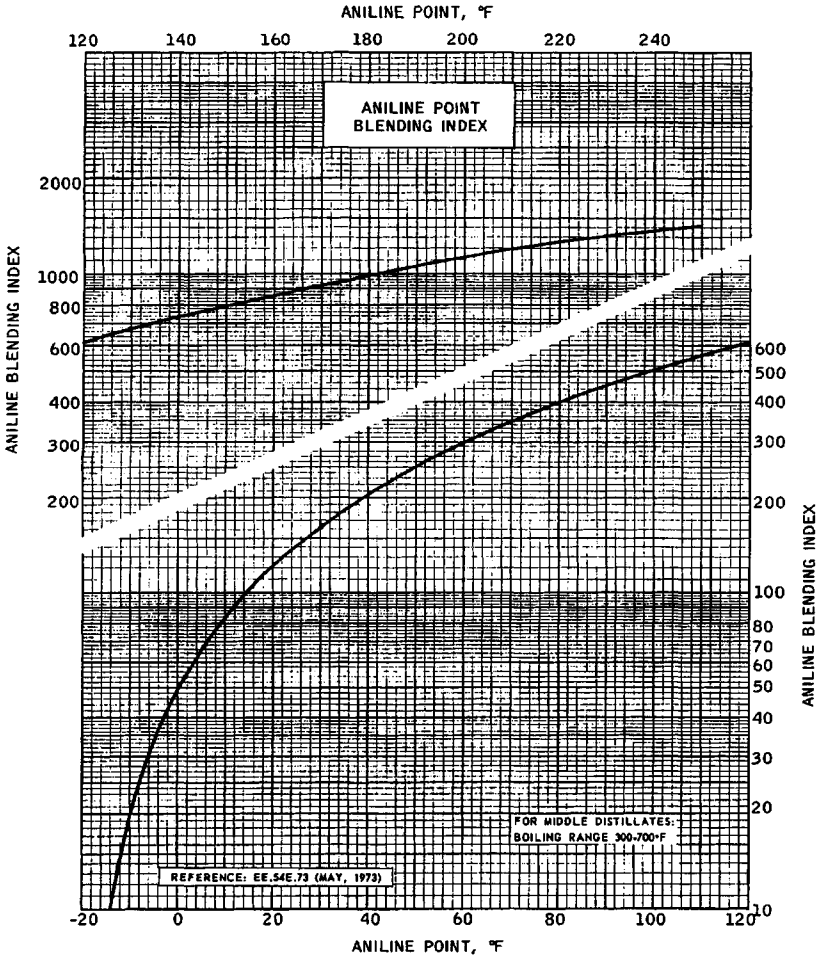


Figure 29. Chart for aniline point blending index.

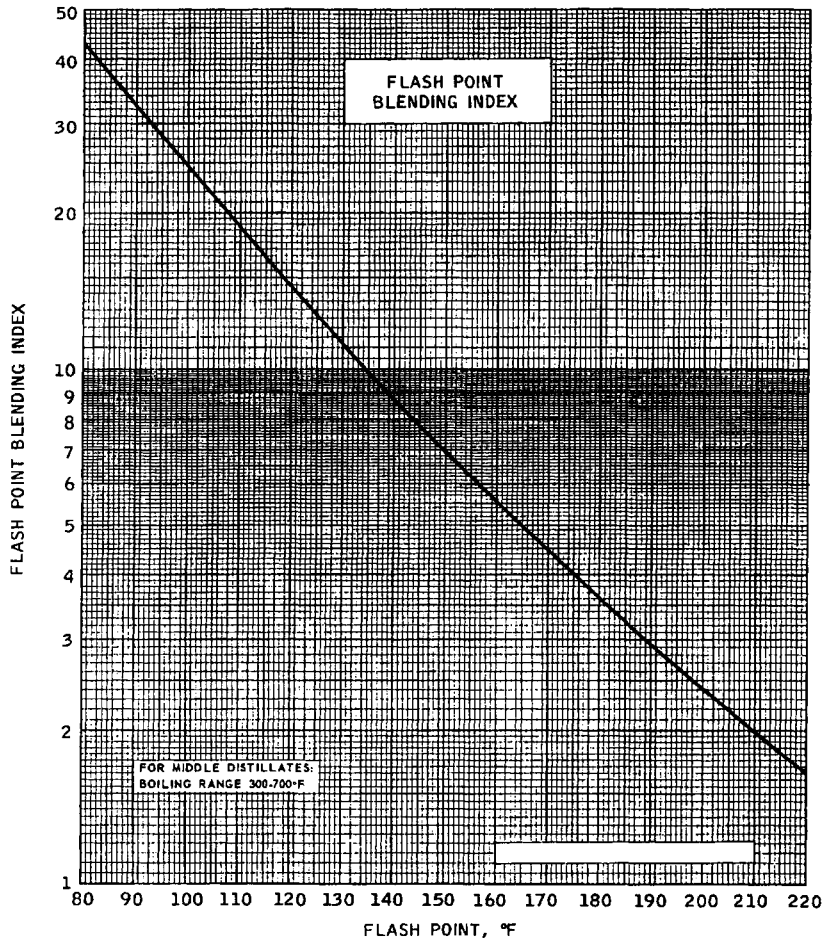


Figure 30. Chart for flash point blending index.

Aniline Point -

The aniline point index of the blend is obtained by volumetrically summing the aniline point indices of the components from Figure 29.

$$I_M = \Sigma V_i I_i \quad (7)$$

where I_M is the aniline point index of the blend
I_i is the aniline point index of component i
V_i is the volume fraction of component i

The resulting sum is converted to the aniline point of the blend by means of the same chart.

Flash Point -

The blend flash point is calculated in an analogous manner (refer to Figure 30), using the flash point blending index. Note, however, that for flash points, the index summation is by mole fractions. For 124 blends, this method predicted 68% of the points to within 5 °F, while 16% showed deviations greater than 10 °F.

MOLECULAR WEIGHT OF PETROLEUM FRACTIONS

Figures 31 and 32 provide charts for the molecular weights of petroleum fractions, derived from an empirical correlation of molecular weight and the function $T_m / s^{0.4}$, where T_m is the mean average boiling point of the fraction in °R and s is the specific gravity at 60 °F/60 °F.

A similar chart is given for n-paraffins in Figure 33.

Note that Figure 31 provides the correlation for the "base" molecular weight and Figure 32 for the correction factor for variations in Modified Naphtha Insoluble (MNI) content.

For highly processed stocks, e.g., deasphalted oil, only the base molecular weight chart in Figure 31 should be used.

The following is an example of how to apply these correlations.

Estimate the molecular weight of a fraction from Bachaquero crude having a mean average boiling point of 1100 °F and a gravity of 10° API. The MNI of the 1050+ residuum from Bachaquero crude is 23 weight %.

From the chart in Figure 31, the base molecular weight is 730 and the

correction factor from Figure 32 is 1.17. The molecular weight is 730 x 1.17 = 854.

For fractions derived from mixed crudes, the weight average of the MNI's of the individual crudes may be used. For those cases where the MNI is unknown, the MNI of a similar crude may be used. If this is not possible, only the "base" molecular weight (Figure 31) can be obtained.

Molecular Weight of Viscous Petroleum Fractions

The molecular weight of viscous, petroleum fractions is given as a function of gravity and viscosity in Figures 34 and 35.

CRITICAL PROPERTIES

Analogous to pure substances the true critical point of a mixture is a unique point on the phase envelope where the density and composition of the vapor phase are identical with those of the liquid phase. Since the compositions of the two phases are the same, fractionation of a mixture is impossible at the critical point. Consequently, the degree of approach to the critical point of a mixture sometimes serves as a rough guide to the feasibility of separating the components by fractionation.

For pure hydrocarbons, it has been found that a number of physical properties may be correlated by reduced temperatures T/T_c, and reduced pressure, P/P_c. Various data have shown conclusively that none of these correlations apply to mixtures if the true critical temperature and pressure of the mixture are used to determine the reduced conditions. This difficulty has been overcome by the concept of pseudo-critical temperature and pressure. By using the pseudo-critical temperature and pressure to predict the reduced conditions, compressibility data on pure hydrocarbons can be applied to mixtures. An old technique used to determine pseudo-critical point is by averaging the critical properties directly for known mixtures and from the average molecular weight for petroleum fractions, however better results are obtained by using average boiling point methods.

Estimation of Critical Properties of Pure Compounds

Charts are provided in Figures 36 through 41 for estimating critical properties. These charts are applicable to hydrocarbons only. For simple non-hydrocarbons, tabulations of measured critical properties are available. However, for more complex compounds (including hydrocarbons) generally there are no experimental data. Moreover, for many of these compounds, there is little likelihood that direct experimental data will ever be available, since they may undergo decomposition, polymerization or other chemical

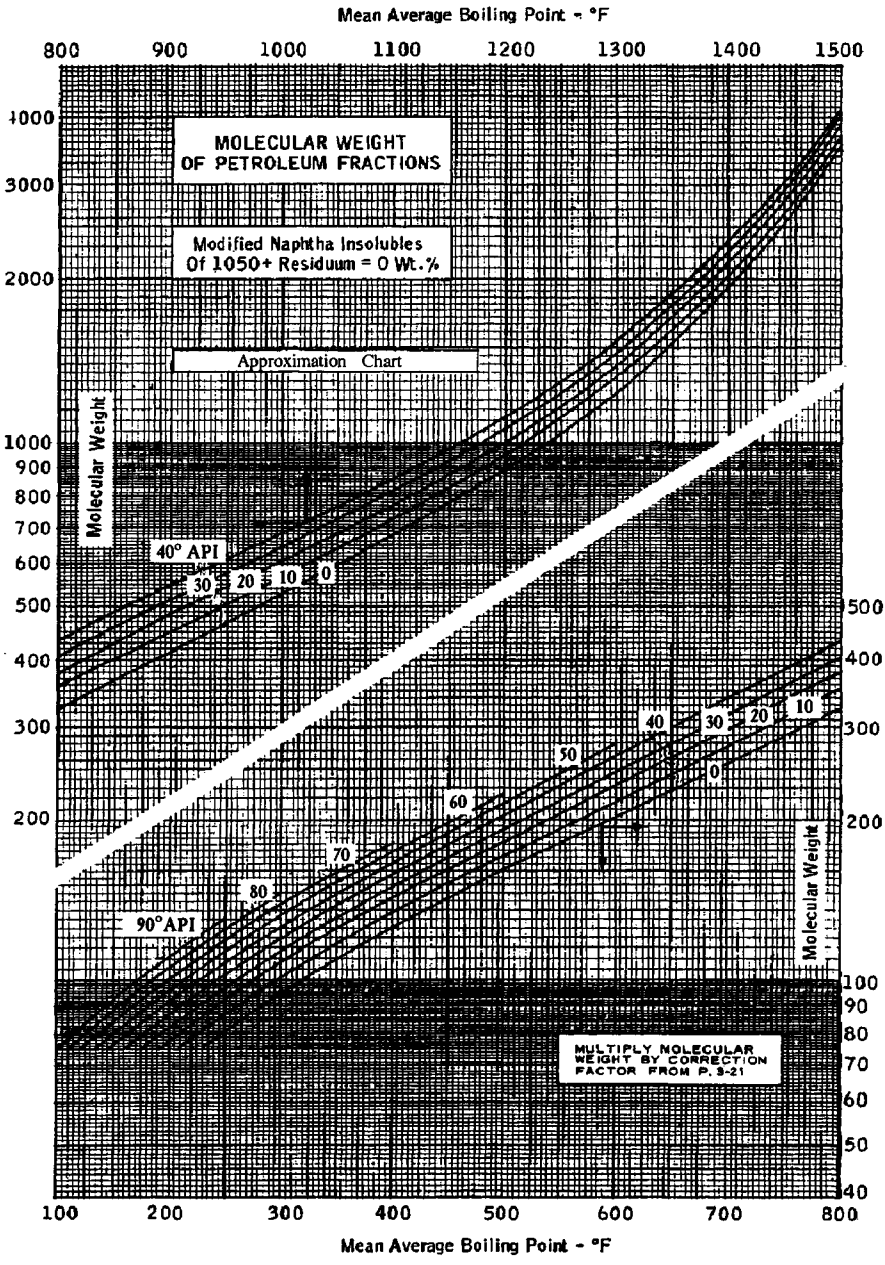


Figure 31. Chart for molecular weight of petroleum fractions.

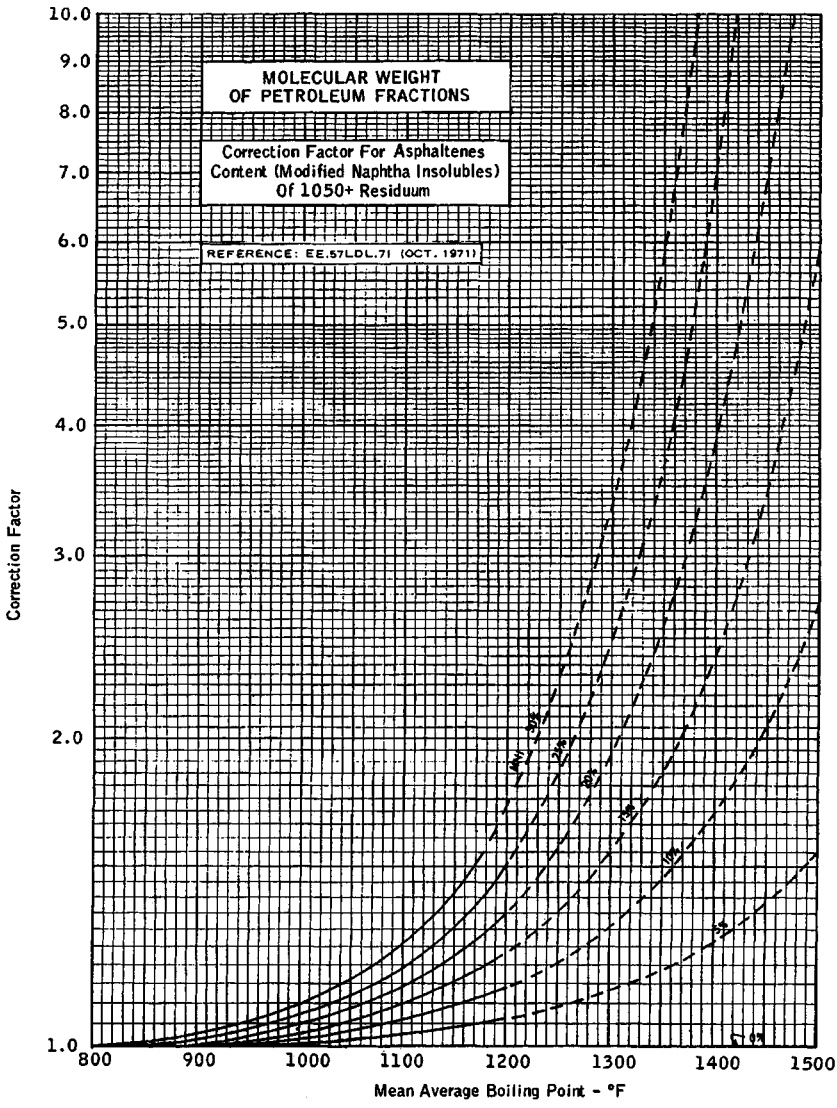


Figure 32. Chart for molecular weight of petroleum fractions.

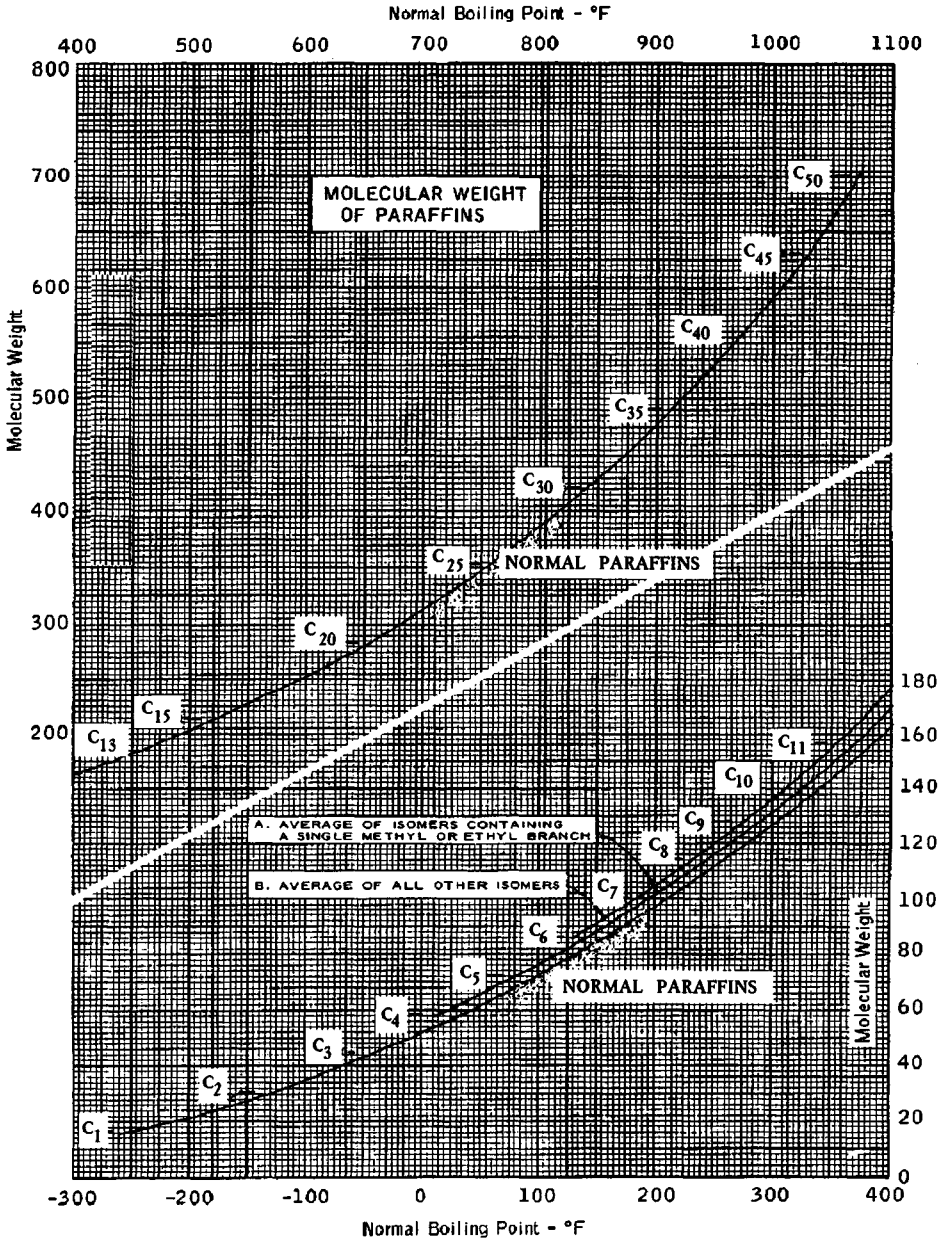


Figure 33. Chart for molecular weight of paraffins.

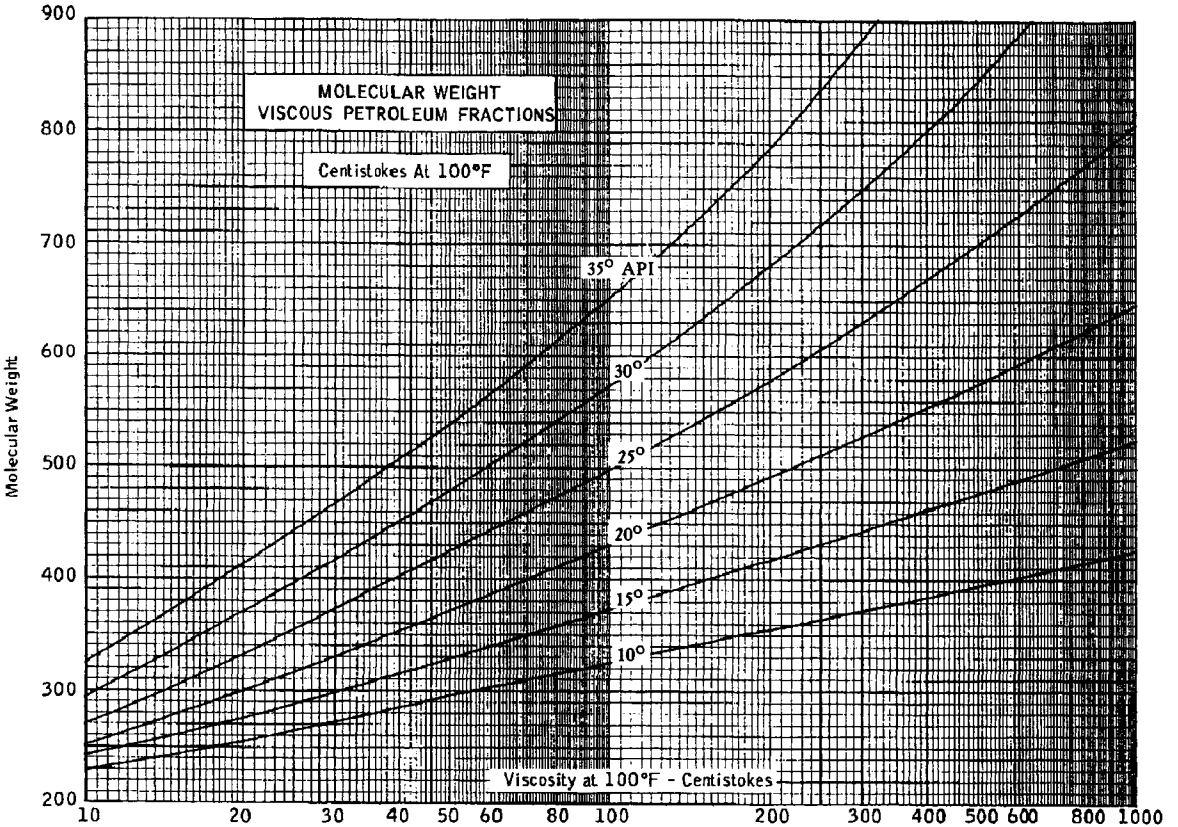


Figure 34. Chart for molecular weight of viscous petroleum fractions.

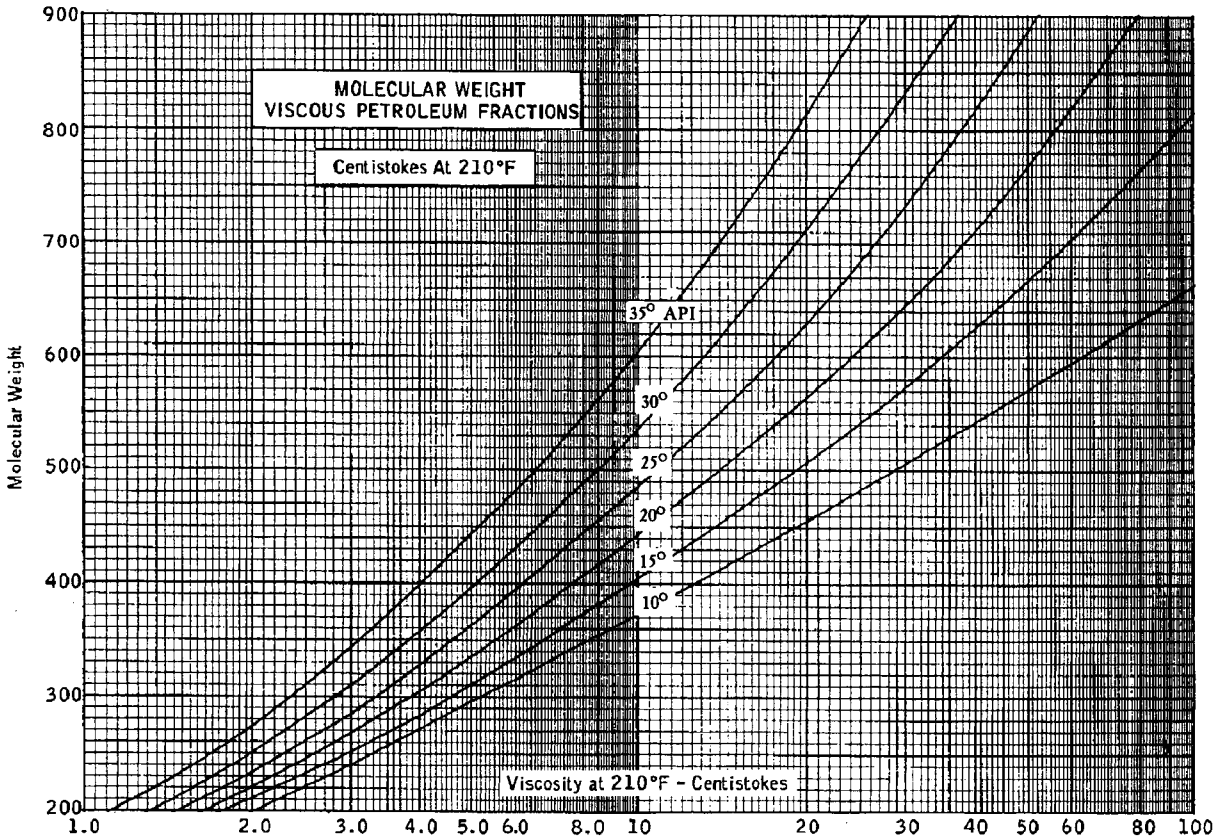


Figure 35. Chart for molecular weight of viscous petroleum fractions.

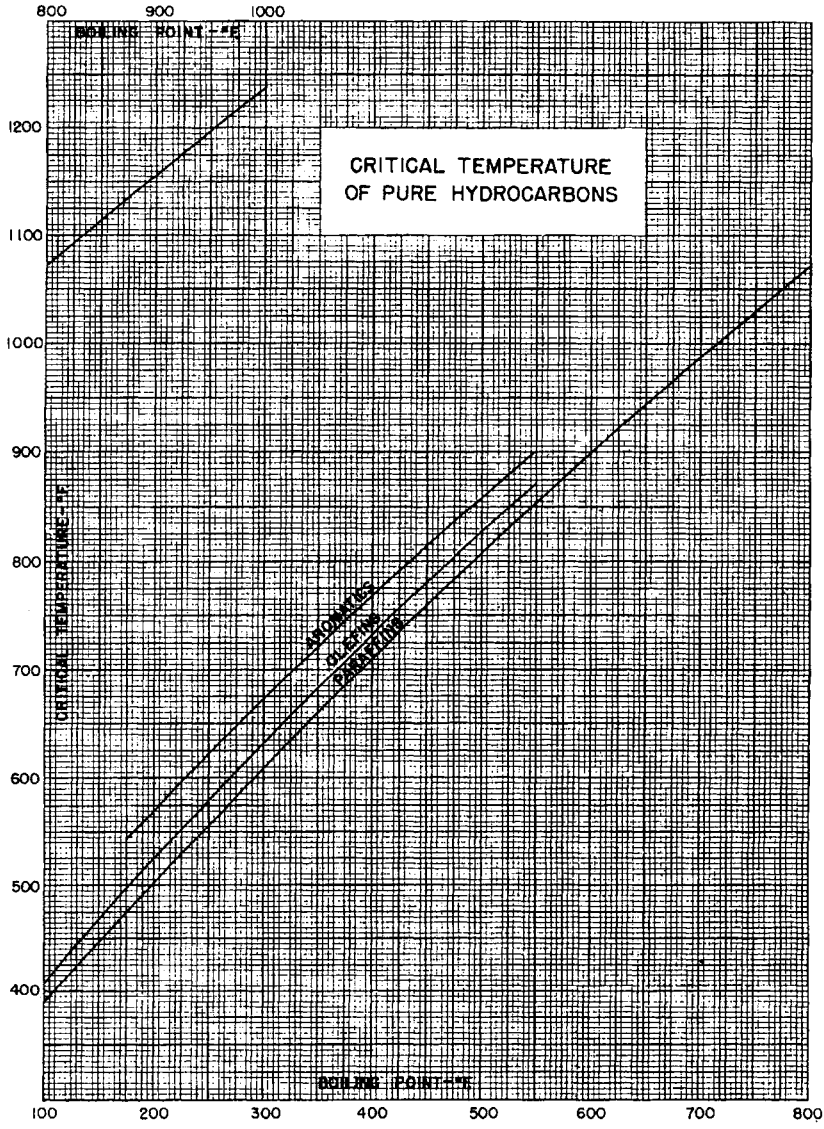


Figure 36. Chart for critical temperatures of pure hydrocarbons.

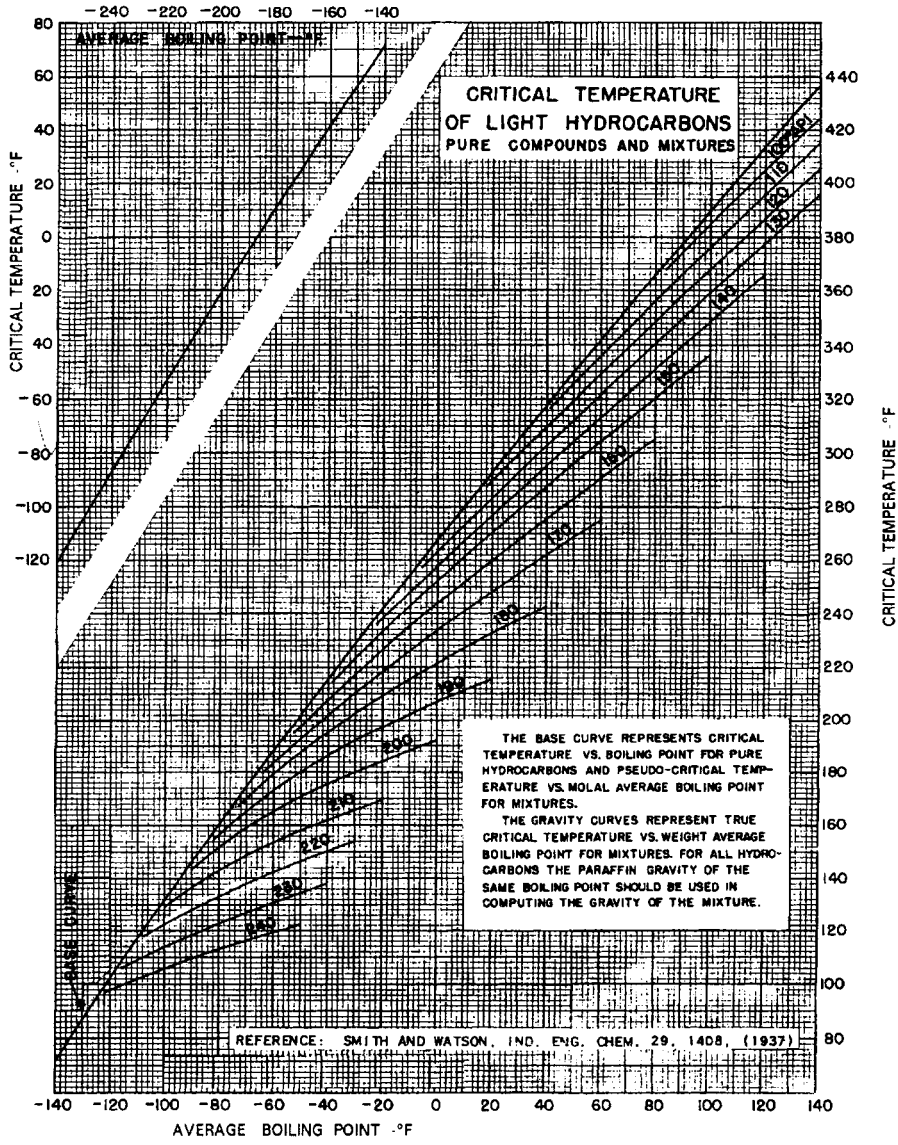


Figure 37. Chart for critical temperatures of light hydrocarbons, both pure and mixtures.

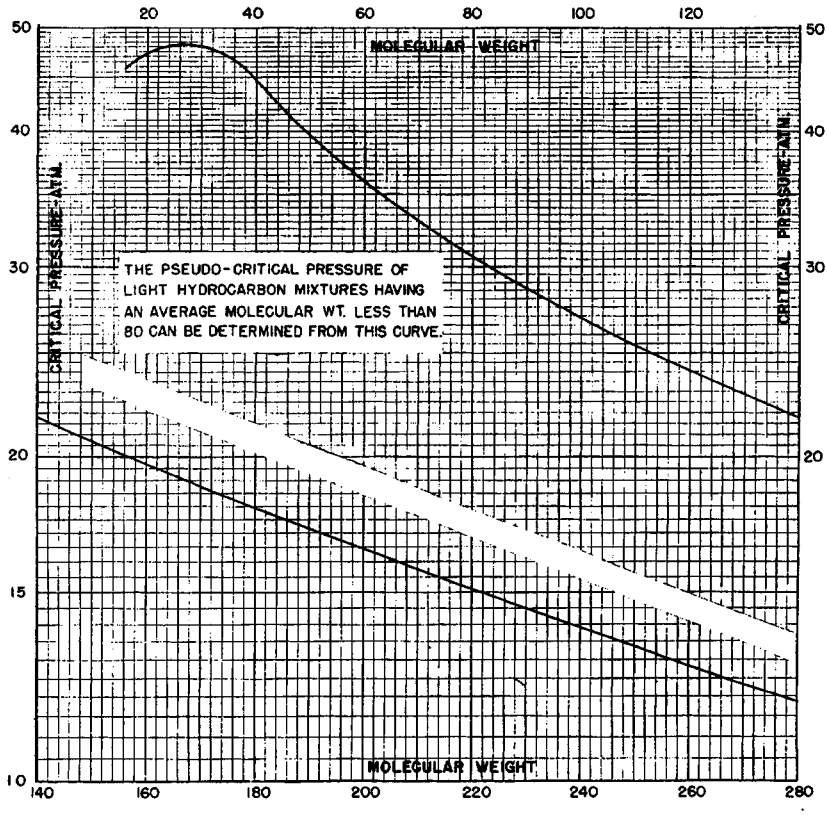


Figure 38. Chart for critical pressure of normal paraffins.

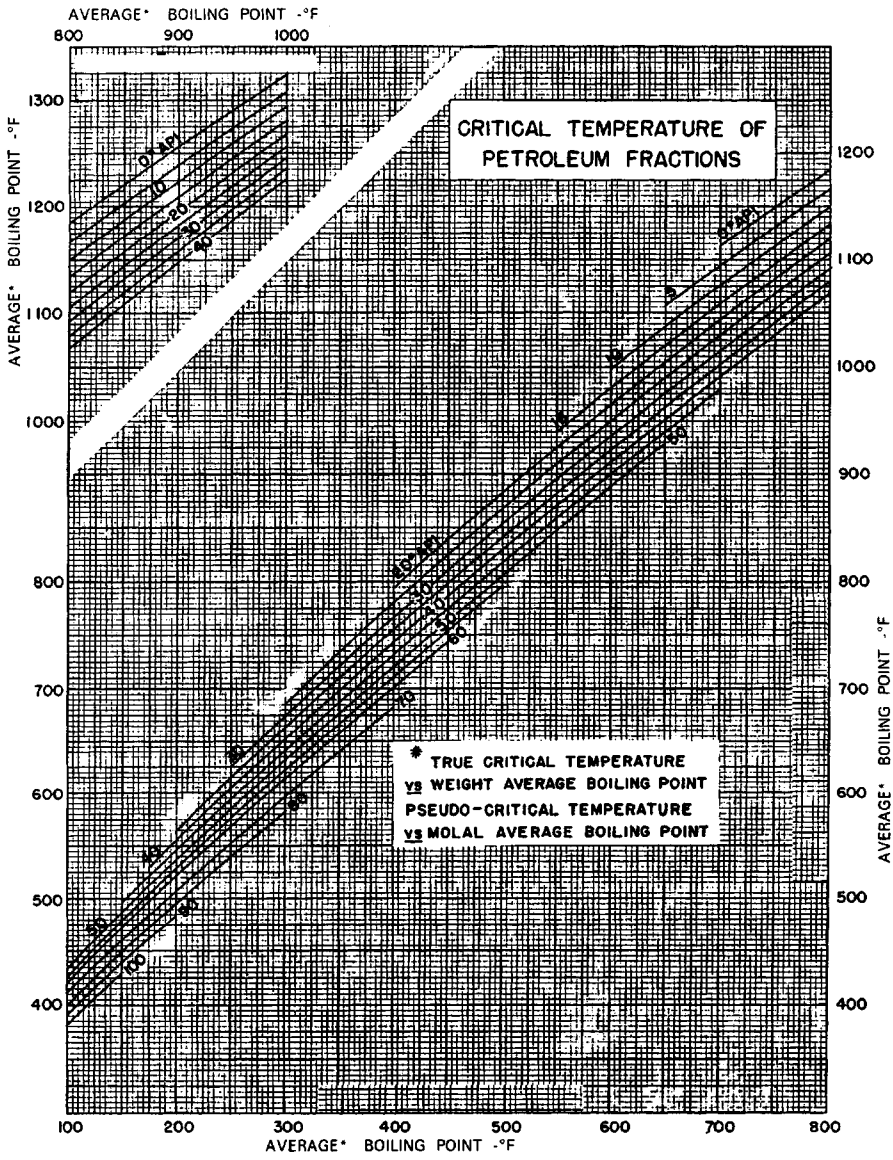


Figure 39. Chart for critical temperatures of petroleum fractions.

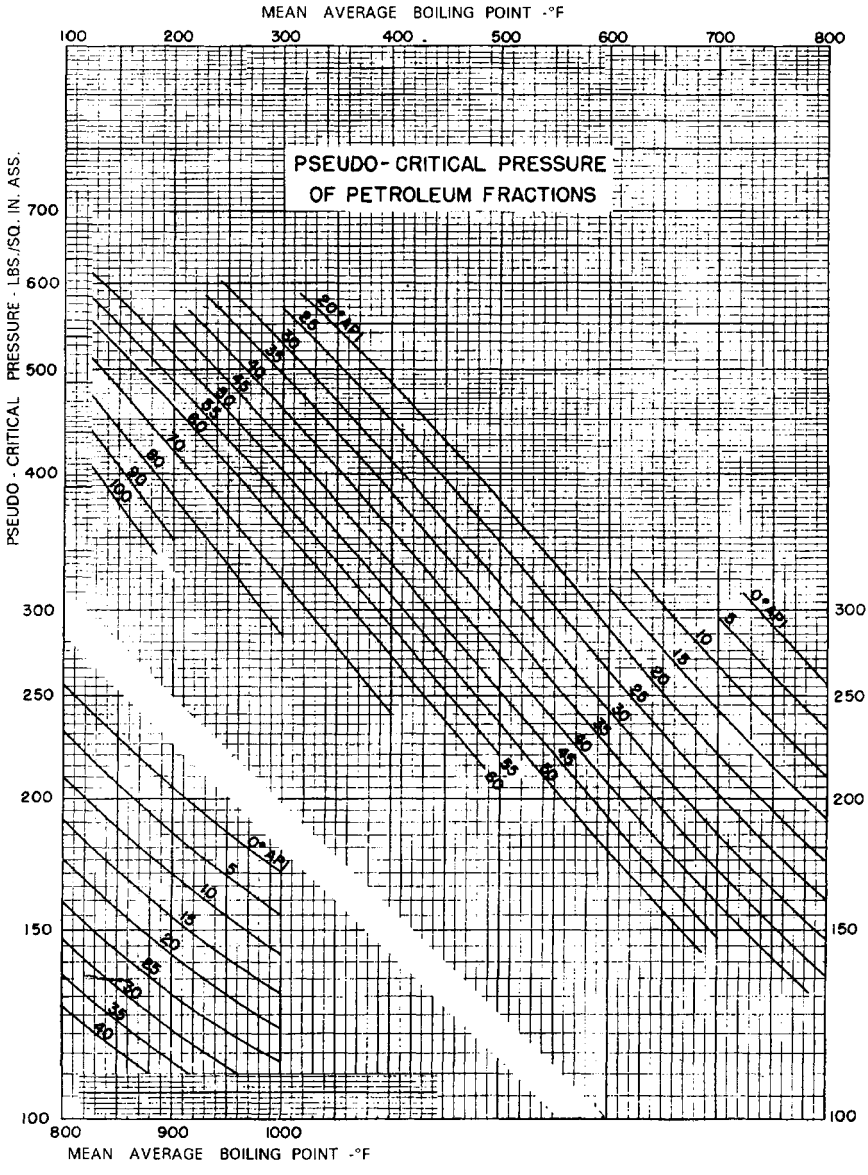


Figure 40. Chart for pseudo-critical pressure of petroleum fractions.

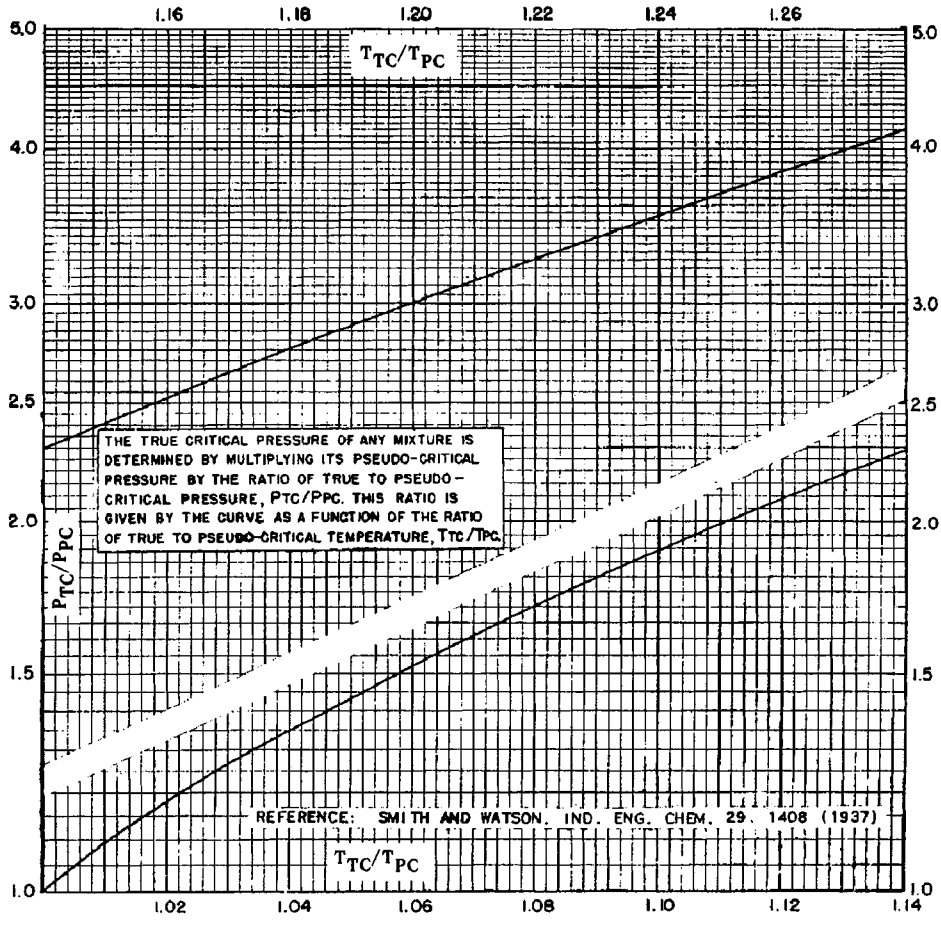


Figure 41. Chart for the critical pressure of hydrocarbon mixtures.

reactions at temperatures well below the critical. Nevertheless, since reduced properties are so important as correlating parameters, it is frequently necessary to estimate the critical constants.

A large number of methods for relating critical properties to other conveniently measurable properties have been developed. Some of these methods are highly accurate for specific classes of compounds. The most useful general method is that due to Lydersen, which is applicable to a broad range of compound types. Basically, the method involves summing contributions due to atomic and structural features of the molecule. The sum of these contributions is the parameter relating the critical properties to some other measurable property. Table 9 lists the atomic and structural contributions for a number of atoms and groups.

The critical temperature is calculated from the normal boiling point by:

$$T_C = T_B/\theta \tag{8}$$

where T_C and T_B are in °R
θ is a constant calculated from the atomic and structural contributions.

$$\theta = 0.567 + \Sigma\,\Delta t - (\Sigma\,\Delta t)^2 \tag{9}$$

where $\Sigma\,\Delta t$ is obtained by summing the values from Table 9.

The critical pressure is calculated from the molecular weight by:

$$P_C = \frac{M}{(\Sigma\,\Delta_p + 0.34)^2} \tag{10}$$

where P_C is in atmospheres
M is the molecular weight
$\Sigma\,\Delta_p$ is obtained by summing the values from Table 9.

The critical volume is obtained directly

$$V_C = 40 + \Sigma\,\Delta_V \tag{11}$$

where V_C is in. cm^3/g mol
$\Sigma\,\Delta_V$ is obtained by summing the values from Table 9.

Example - Estimate the critical properties of diethyl sulfide:
(t_B = 197.8 °F, MW = 90.12)
$CH_3 - CH_2 - S - CH_2 - CH_3$

From Table 9, the following values are tabulated:

	Δ_t	Δ_p	Δ_v
2-CH_3	2 x 0.020	2 x 0.227	2 x 55
2-CH_2	2 x 0.020	2 x 0.227	2 x 55
1-S-	0.015	0.27	55
	Σ=0.095	Σ=1.178	Σ=275

$\theta = 0.567 + 0.095 - (0.095)2 = 0.6529$
$T_C = (197.8 + 459.7)/0.6529 = 1007\ ^\circ R = 547\ ^\circ F$ (Obs = 543 °F)

$$P_C = \frac{90.12}{(1.178 + 0.34)^2} = 39.1 \quad \text{Atm (Obs = 39.1 atm)}$$

$V_c = 40 + 275\ cm^3/g\ mol = 315\ cm^3/g\ mol$ (Obs = 317 cm^3/g mol)

Although the agreement between estimated and observed values is excellent, in many cases, the difference will be larger.

THERMAL PROPERTIES

Specific Heat

Since hydrocarbon vapors deviate considerably from a perfect gas, except at low pressures, their specific heats are a function of pressure as well as temperature. However, vapor specific heats at higher pressures have limited application as enthalpy correlations but may be more readily used for thermal calculations. For this reason, the specific heat charts for gases and vapors provided in this chapter are given only for low pressures (0-1 atm) where deviations from a perfect gas are so small that specific heat may be considered to be a function of temperature alone. This charts are given in Figures 42 through 47. The specific heat of a mixture of two or more gases at low pressure may be calculated from either their weight fractions multiplied by their specific heats or their mole fractions by their molal heat capacities (MC_p).

Two charts are given for the specific heat of petroleum fraction vapors. The chart in Figure 44 provides the specific heat as a function of temperature and characterization factor. The charts give a correction to be applied as a function of the mean average boiling point.

Note that in general, enthalpy charts should be used in preference to specific heat charts.

Table 9. Increments for Estimating Critical Constants

Use no increment for hydrogen. All bonds indicated as free are connected with atoms other than hydrogen.

Atoms and Atomic Groups		Δ_t	Δ_p	Δ_v
$-CH_3$ and $-CH_2-$		0.020	0.227	55
$-CH_2-$	In ring	0.013	0.184	44.5
$-\overset{|}{C}H$		0.012	0.210	51
	In ring	0.012	0.192	46
$=CH$ and $=CH_2$		0.018	0.198	45
$=CH$	In ring	0.011	0.154	37
$-\overset{|}{\underset{|}{C}}-$		0.0	0.210	41
	In ring	(-0.007)	(0.154)	(31)
$=\overset{|}{C}-$ and $=C=$		0.0	0.198	36
	In ring	0.011	0.154	36
$\equiv C-$ and $\equiv CH$		0.005	0.153	(36)
$-F$		0.018	0.224	18
$-Cl$		0.017	0.320	49
$-Br$		0.010	(0.50)	(70)
$-I$		(0.012)	(0.83)	(95)
$-O-$		0.021	0.16	20
	In ring	(0.014)	(0.12)	(8)
$-OH$	primary alcohols	0.082	0.06	(18)
	secondary and tertiary alcohols	0.082	(0.12)	(18)
	phenols	(0.035)	(-0.02)	(3)
$>CO$		0.040	0.29	60
	In ring	(0.033)	(0.2)	(50)
$-CHO$		0.048	0.33	73
$-COO-$		0.047	0.47	80
$-COOH$		0.085	(0.4)	80
$-NH_2$		0.031	0.095	28
$>NH$		0.031	0.135	(37)
	In ring	(0.024)	(0.09)	(27)
$>N-$		0.014	0.17	(42)
	In ring	(0.007)	(0.13)	(32)
$-CN$		(0.060)	(0.36)	(80)
$-SH$ and $-S-$		0.015	0.27	55
$-S-$	In ring	(0.008)	(0.24)	(45)
$=O$	except for combinations above	(0.02)	(0.12)	(11)
$-NO_2$		(0.055)	(0.42)	(78)
$=S$		(0.003)	(0.24)	(47)

Numbers in parentheses are based on too few experimental data to be reliable.

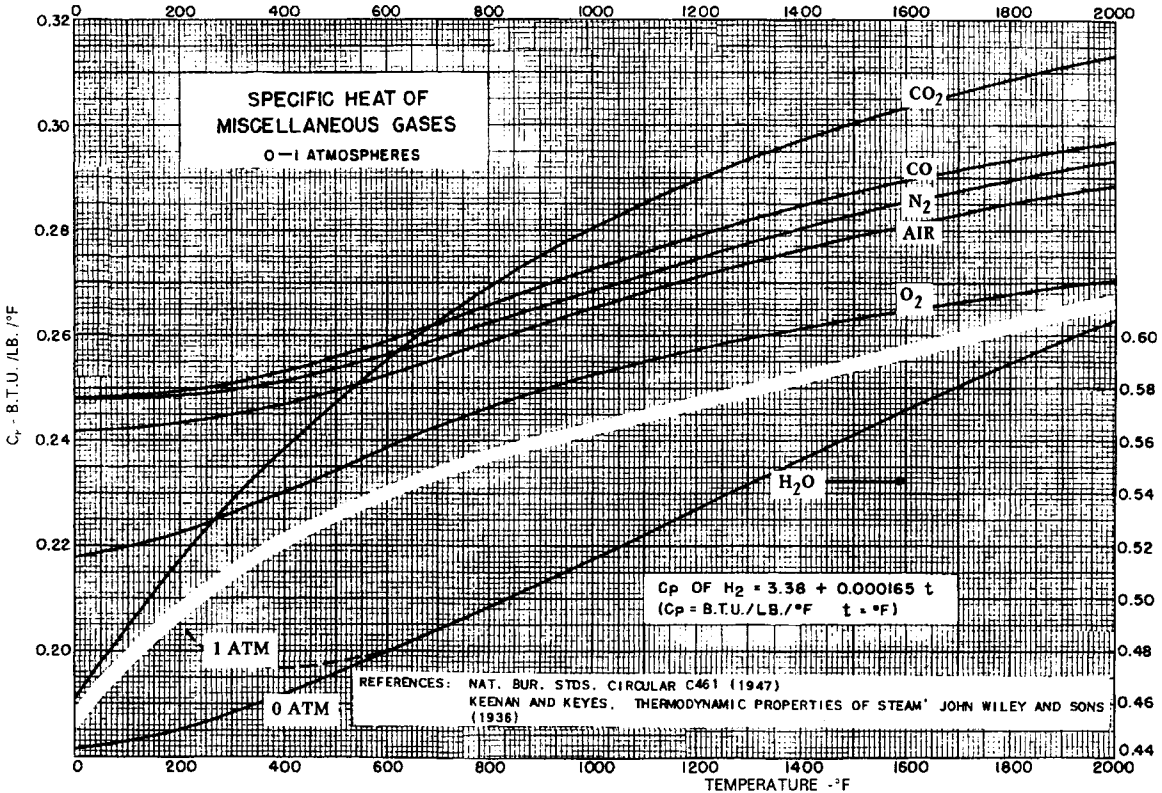


Figure 42. Chart for the specific heats of miscellaneous gases at 0 to 1 atmospheres.

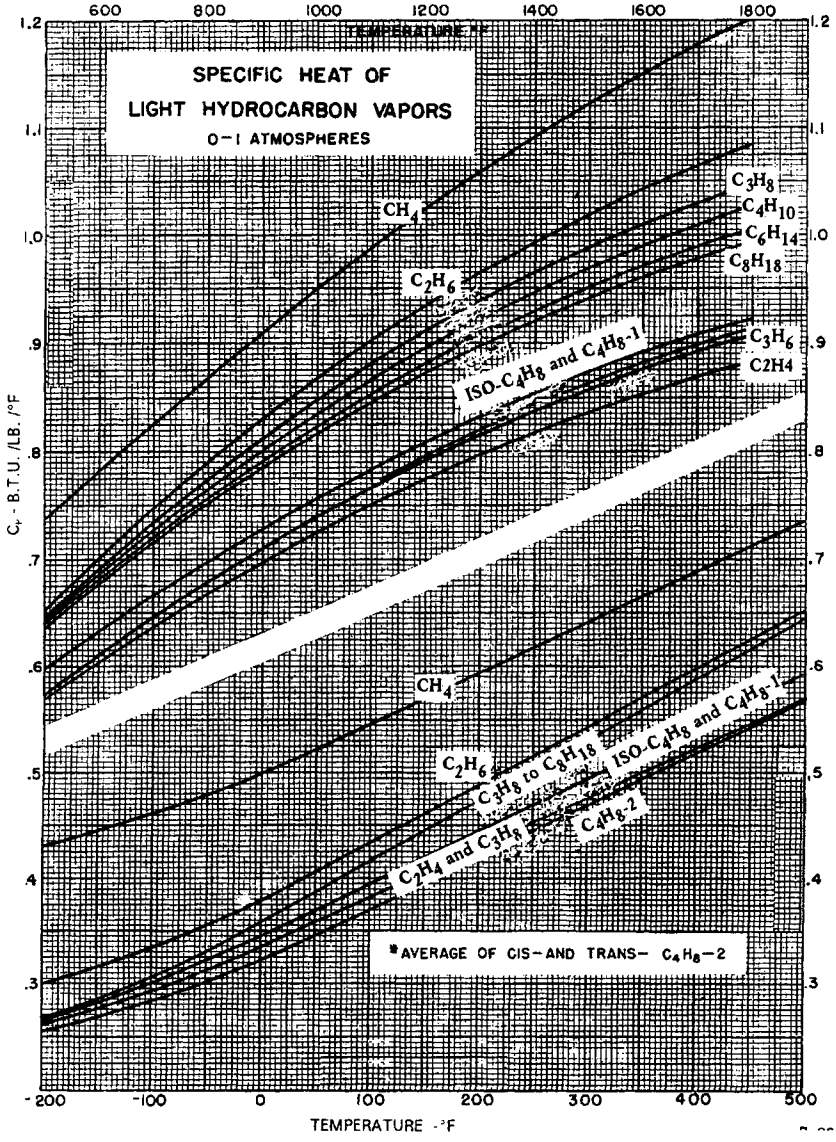


Figure 43. Chart for the specific heats of hydrocarbon vapors at 0 to 1 atmospheres.

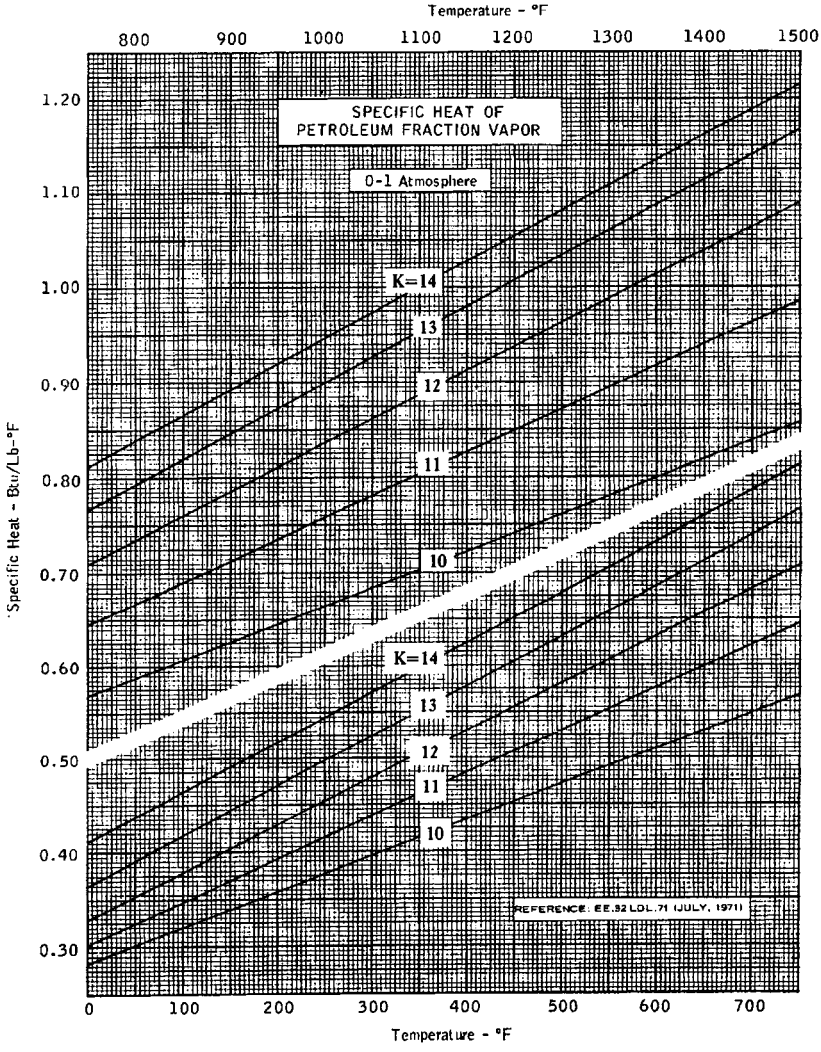


Figure 44. Chart for the specific heats of petroleum fraction vapors at 0 to 1 atmospheres.

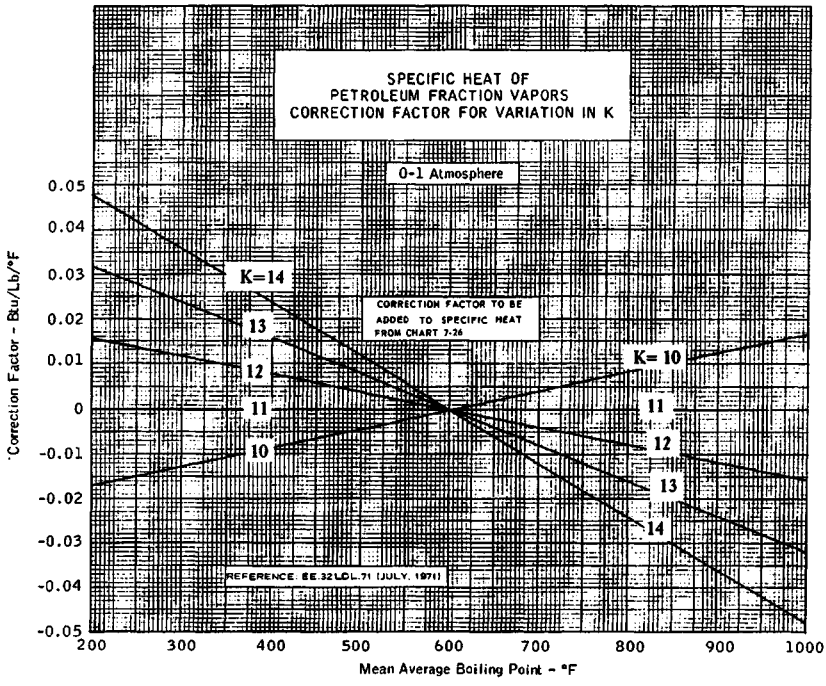


Figure 45. Chart for the specific heats of petroleum fraction vapors correction factor for variation in K.

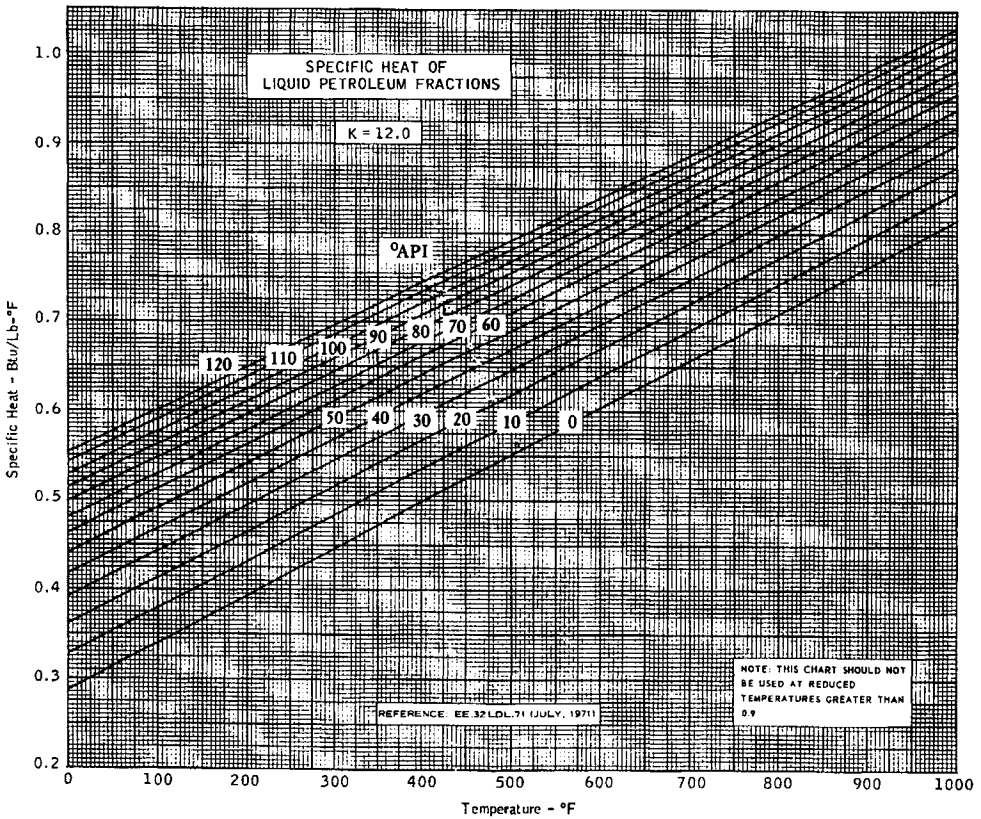


Figure 46. Chart for the specific heats of liquid petroleum fractions for K = 12.0

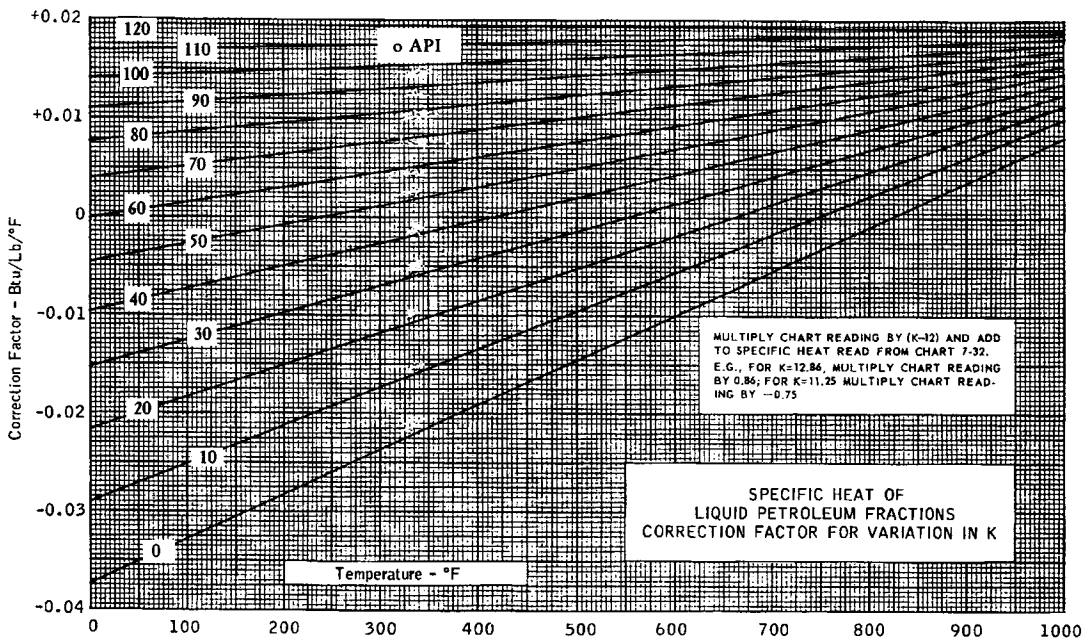


Figure 47. Chart for the specific heats of liquid petroleum fractions for correction factor for variation in K.

Latent Heat of Vaporization

The latent heat of vaporization of any compound is the difference in enthalpy between its saturated vapor and its saturated liquid at constant temperature and may be expressed either as a function of temperature or as a function of vapor pressure. The latent heats of low-boiling hydrocarbons and, also, higher-boiling normal paraffins of even boiling point are plotted against vapor pressure in Figures 48 through 51. While the use of temperature instead of vapor pressure as the correlating variable would have advantages, it would also result in the curves crossing each other, thus making the plots difficult to read.

The latent heat charts were derived by using a direct proportionality between the molal heats of vaporization of any two hydrocarbons at the same reduced pressures. For the lower boiling hydrocarbons, the latent heat data were smoothed out and extrapolated by the use of a reference compound (ethane, butane, or hexane). Where no data were available, as in the case of a few of the light hydrocarbons and all of the higher- boiling normal paraffins, the latent heats were calculated directly from this reduced pressure relationship. The slope or proportionality constant was predicted from the normal boiling point of the hydrocarbon.

The latent heat of vaporization of other hydrocarbons may be calculated from the normal paraffin curves by the use of this same relation. That is, the unknown compound will have the same molal heat of vaporization as a paraffin of the same normal boiling point at the same reduced pressure. In the case of petroleum fractions, the mean average boiling point is used for the normal boiling point and the reduced pressure is computed from the pseudo-critical pressure of the mixture. The "vapor pressure" of the fraction corresponds to that of a pure hydrocarbon of the same normal boiling point at the temperature of the fraction and never refers to the bubble point, dew point, or operating pressure of the system.

Since the difference in enthalpy between the liquid and the saturated vapor of a petroleum fraction always involves change of enthalpy of the vapor at constant temperature in addition to latent heat, except at low pressures, the enthalpy correlations are much more convenient to use than these individual thermal properties.

The following examples illustrate the use of the latent heat charts:

Example 1.

Compute the latent heat of benzene at 1 atm.

The boiling point of benzene is 176.2 °F and its critical pressure is 47.9 atm. The molecular weight of a normal paraffin boiling at 176.2 °F is 91.5 and its critical pressure 28.3 atm. The vapor pressure of the normal

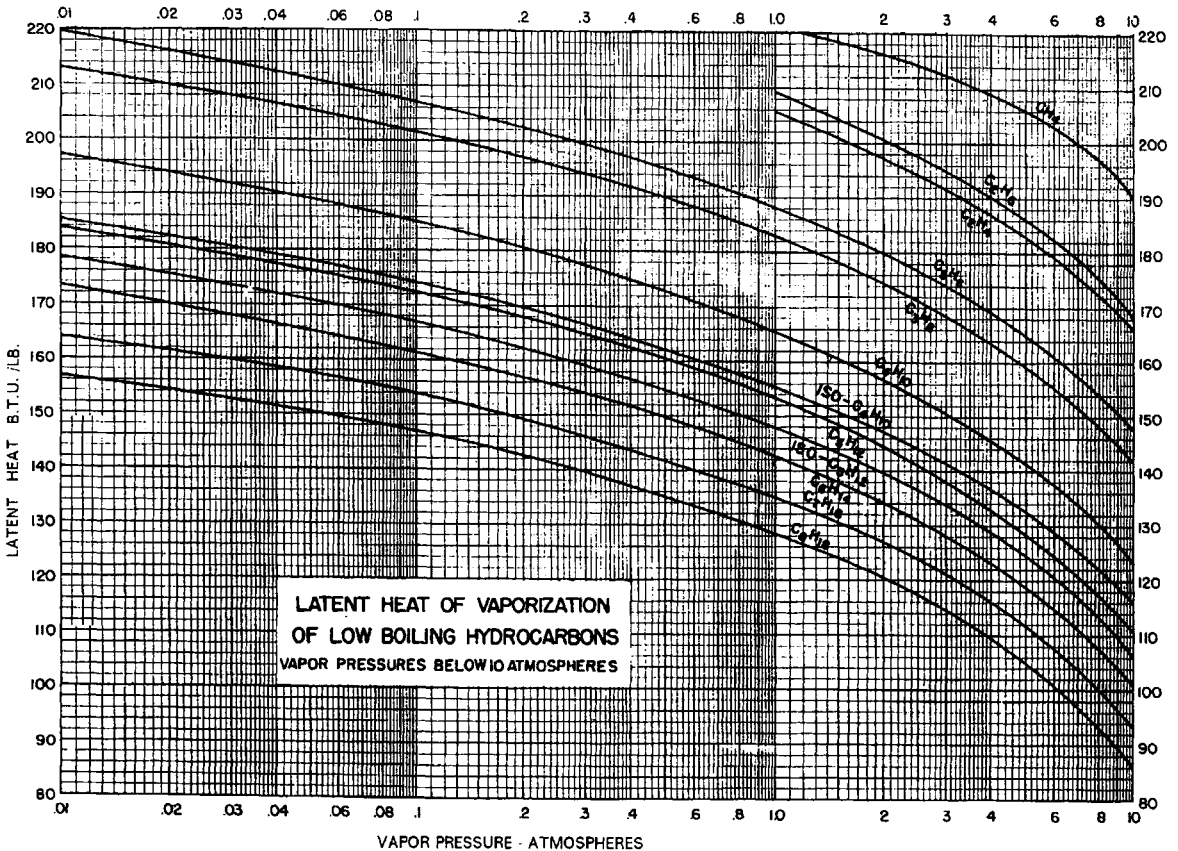


Figure 48. Chart for latent heat of vaporization of low boiling hydrocarbons at vapor pressures below 10 atmospheres.

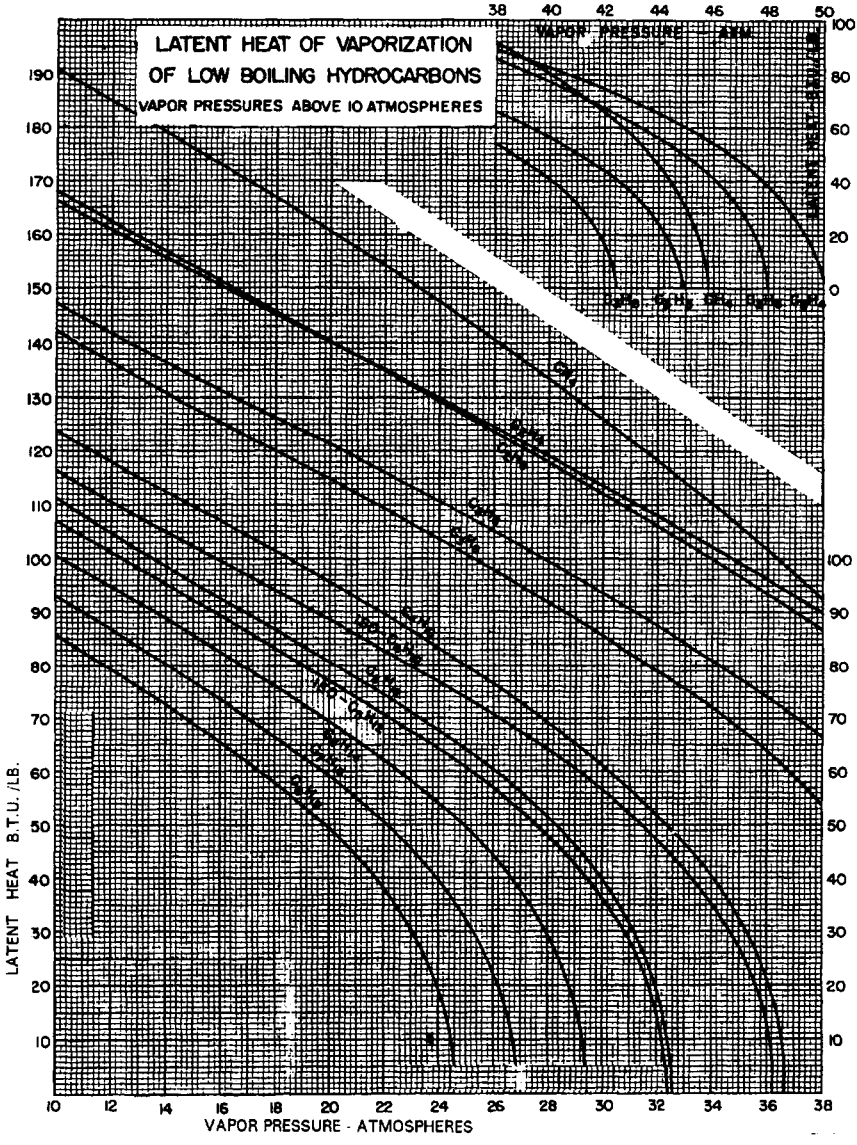


Figure 49. Chart for latent heat of vaporization of low boiling hydrocarbons at vapor pressures above 10 atmospheres.

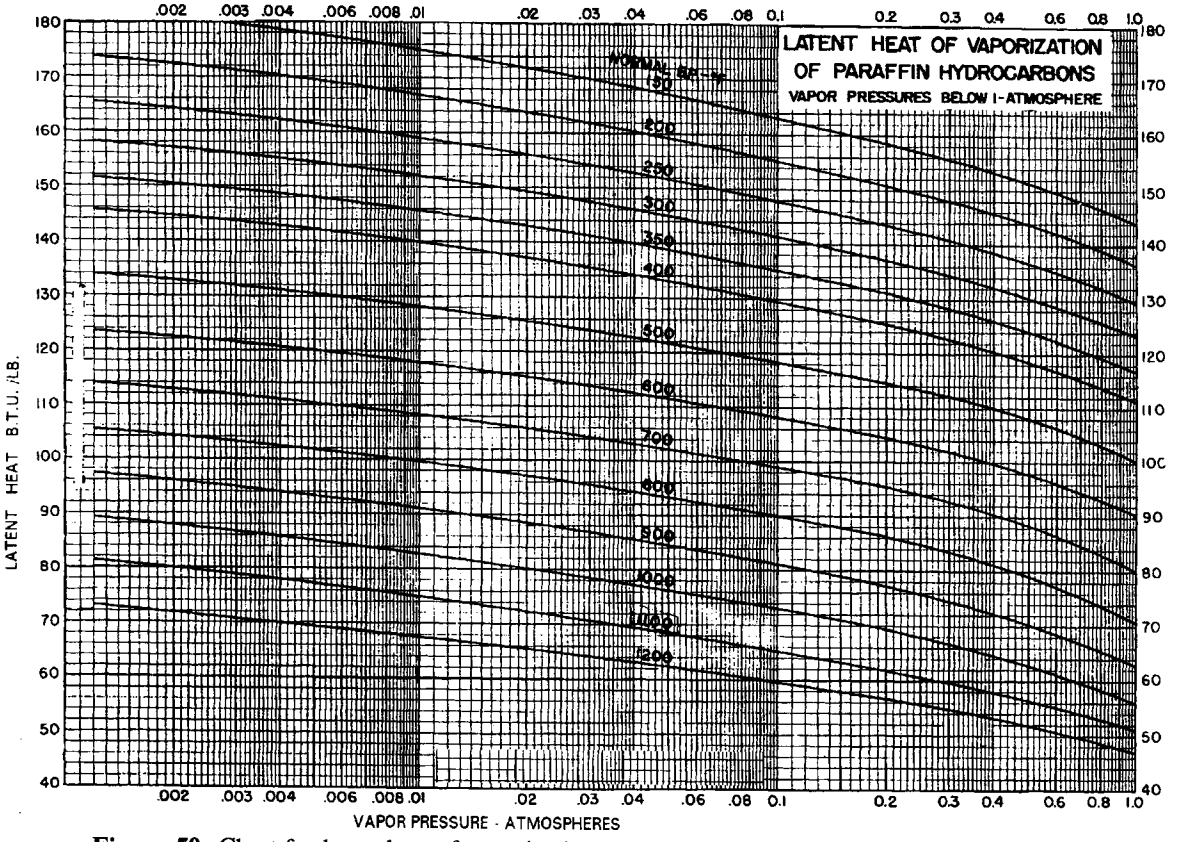


Figure 50. Chart for latent heat of vaporization of paraffin hydrocarbons at vapor pressures below 1 atmospheres.

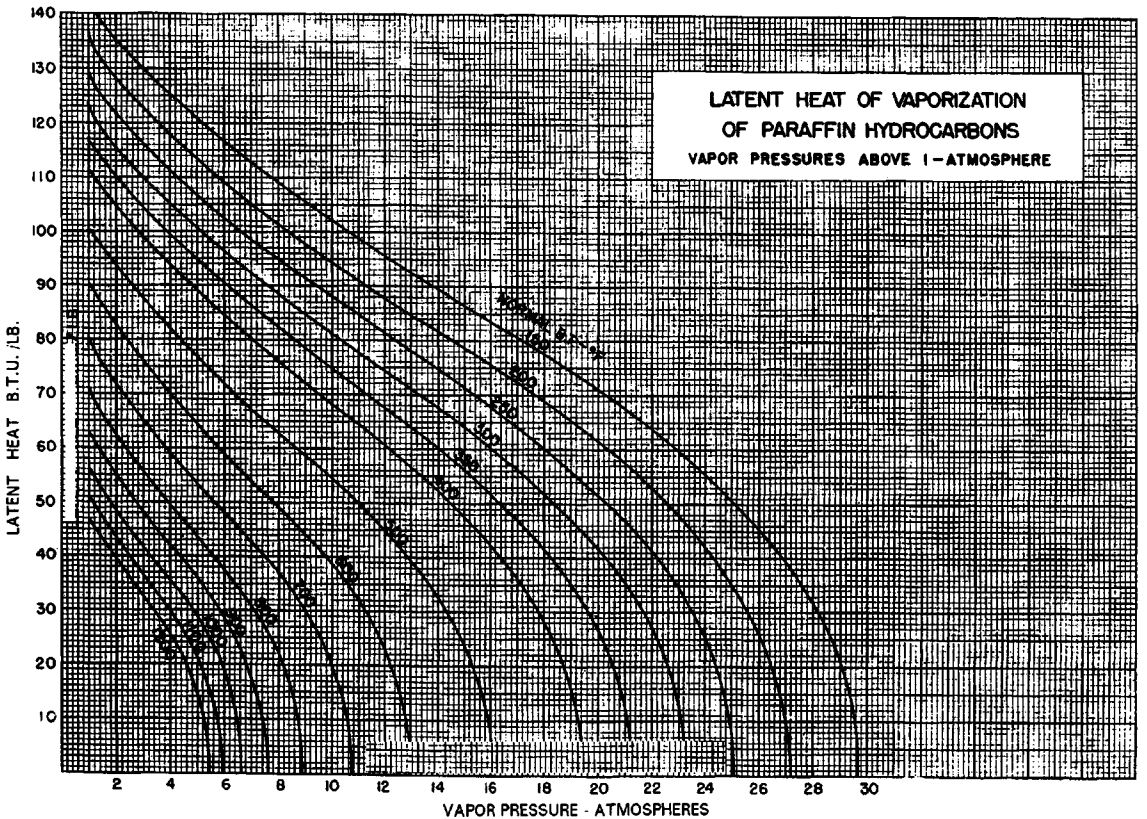


Figure 51. Chart for latent heat of vaporization of paraffin hydrocarbons at vapor pressures above 1 atmospheres.

paraffin corresponding to a reduced pressure of l/47.9 (= 0.0209) is 0.0209 x 28.3 = 0.59 atm.

The molal heat of vaporization of the normal paraffin at 0.59 atm is 91.5 x (l46 Btu/lb) = 13,360 Btu/mole.

The latent heat of benzene at 1 atm is then equal to 13,360 Btu/mcMe or 171 Btu/Ib. The Bureau of Standards Circular C461 gives 169.3 Btu/lb as the latent of vaporization of benzene at 1 atm.

Example 2.

Determine the latent heat of vaporization of the following gas oil at 500 °F.

15/5 Distillation	**Gravity**
0% @ 330 °F	35 °API
10% la *00 °F	
50% @ 550 °F	
70% @ 634 °F	
100% @ 750 °F	

Vol. Av. B.P. = 547 °F; Slope = 3.9 °F/%
Mean Av. B.P. = 547 - 9 = 538 °F
Mol. wt. = 214
Vapor Pressure (538 °F normal B.P.) = 0.63 atm. at 500 °F
Pseudo-critical pressure = 266 psia = 18.1 atm.

Mol. wt. of normal paraffin (538 °F normal B.P.) = 222
Critical pressure of normal paraffin = 15.0 atm.
Vapor pressure of normal paraffin = (15.0/18.1) 0.63 = 0.52 atm.
Latent heat of normal paraffin = 104 Btu/lb
Latent heat of vaporization of the gas oil at 400 °F

Enthalpy of Light Hydrocarbons

The enthalpy or heat content of low-boiling paraffins, olefins, and aromatics is given by the charts in Figures 52 through 59. Some of the charts are based on an enthalpy of zero for the saturated liquid at -200 °F, while others employ 0 °R as the datum point. In the absence of chemical reactions, use of different base points causes no error. These charts can be applied to mixtures of light hydrocarbons on the basis of the following

assumptions:

1. The enthalpies of individual components of a mixture are additive in the liquid phase, that is, the molal heat content of the mixture equals the sum of the products of the molal heat contents of the components by their mole fractions.

2. The enthalpies of individual components are additive in the vapor phase at low pressures (0-1 atm).

3. The change in enthalpy of the vapor with pressure at constant temperature is the same for a mixture as for a single compound having the same molecular weight as the mixture.

The first assumption is substantially true for hydrocarbon mixtures (especially for homologous series) at temperatures below the critical region of all components. At temperatures near, or above the critical temperatures of any of the components, the liquid mixture is no longer an ideal solution of its components and there is some deviation from the rule of additive heat contents. However, since these deviations are not too serious, and since no other simple method has been developed for determining the heat content of a liquid mixture, the rule of additive enthalpies should be used for all hydrocarbon mixtures irrespective of the critical temperatures and chemical composition of the components.

The second assumption is strictly true only for vapor mixtures at infinite dilution (0 atm) but is a very close approximation for pressures up to 1 atm.

The third assumption is empirical but has been shown indirectly to give quite accurate results for mixtures of homologous series and petroleum fractions. Also, the use of the average molecular weight to determine the change of enthalpy with pressure is the simplest average which can be used. Above the critical temperature a dashed line is shown for the heat content of the gas in solution. This line was based on the assumption that the gas in solution at any temperature would have the same partial density and enthalpy as the pure compound at a pressure corresponding to an extrapolation of its vapor pressure curve above the critical point. Obviously, this is only a rough approximation since both a vapor pressure curve and an ideal liquid solution are meaningless in this region.

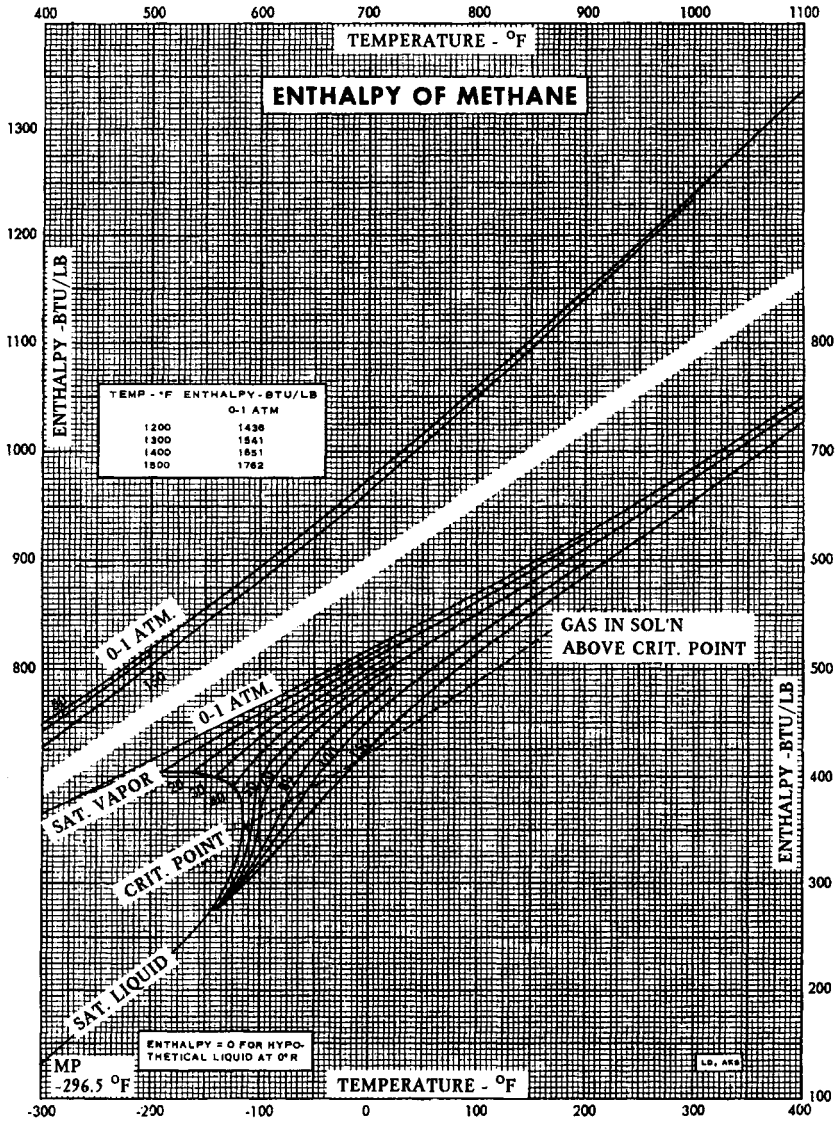


Figure 52. Chart for enthalpy of methane.

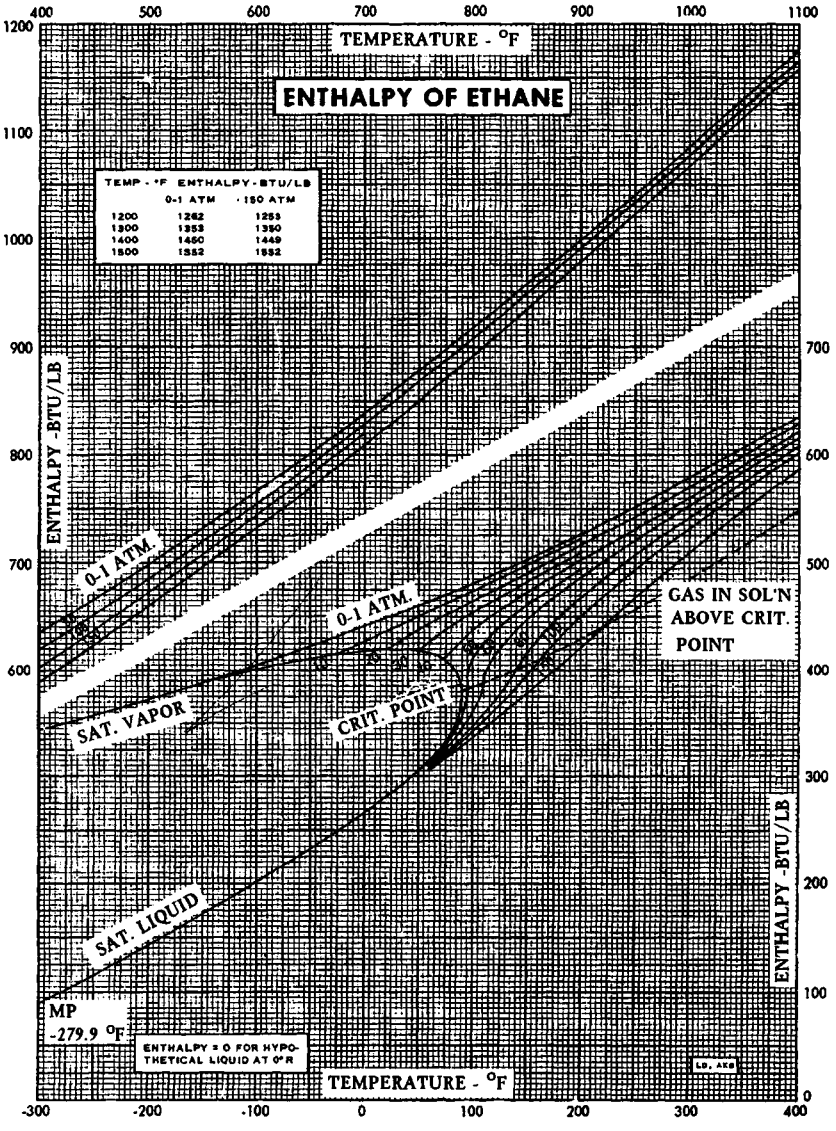


Figure 53. Chart for enthalpy of ethane.

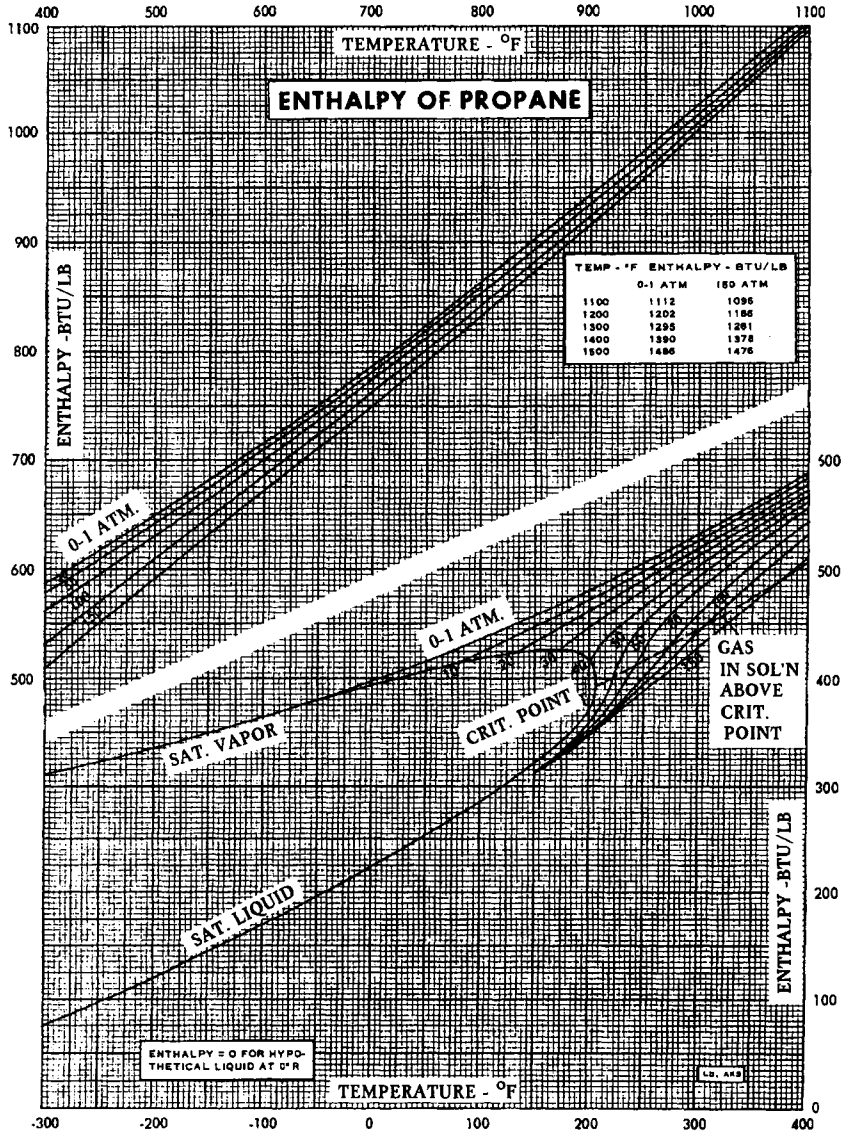


Figure 54. Chart for enthalpy of propane.

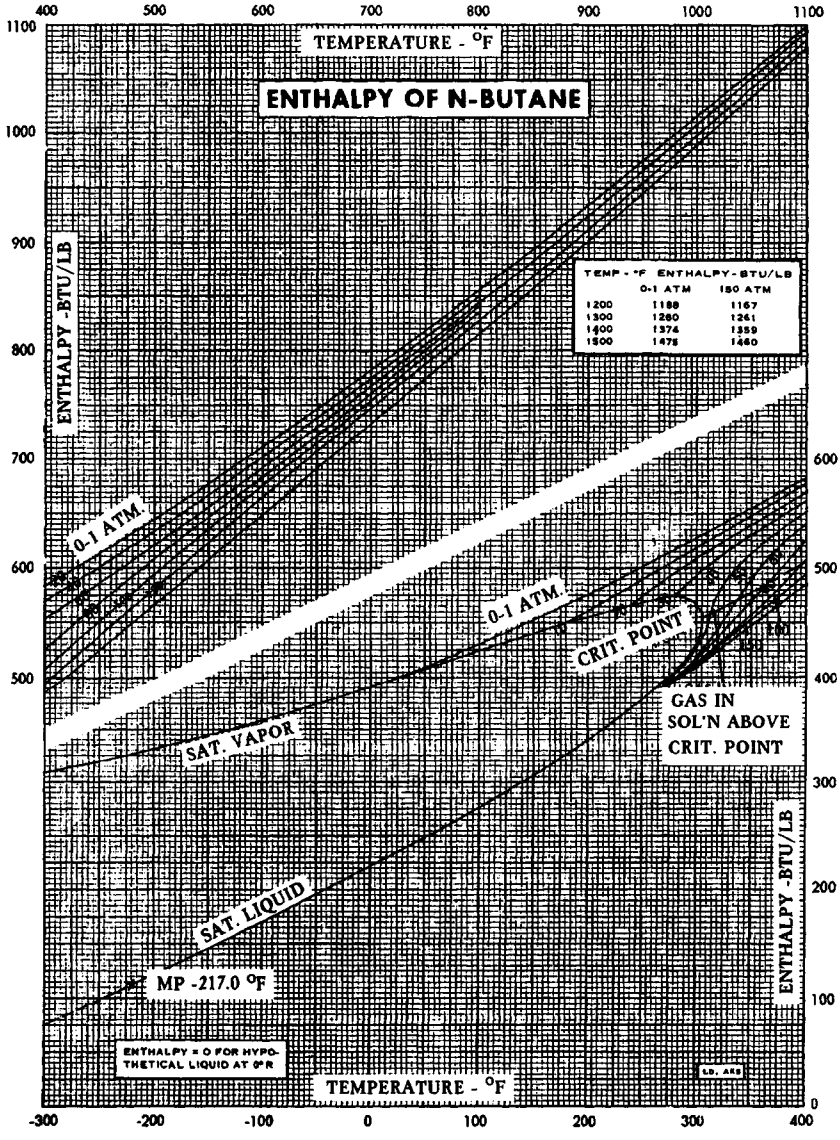


Figure 55. Chart for enthalpy of n-butane.

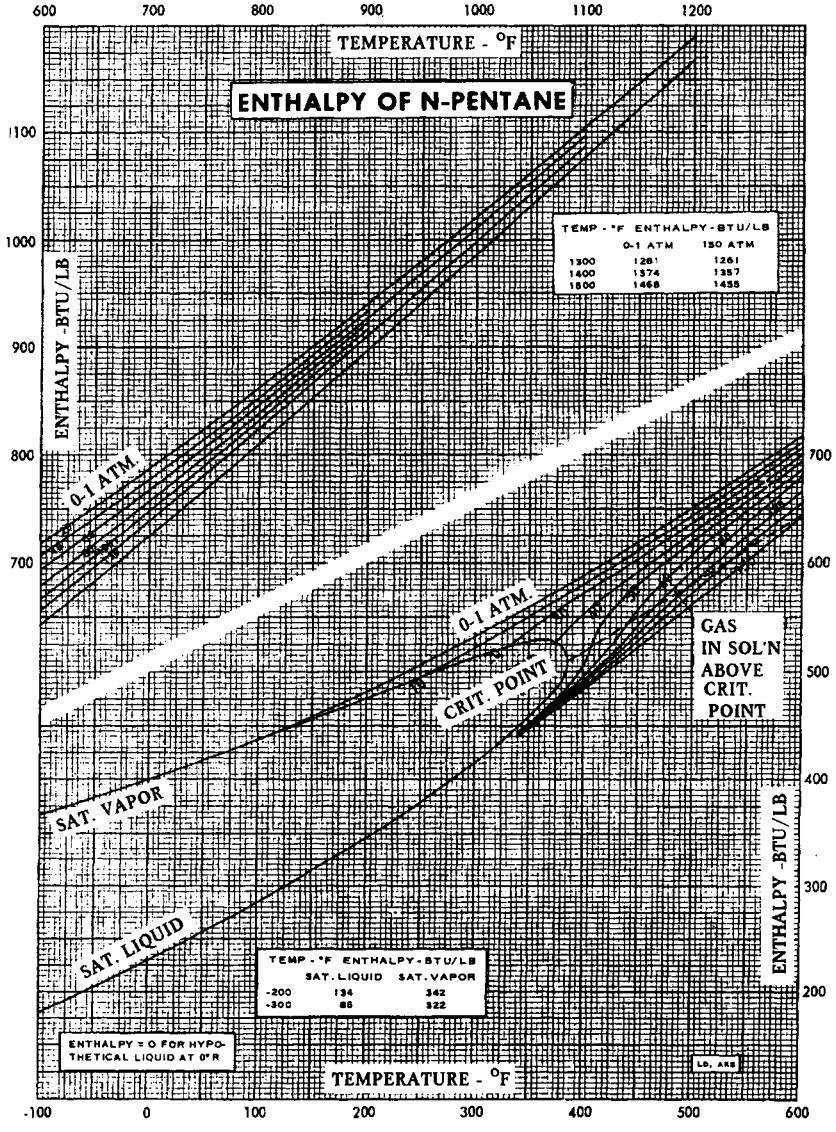


Figure 56. Chart for enthalpy of n-pentane.

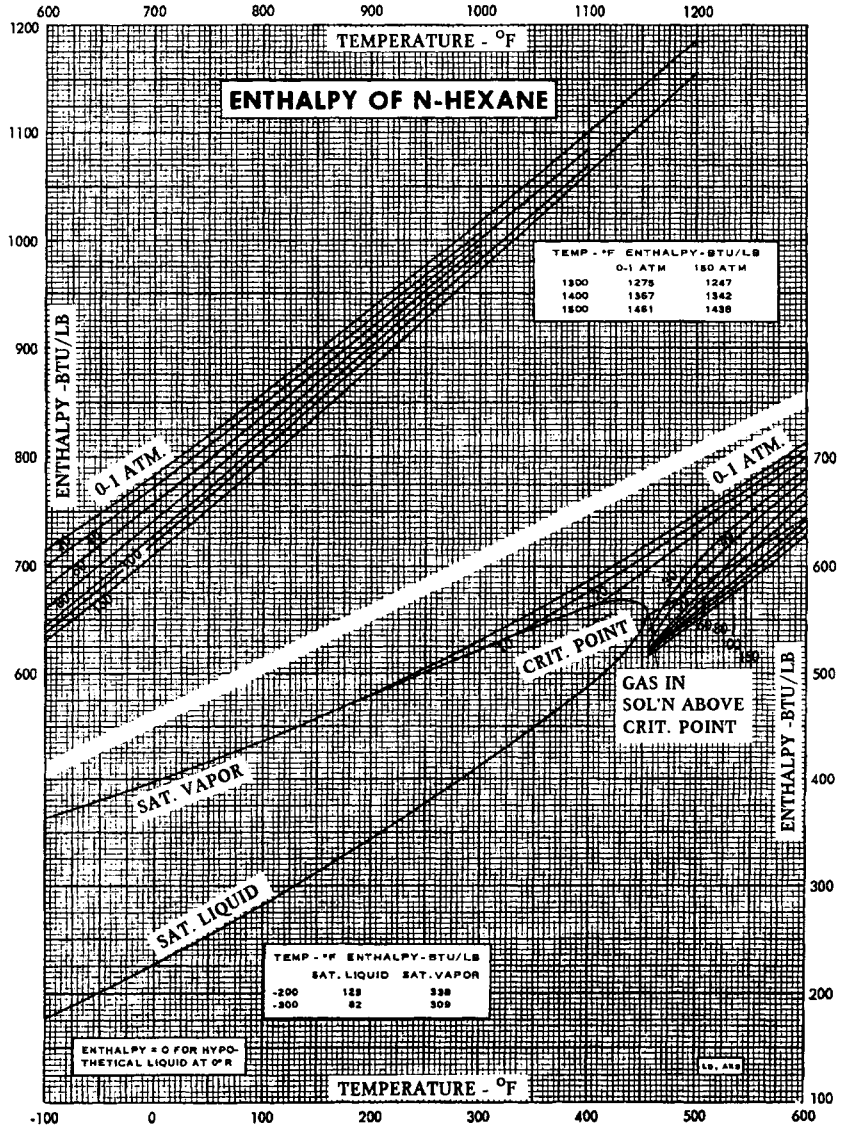


Figure 57. Chart for enthalpy of n-hexane.

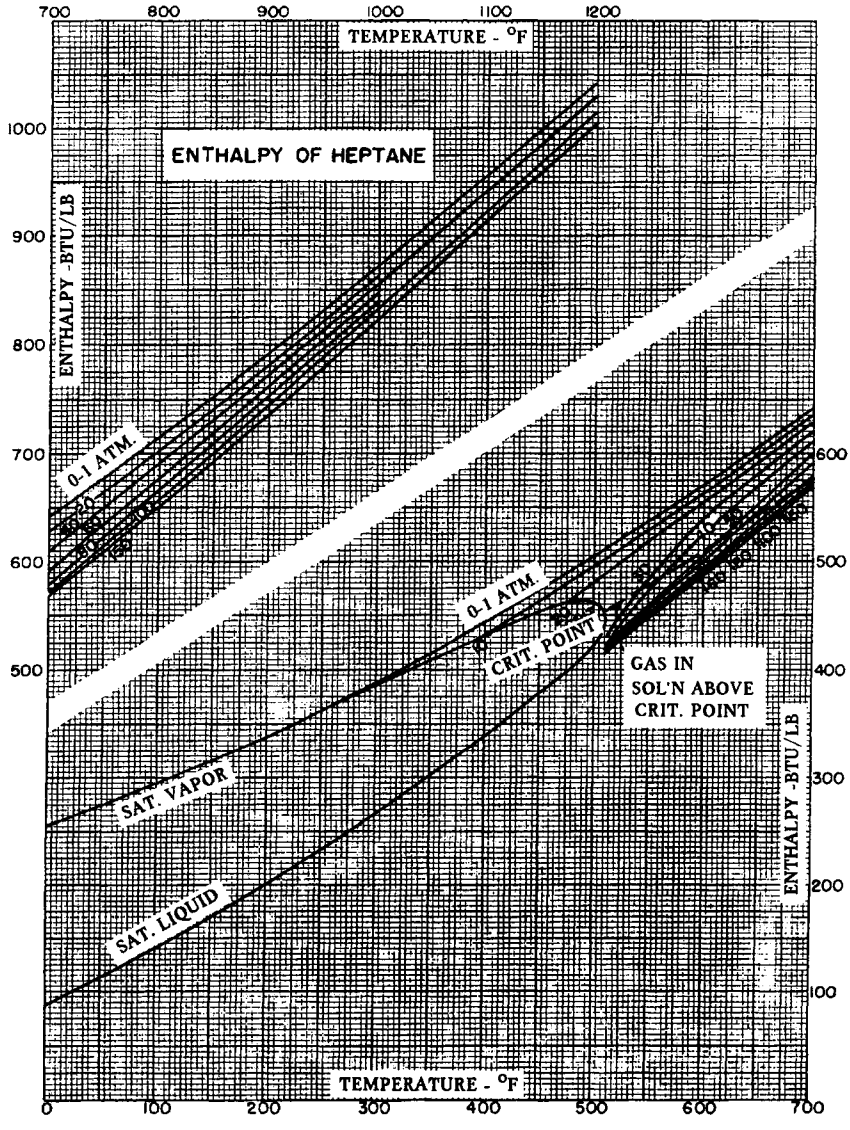


Figure 58. Chart for enthalpy of heptane.

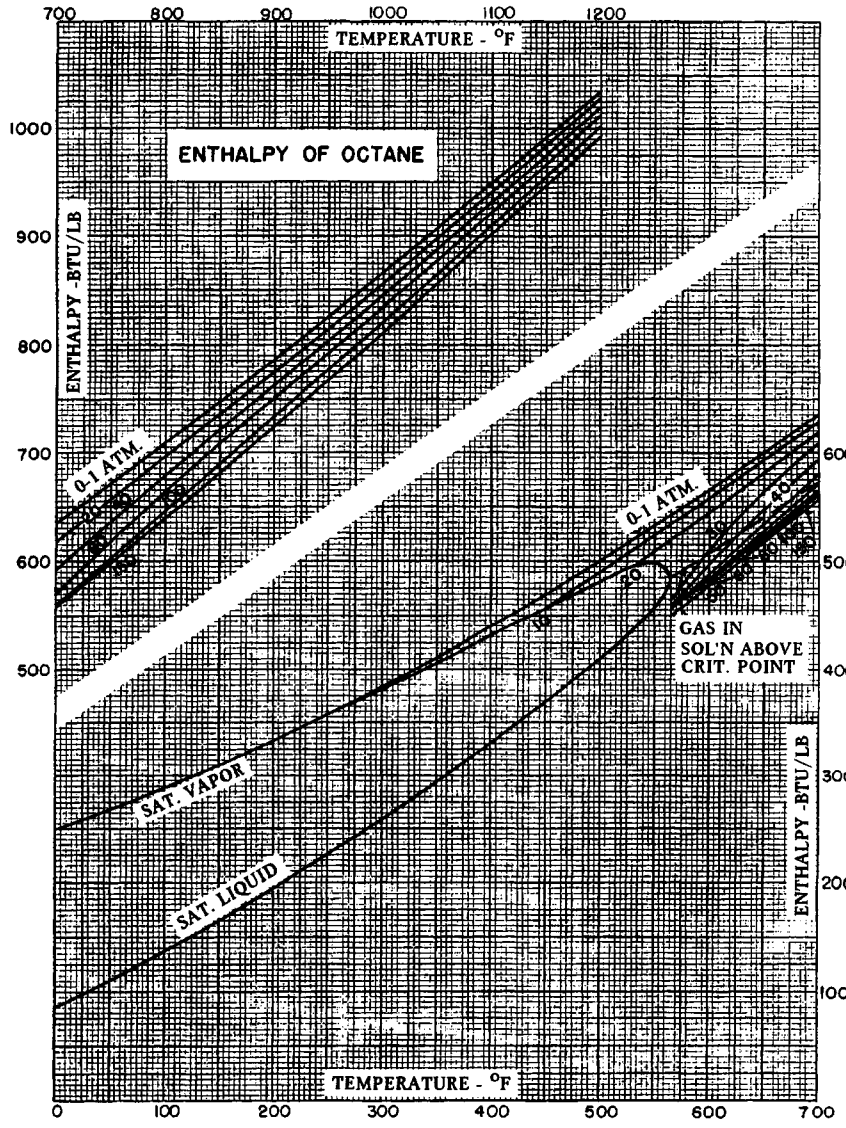


Figure 59. Chart for enthalpy of octane.

Example 3.

Determine the difference in enthalpy between the liquid at 100 °F of and the vapor at 500 °F and 20 atm for a mixture having the following composition:

Component	Mole Fraction
C_2H_6	0.100
C_3H_8	.500
C_4H_{10}	.100
C_2H_4	.050
C_3H_6	.250
	1.000

The enthalpy of the mixture as a liquid at 100 °F and as a vapor at 500 °F and 20 atm is computed from the individual components as tabulated below:

Component	Mole . Fract.	Molec. Wt Lb/Mole of Mixture	Enthalpy of Liquid 100 °F		Enthalpy of Vapor 500 °F and 0-1 atm	
			Btu/lb	Btu/Mole of Mixture	Btu/lb	Btu/mole of Mixture
C_2H_6	0.100	3.0	384	1152	698	2094
C_3H_8	0.500	22.0	285	6270	649	14278
C_4H_{10}	0.100	5.8	275	1595	645	3741
C_2H_4	0.050	1.4	223	312	506	708
C_3H_6	0.250	10.5	169	1175	508	5334
		42.7		11104		26155

H_V (500 °F, 0-1 atm) - H_L = 26,155 - 11,104 = 15,051 Btu/mole

The change of enthalpy of the vapor at 500 °F between 0-1 atm. and 20 atm is computed by interpolating between C_2H_6 and C_3H_8.

C_2H_6 :
H_V(500°F, 20 atm)-H_V(500°F, 0-1 atm)=30(693-698) =-150 Btu/mole

C_3H_8 :
H_V (500 °F, 20 atm) -H_V (500 °F, 0-1 atm) = 44(641-649)= -352 Btu/mole

Mixture:
H_V (500 °F, 20 atm) -H_V (500 °F, 0-1 atm) =-150 + (42.7-30)/(44-30)×
× [-352 - (-150)] = -333 Btu/mole

Therefore,
H_V (500 °F, 20 atm) -H_L (100 °F)=-333 + 15,051 = 14.718 Btu/mole

or 14,718/42.7=345 Btu/lb

The foregoing procedure can be simplified, with a loss of accuracy which does not usually exceed 5%, by interpolating on a basis of molecular weight and total olefin content between the initial and final states:
C_3H_8 :
H_V (500 °F, 20 atm) -H_L (100 °F)= 44(641 - 285) = 15.664 Btu/mole

C_2H_4 :
H_V (500 °F, 20 atm) -H_L (100 °F)= 28 (500 - 223) = 7756 Btu/mole

C_3H_6 :
H_V (500 °F, 20 atm) -H_L (100 °F)= 42 (500 - 169) = 13,902 Btu/mole

Since the average molecular weight of the paraffin portion of the mixture is 44, the propane values can be used directly, making interpolation unnecessary.

The average molecular weight of the olefin portion is 39.7; hence, the enthalpy difference between the initial and final states will be:

7756 +[(39.7-28)/(42-28)] (13,902 - 7756) = 12,892 Btu/mole

Interpolating between the paraffin and olefin portions,
H_V (500 °F, 20 atm) -H_L (100 °F)= 0.70 x 15.664 + 0.30 x 12,892
= 14.832 Btu/mole
or [14,832/42.7]= 346 Btu/lb vs. 345 Btu/lb by the longer method.

In making these interpolations, occasionally the temperature and pressure of the vapor will be such that its enthalpy will fall inside the saturation "dome" on the higher molecular weight chart. Under these circumstances the two adjacent lower molecular weight charts should be extrapolated upward. If this is impossible, as in the case of an average molecular weight between CH_4 and C_2H_6 and C_2H_4 and C_3H_6, then an approximation must be made within the "dome." The latter may also be used as a rough check for extrapolations.

Additional enthalpy charts for various light-ends materials are given in Figures 60 through 77.

Enthalpy of Petroleum Fractions

The enthalpies of petroleum fractions (saturated liquid and vapor and 0-1 atmosphere vapor) are given by the charts in Figures 78 through 85, for fractions showing characterization factors from 10.0 to 13.0 and mean

average boiling points from 200 to 1000 °F.

Theoretically, these charts represent pure hydrocarbons of the designated characterization factor and boiling point, but they may be applied to petroleum fractions if the following assumption is made in addition to the three previous ones pertaining to light hydrocarbon mixtures:

4. The average difference between the enthalpy of the vapor at low pressures (0-1 atm) and the enthalpy of the liquid, at constant temperature is the same for a mixture of chemically similar hydrocarbons as for a single compound of the same molecular weight (or mean average boiling point).

While this assumption is empirical, it is accurate within a few percent except in the region of the pseudo-critical temperature where the enthalpy of the liquid is subject to variation depending upon the true critical temperature of the mixture.

The pressure correction to the vapor enthalpy is based on a three parameter corresponding states approach. It is calculated by:

$$\left(\frac{H^o - H^P}{T_c}\right) = \left(\frac{H^o - H^P}{T_c}\right)^0 + \omega\left(\frac{H^o - H^P}{T_c}\right)^1 \qquad (12)$$

where $\left(\frac{H^o - H^P}{T_c}\right)$ is the total pressure correction, Btu/(lb-mole) (°R)

$\left(\frac{H^o - H^P}{T_c}\right)^0$ is the pressure correction for the "simple fluid",

$\left(\frac{H^o - H^P}{T_c}\right)^1$ is a correction term for deviation from "simple fluid" behavior.

ω is the acentric factor
H^o is the enthalpy of the vapor at zero pressure, Btu/lb-mole
H^P is the enthalpy of the vapor at pressure, P
T_C is the pseudo-critical temperature of the fraction, °R

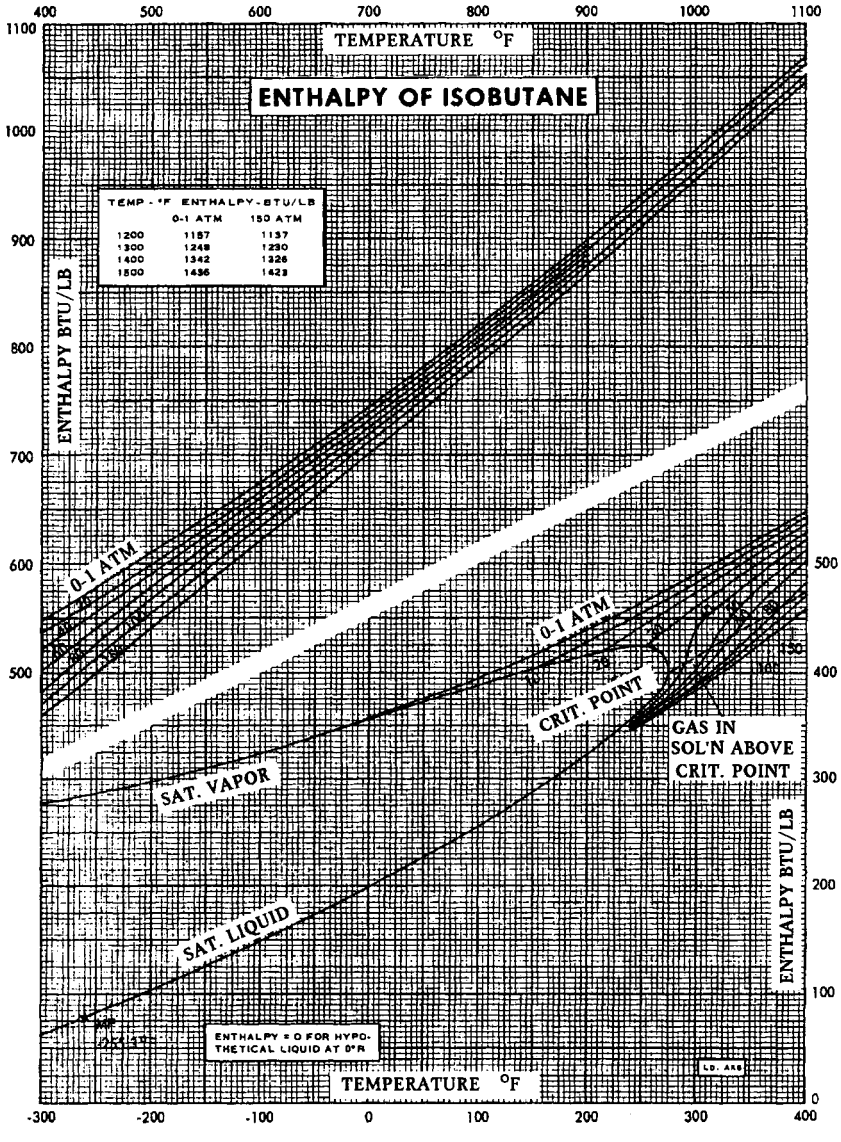


Figure 60. Chart for enthalpy of isobutane.

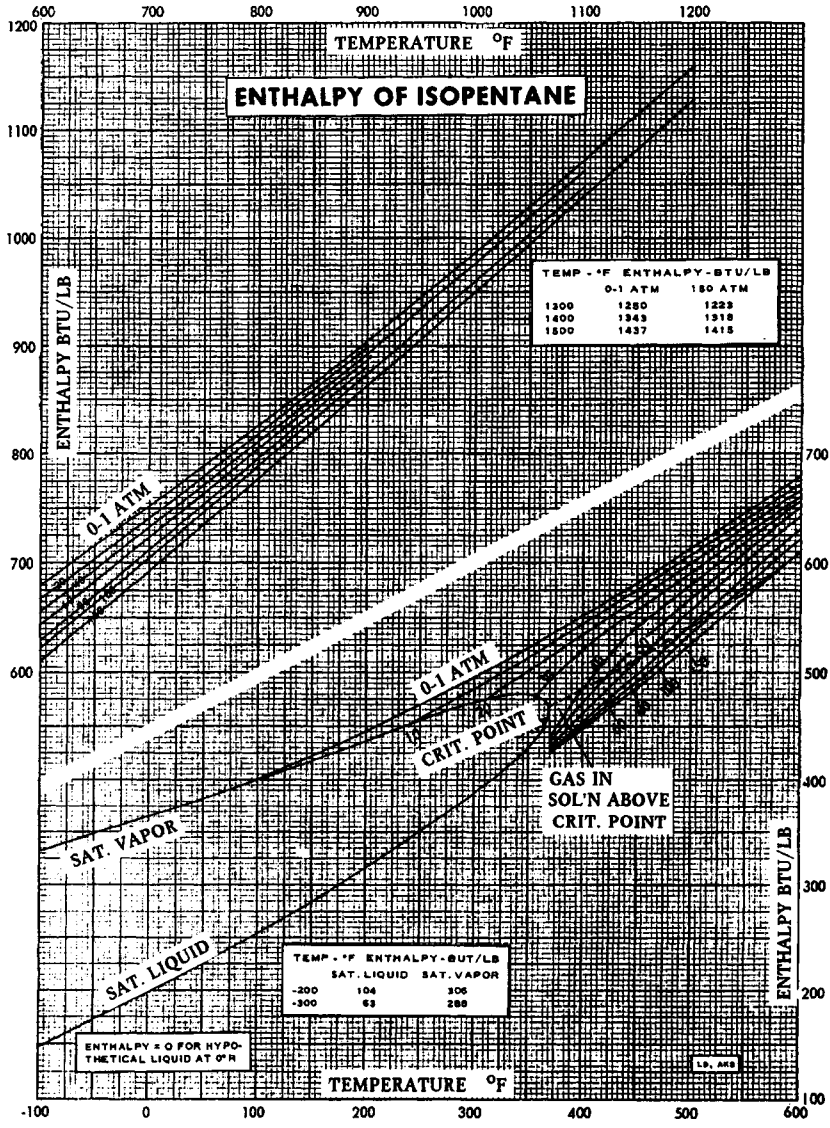


Figure 61. Chart for enthalpy of isopentane.

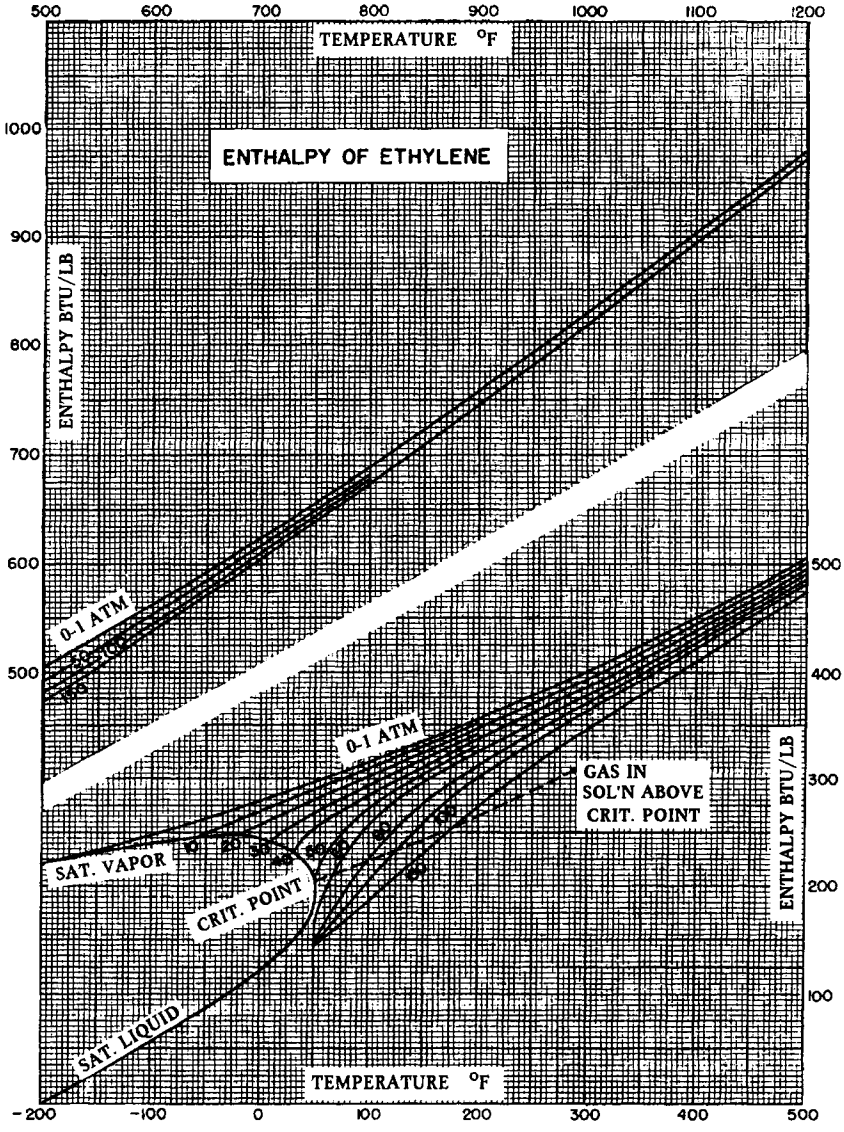


Figure 62. Chart for enthalpy of ethylene.

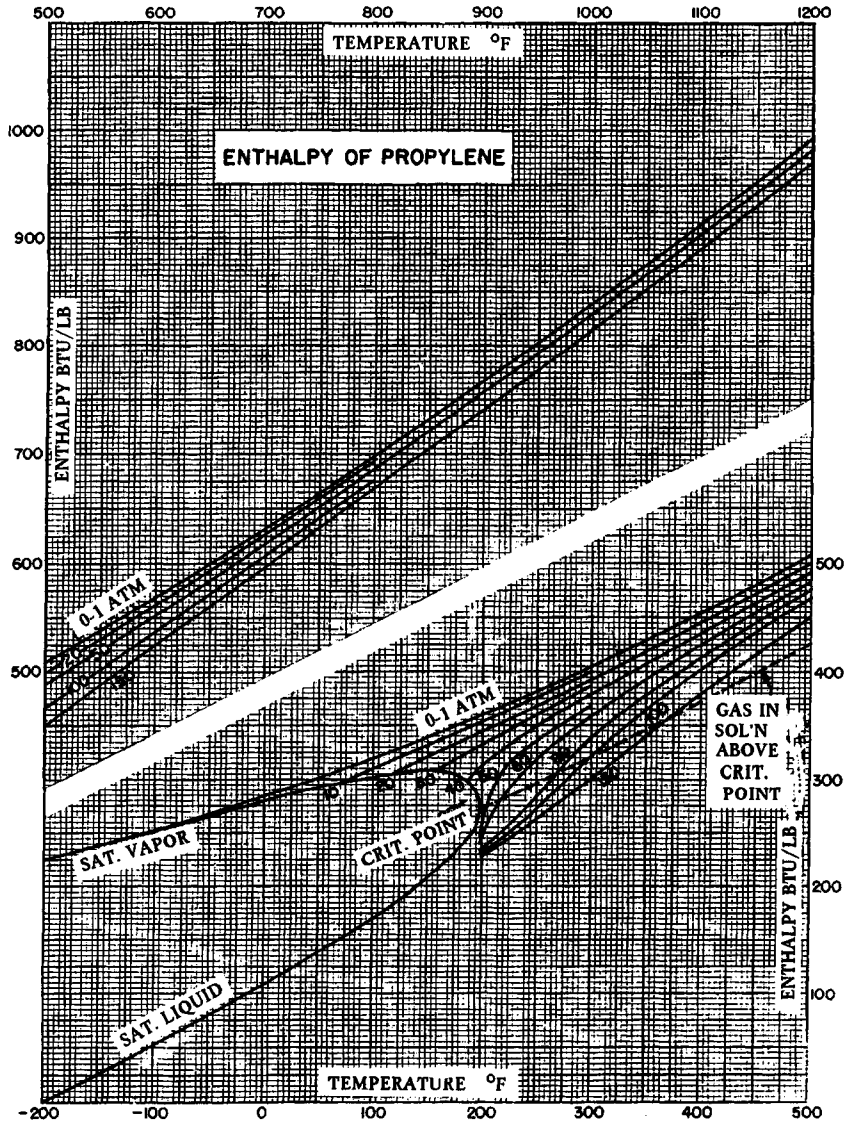


Figure 63. Chart for enthalpy of propylene.

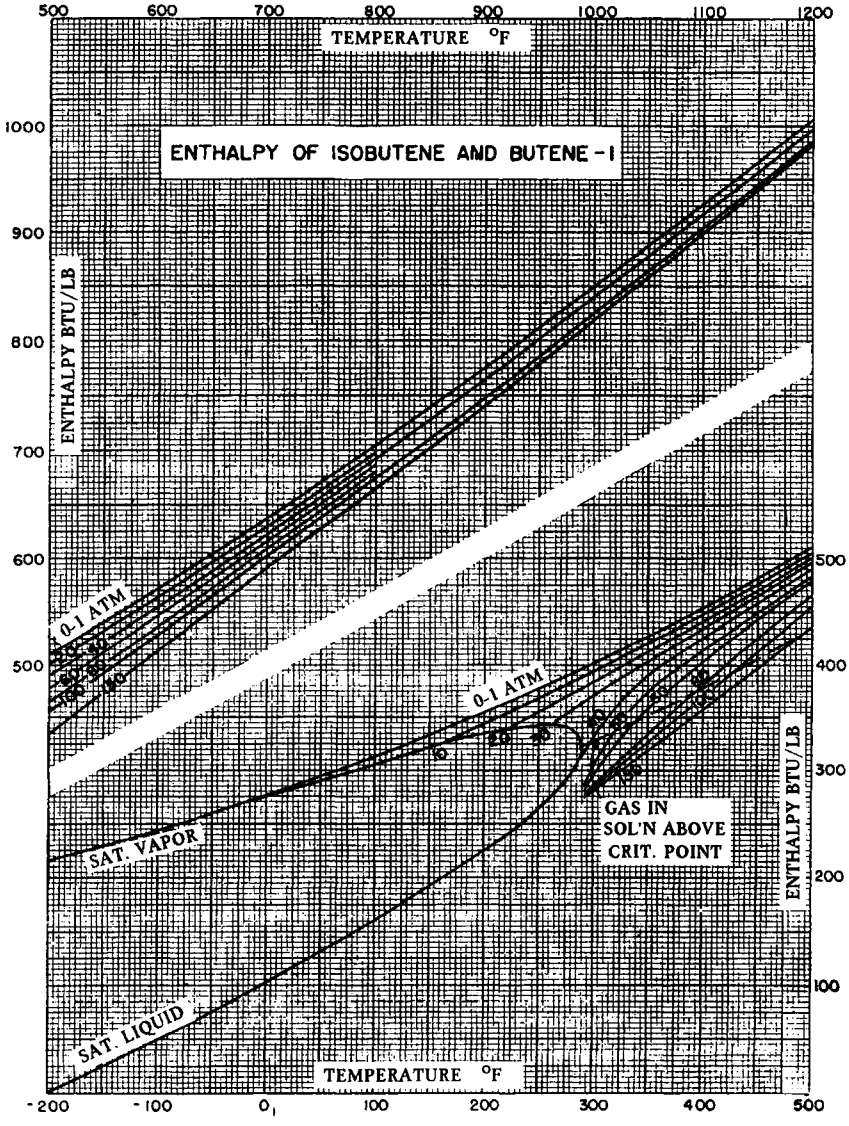


Figure 64. Chart for enthalpy of isobutene and butene-1.

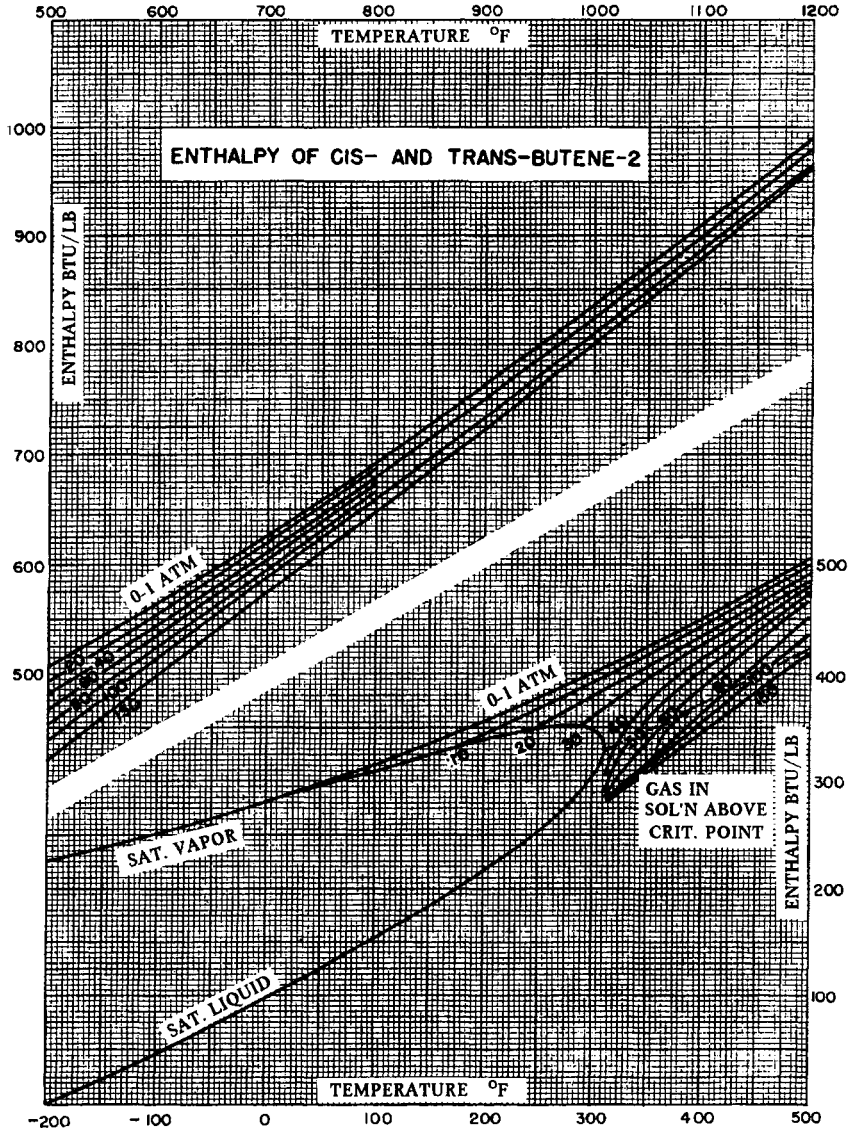


Figure 65. Chart for enthalpy of cis- and trans- butene-2.

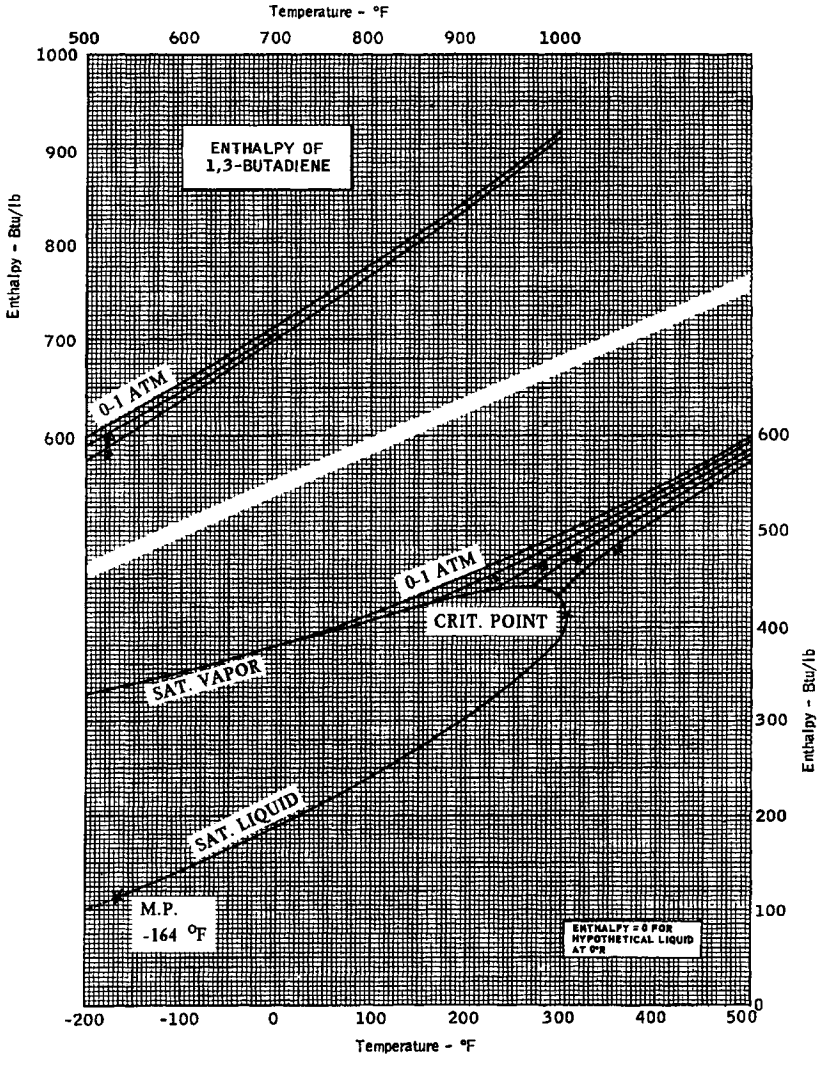


Figure 66. Chart for enthalpy of 1,3-butadiene.

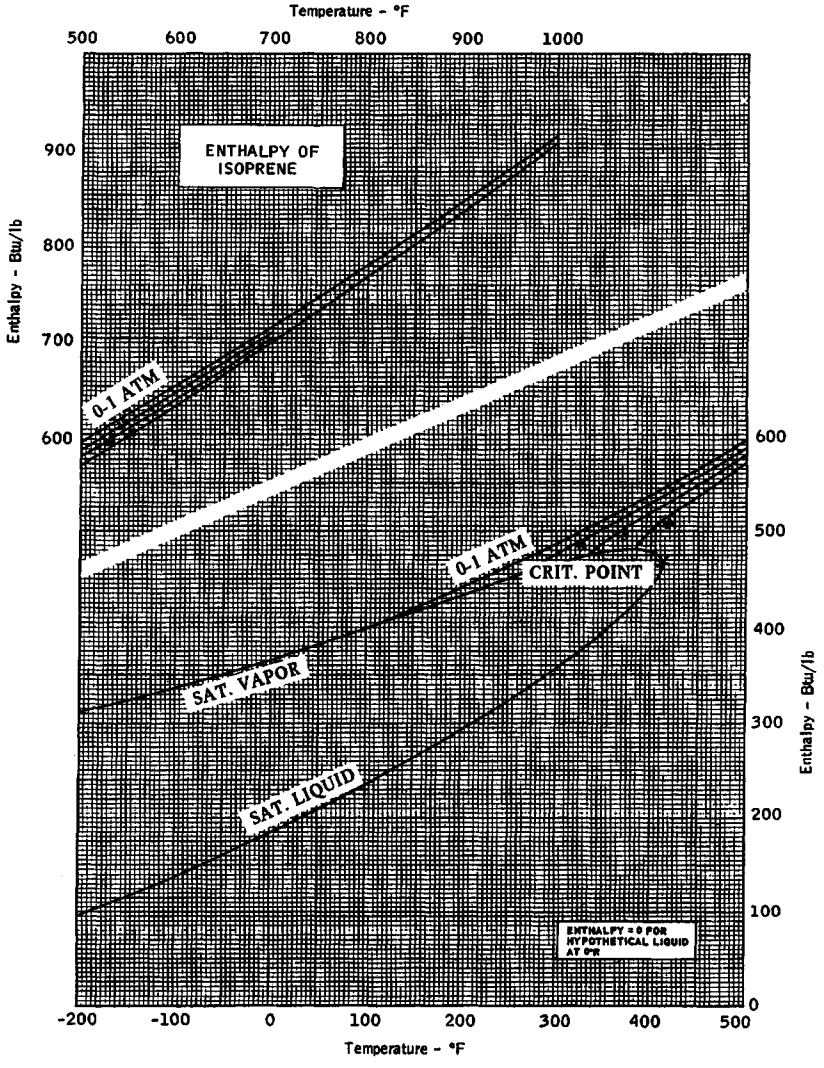


Figure 67. Chart for enthalpy of isoprene.

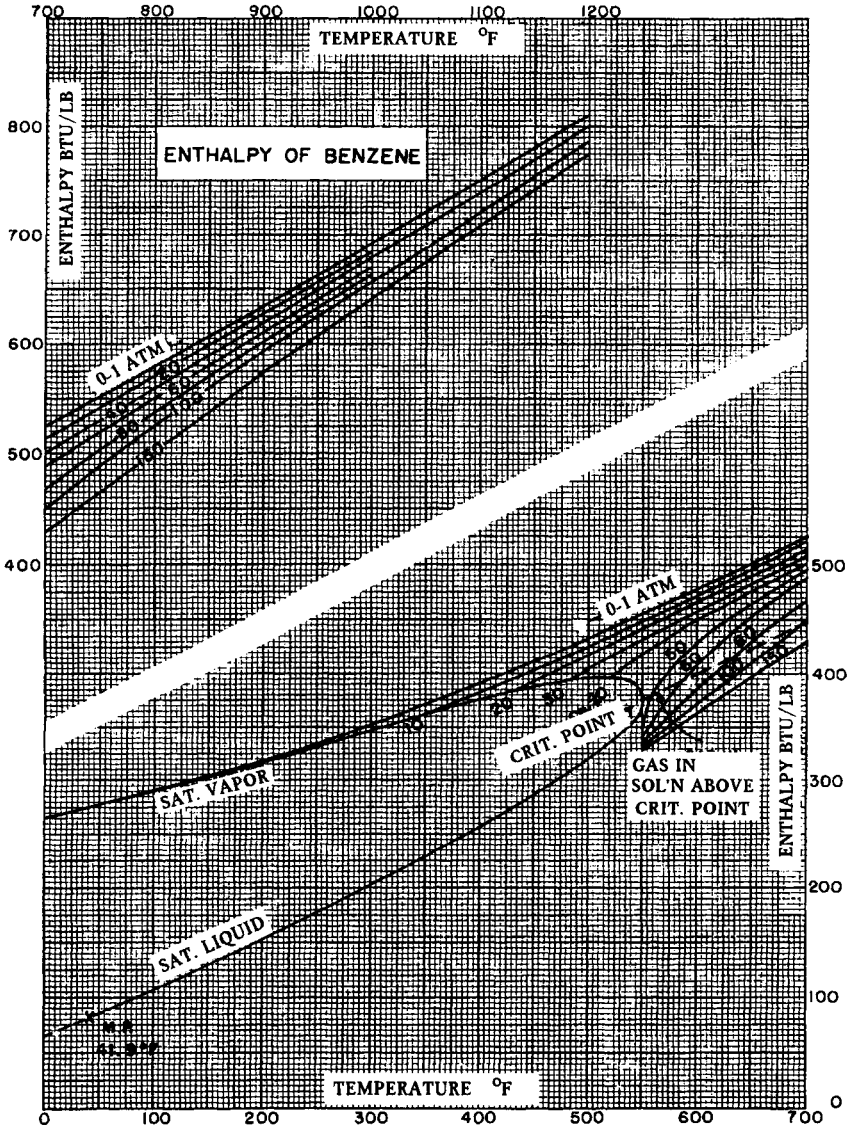


Figure 68. Chart for enthalpy of benzene.

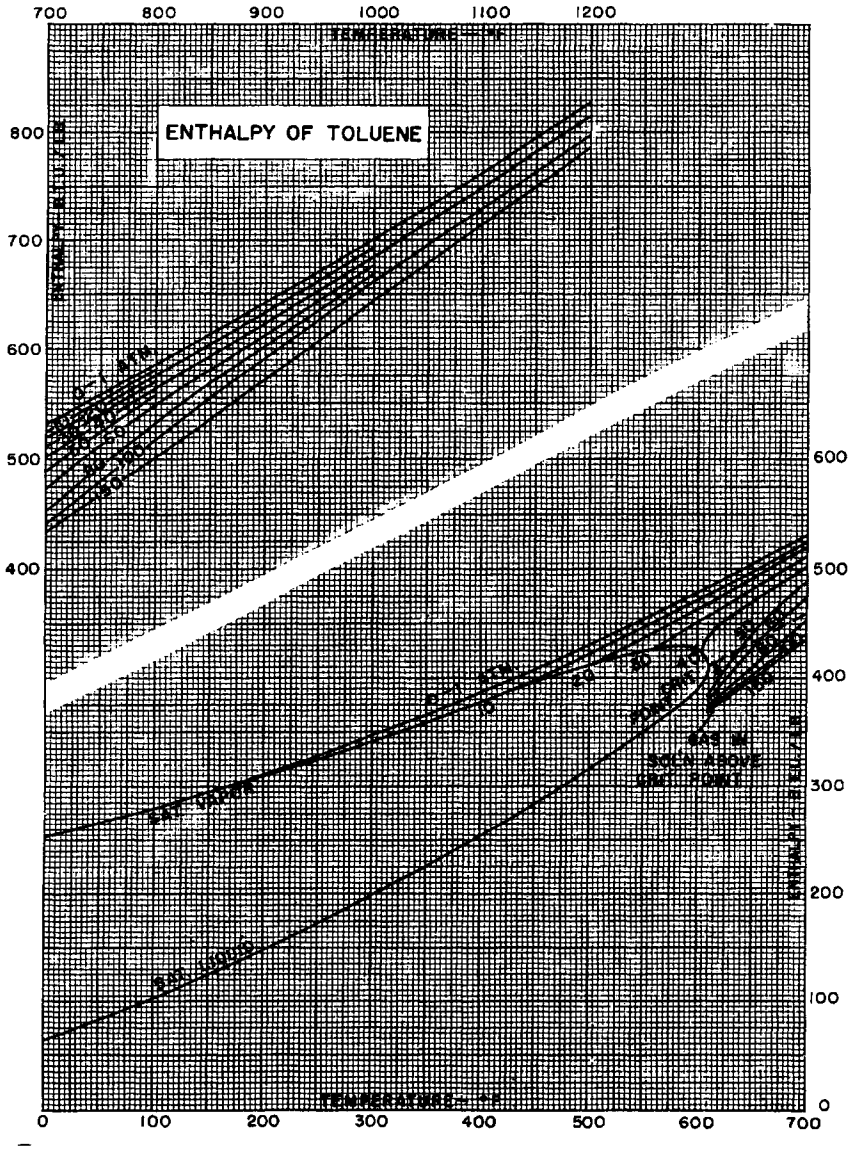


Figure 69. Chart for enthalpy of toluene.

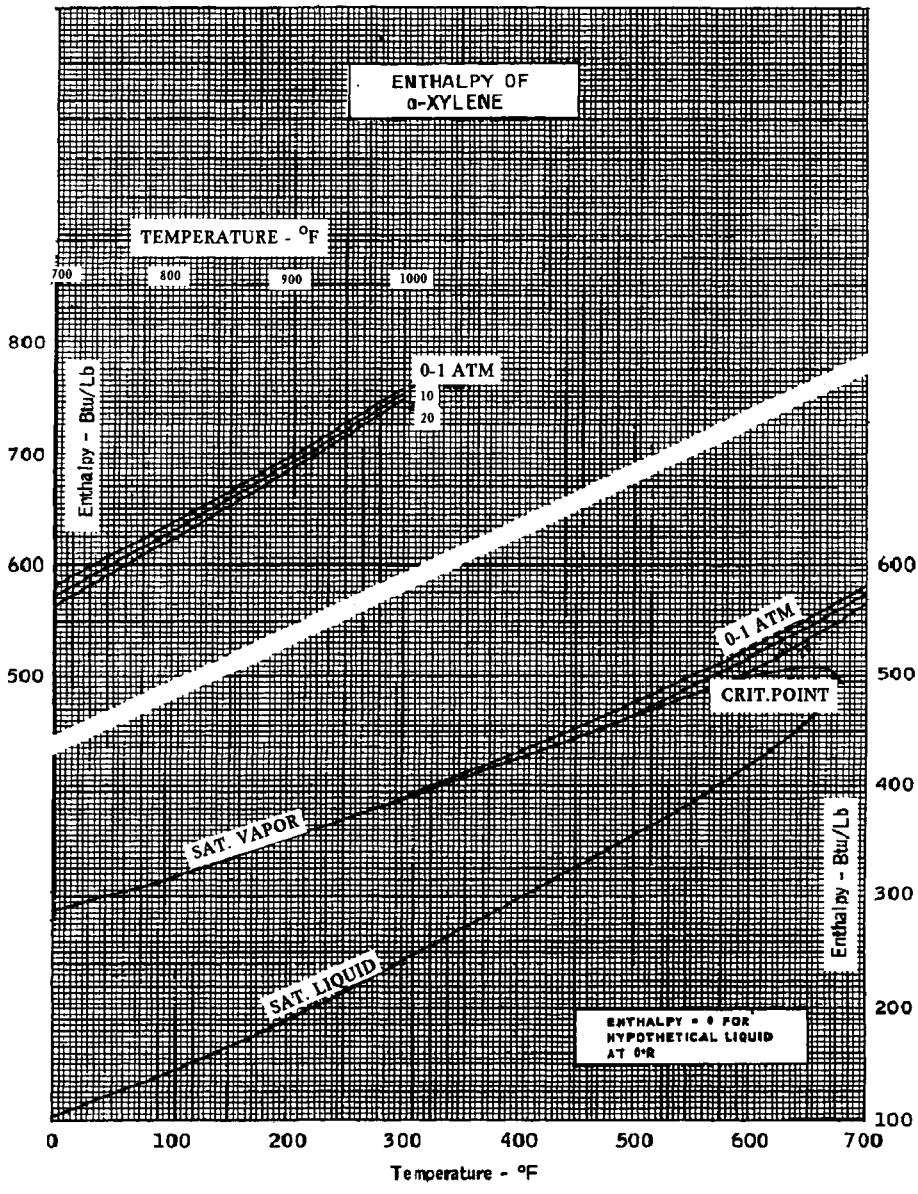


Figure 70. Chart for enthalpy of o-xylene.

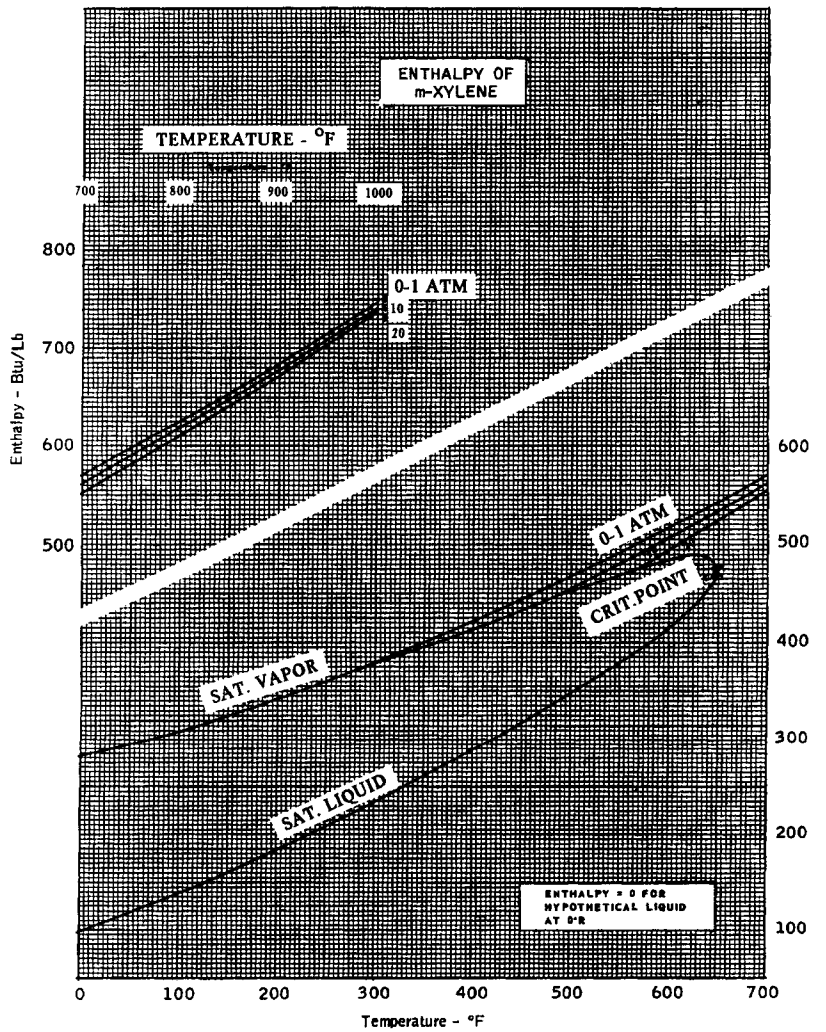


Figure 71. Chart for enthalpy of m-xylene.

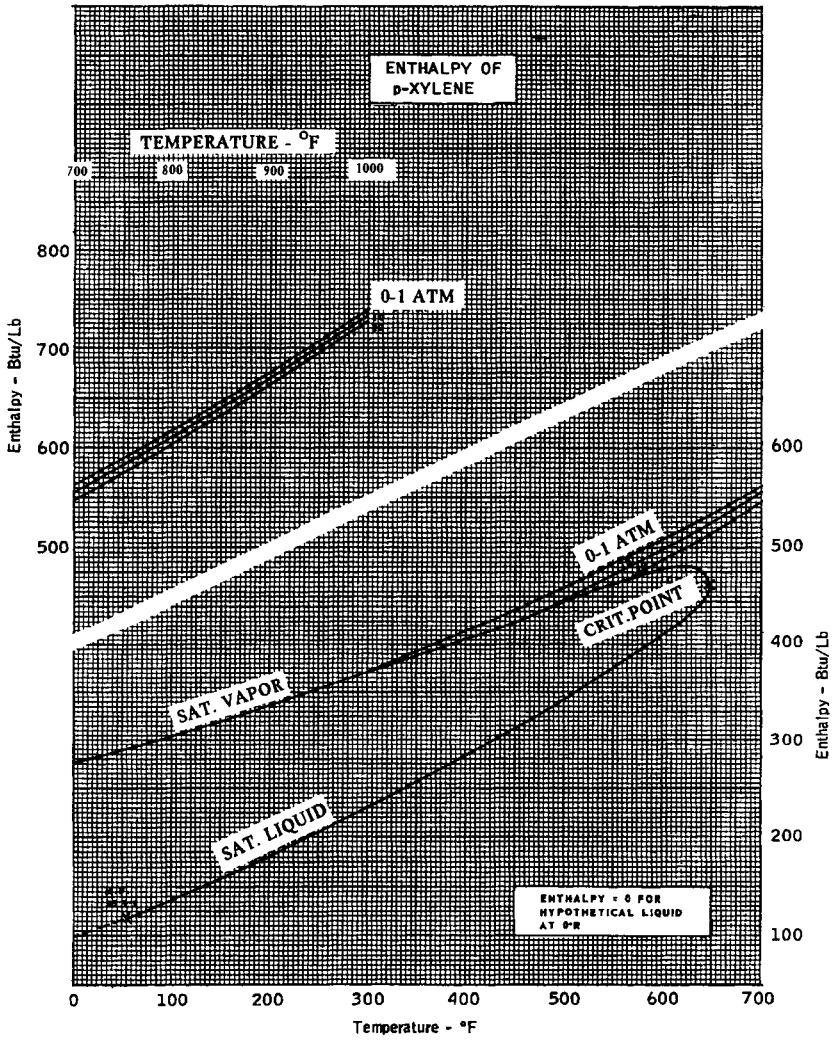


Figure 72. Chart for enthalpy of p-xylene.

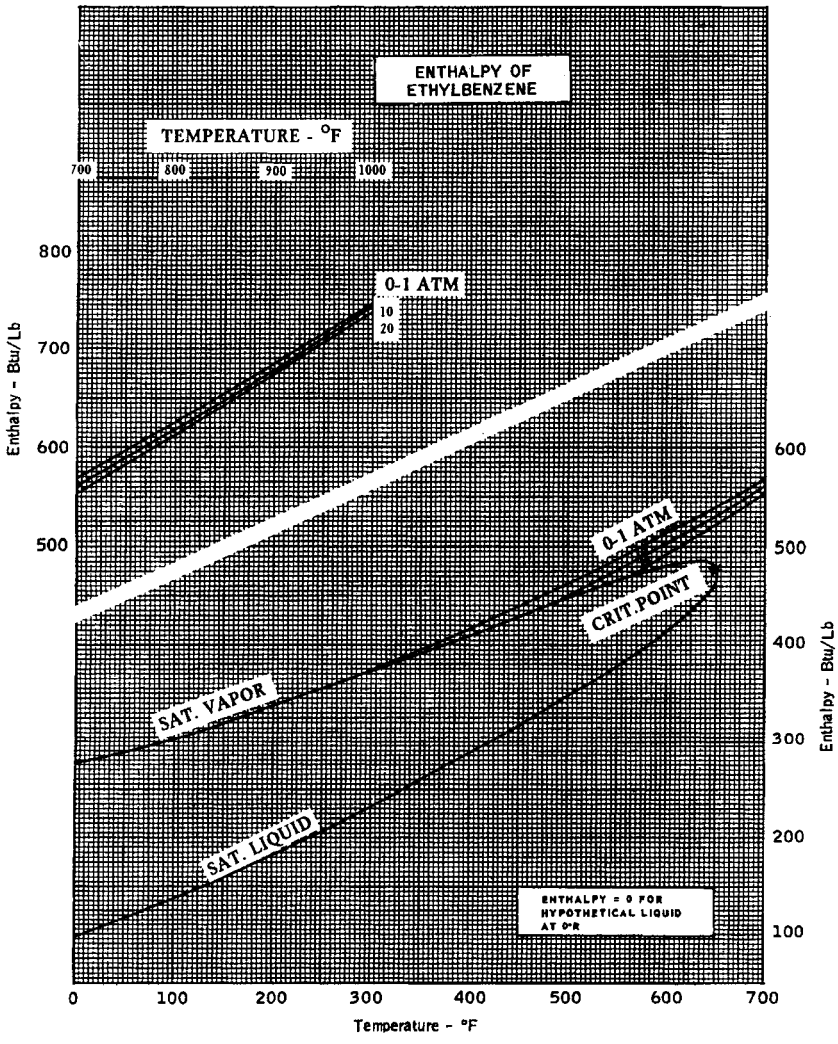


Figure 73. Chart for enthalpy of ethylbenzene.

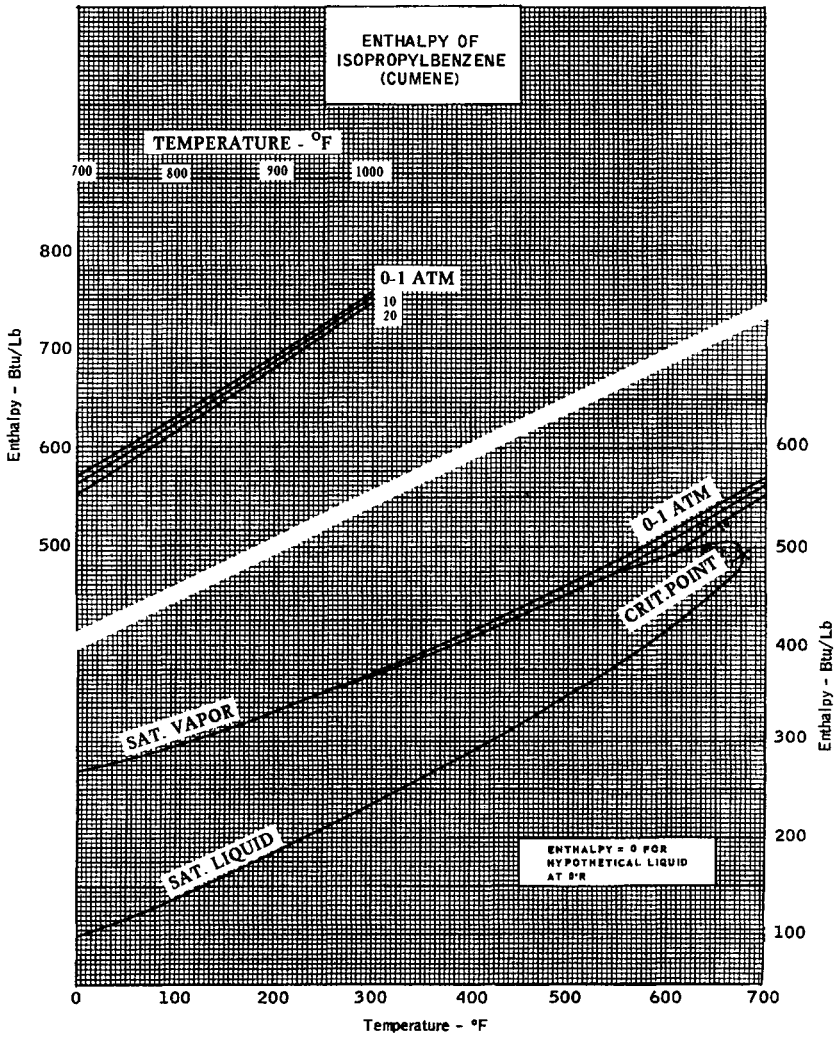


Figure 74. Chart for enthalpy of isopropylbenzene (cumene).

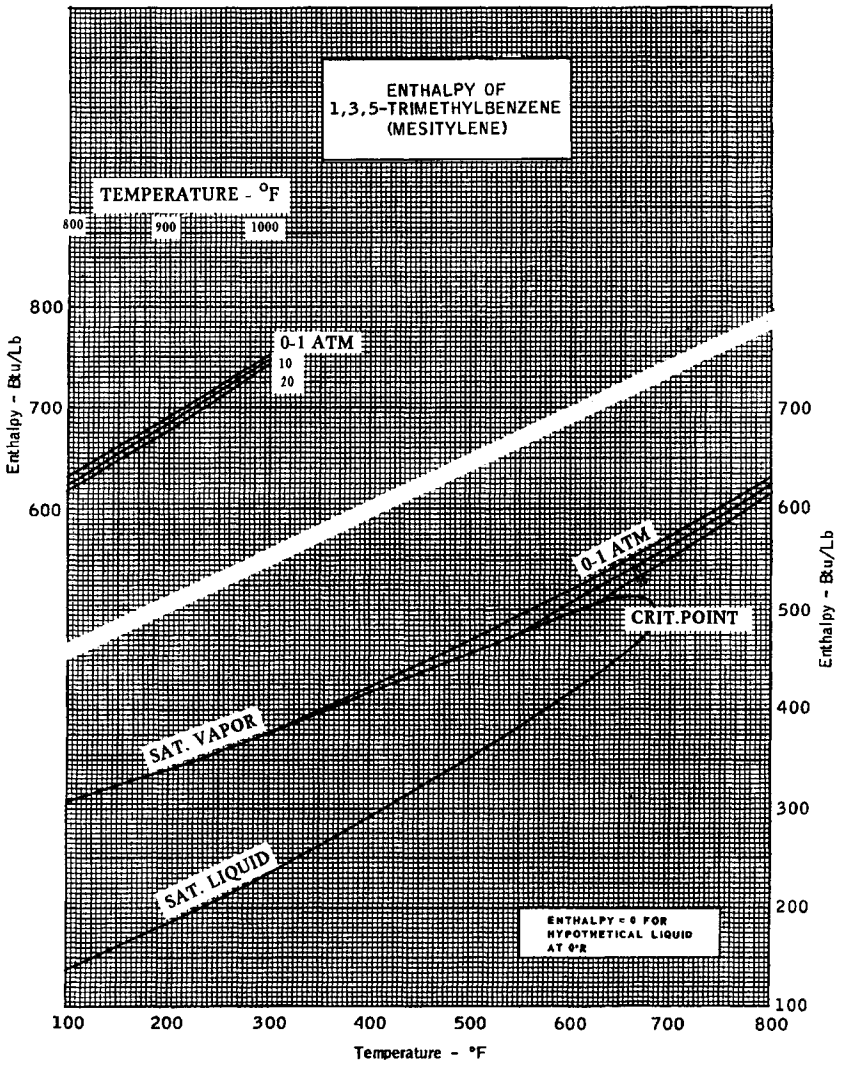


Figure 75. Chart for enthalpy of 1,3,5-trimethylbenzene (mesitylene).

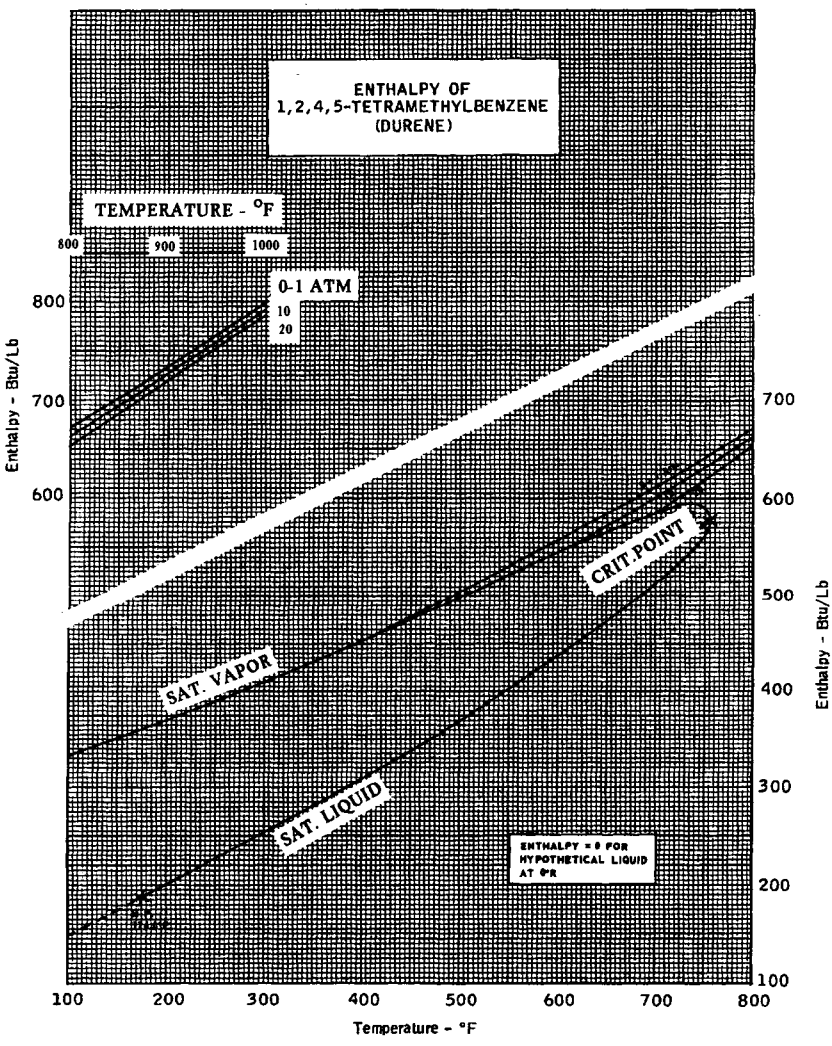


Figure 76. Chart for enthalpy of 1,2,4,5-tetramethylbenzene (Durene).

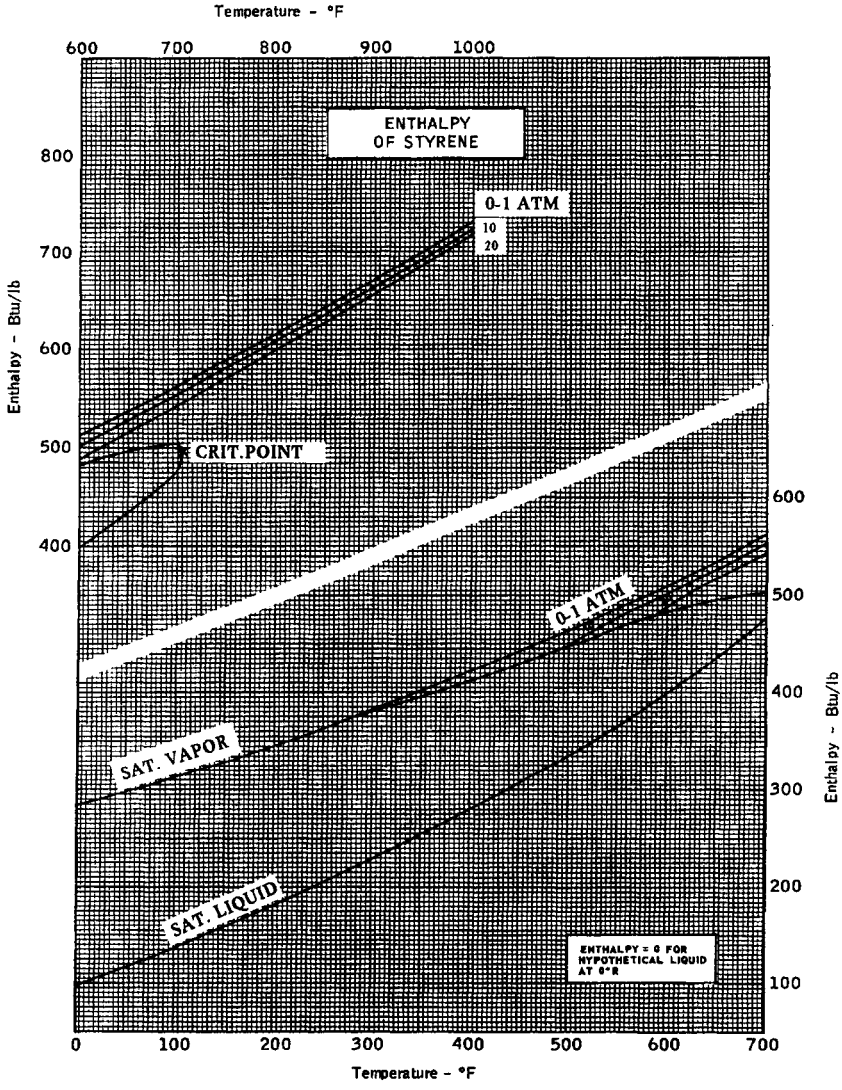


Figure 77. Chart for enthalpy of styrene.

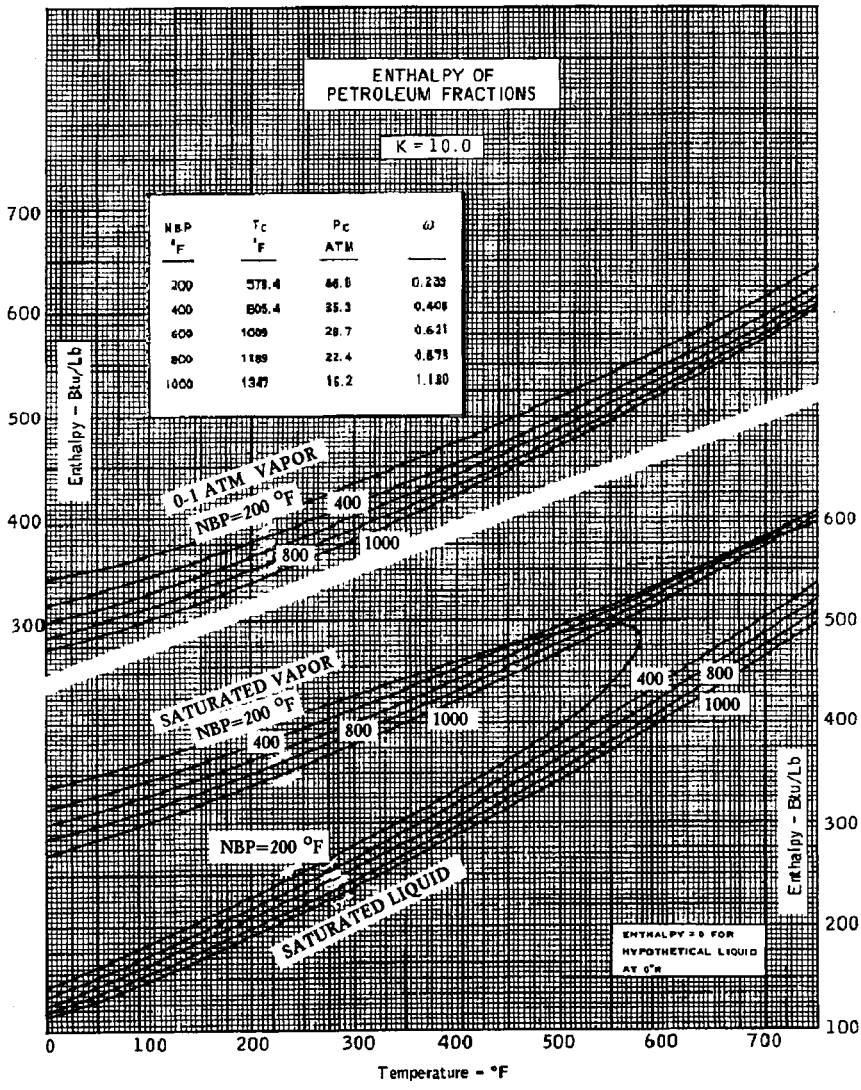


Figure 78. Chart for enthalpy of petroleum fractions, K = 10.0.

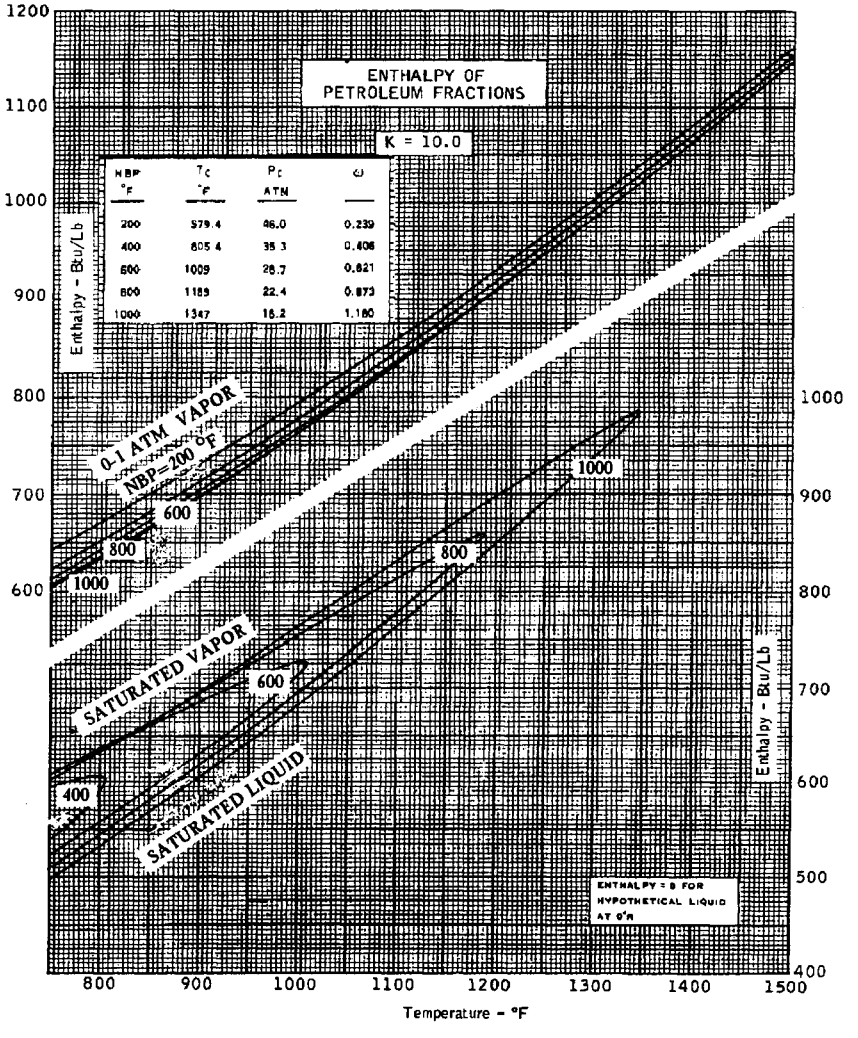


Figure 79. Chart for enthalpy of petroleum fractions, K = 10.0.

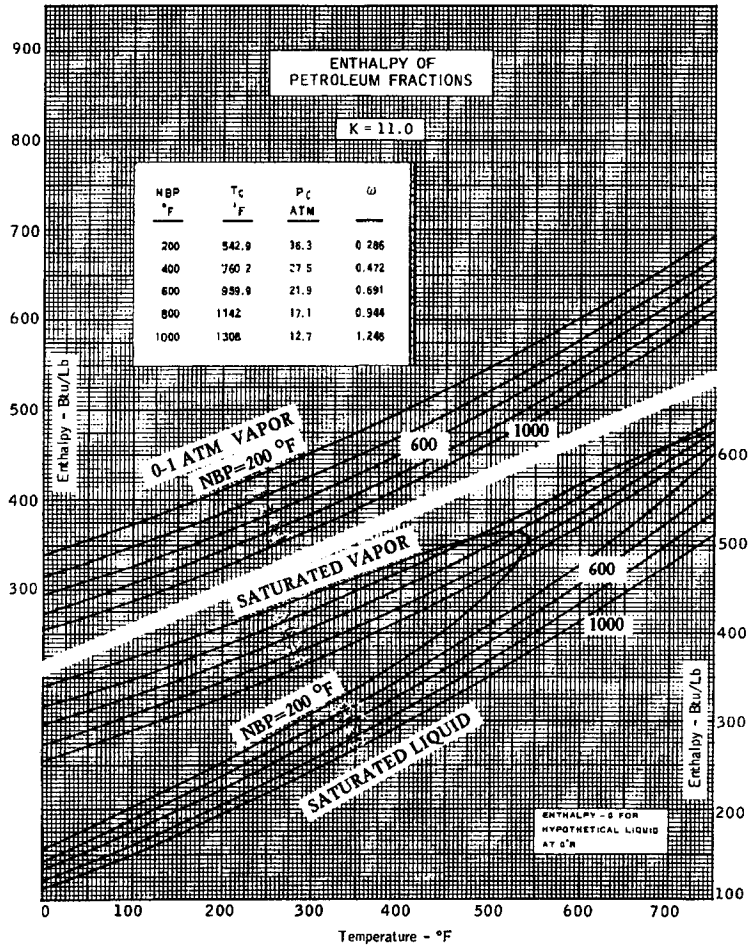


Figure 80. Chart for enthalpy of petroleum fractions, K = 11.0.

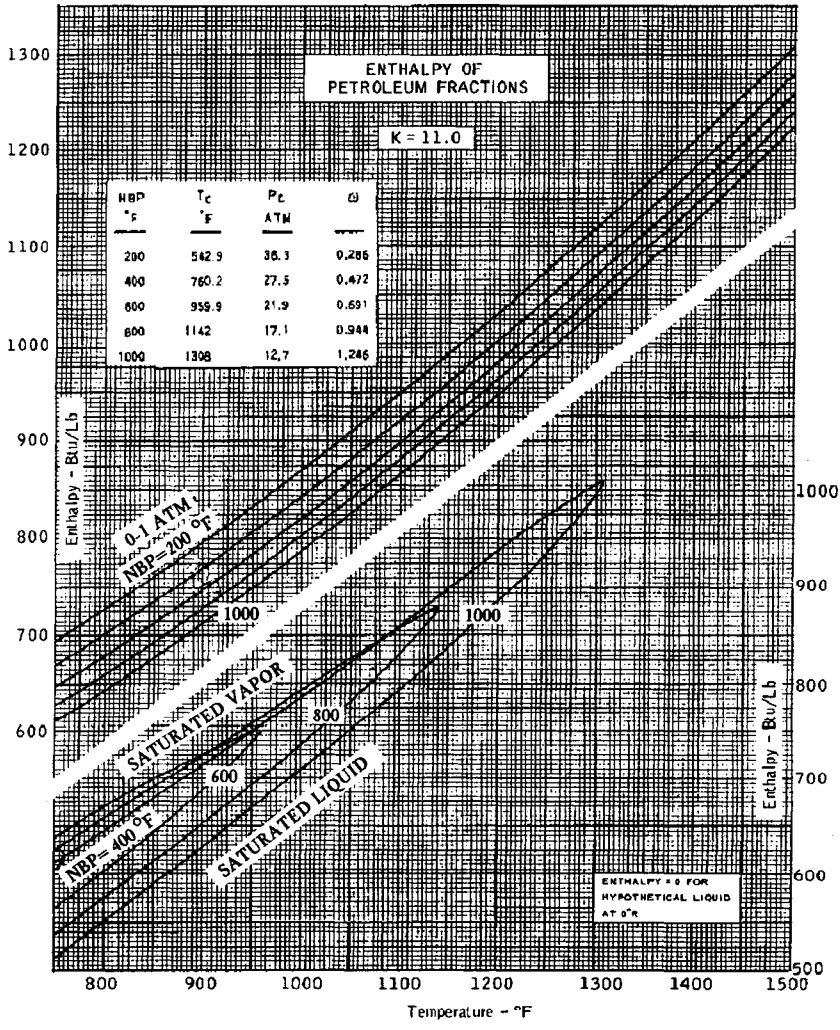


Figure 81. Chart for enthalpy of petroleum fractions, K = 11.0.

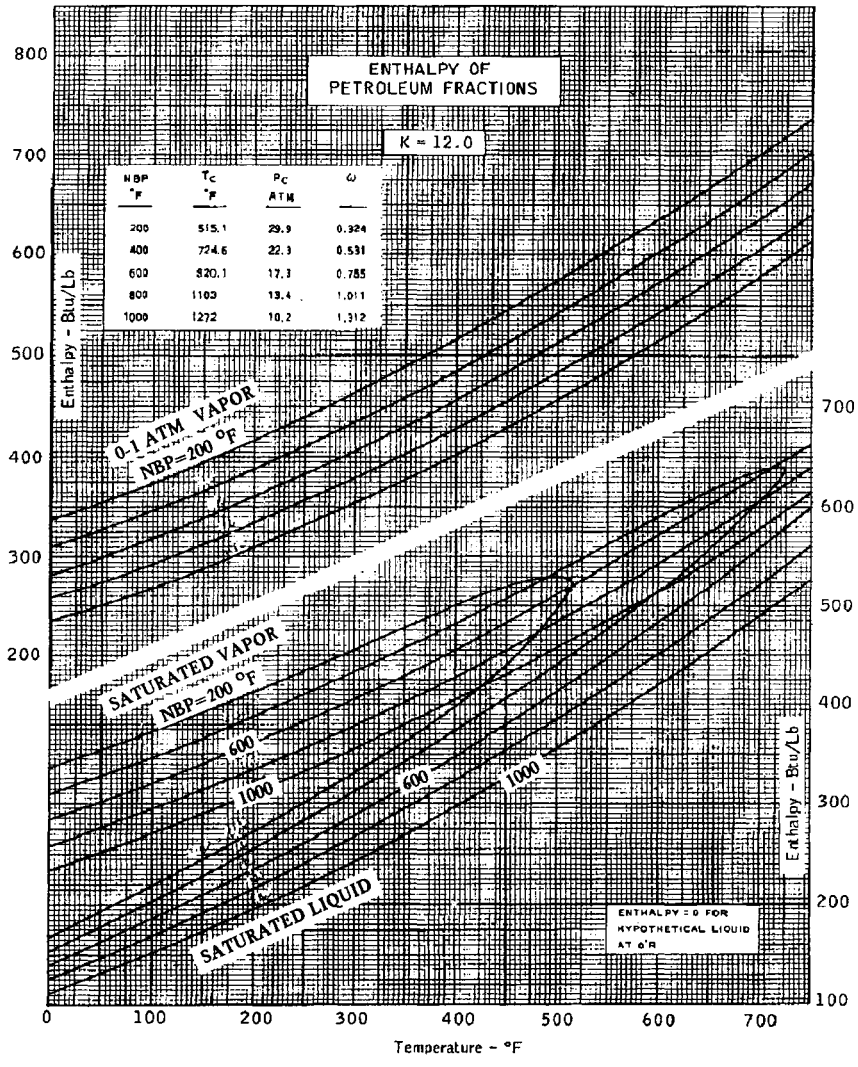


Figure 82. Chart for enthalpy of petroleum fractions, K = 12.0.

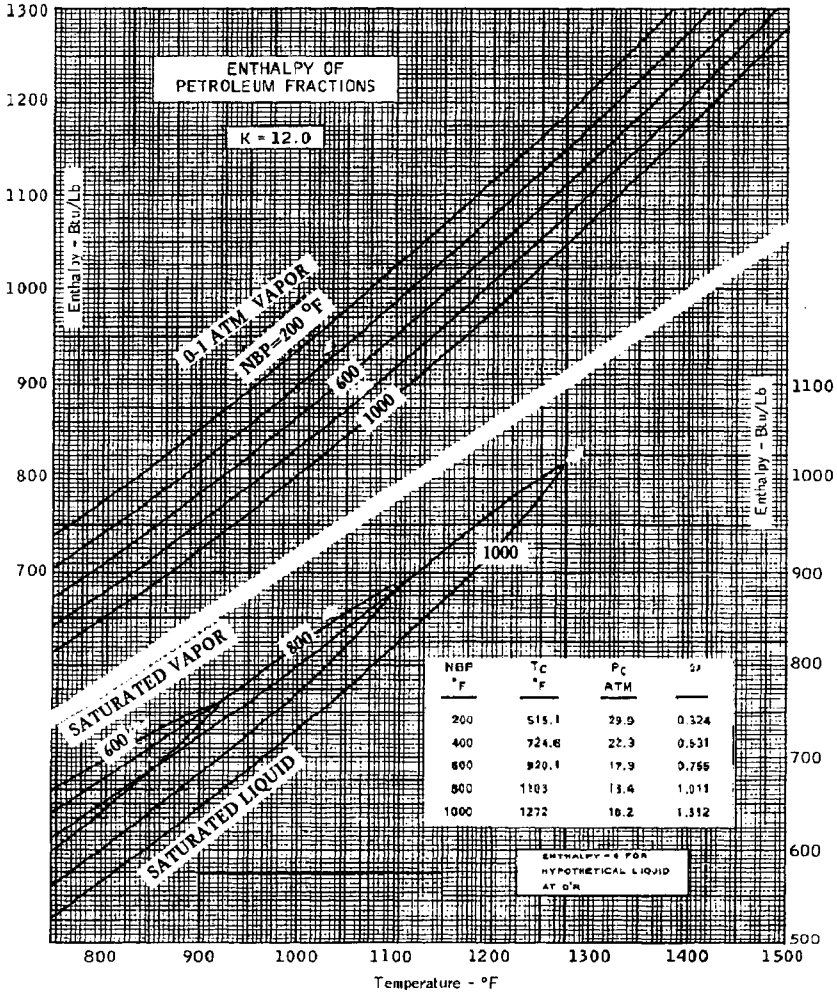


Figure 83. Chart for enthalpy of petroleum fractions, K = 12.0.

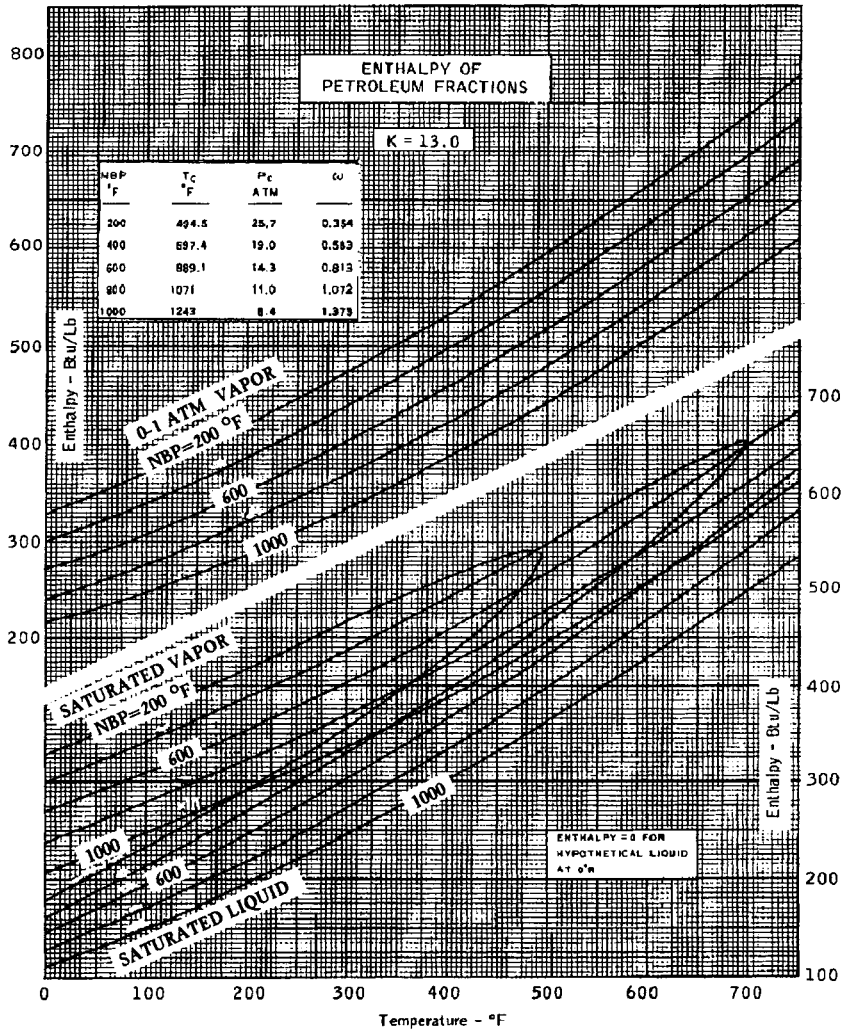


Figure 84. Chart for enthalpy of petroleum fractions, K = 13.0.

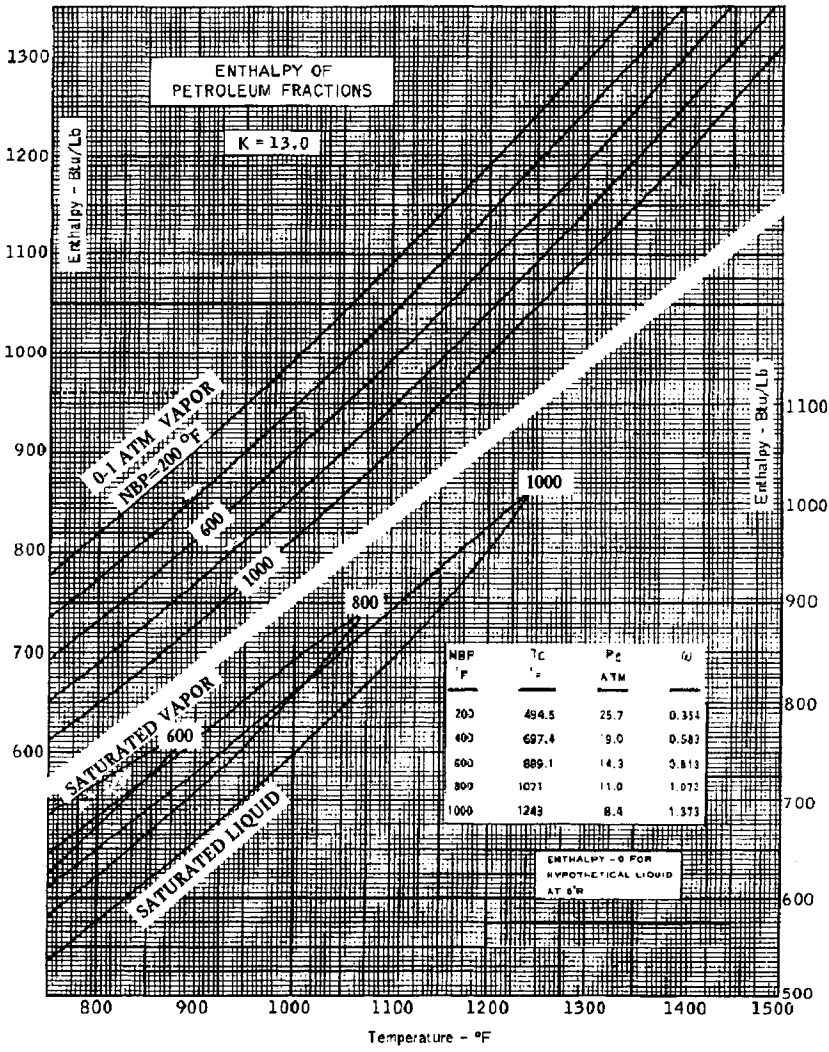


Figure 85. Chart for enthalpy of petroleum fractions, K = 13.0.

The acentric factor, ω, is calculated from the relationship:

$$\omega = \frac{3}{7}\left(\frac{log_{10} P_C}{\frac{T_C}{T_B} - 1} \right) - 1 \qquad (13)$$

where P_C is the pseudo-critical pressure, atmospheres
T_B is the mean average boiling point, °R

The enthalpy charts may be linearly interpolated with both characterization factor and mean average boiling point.

As in the case of light hydrocarbon mixtures, interpolation may result in the enthalpy of the vapor falling within the saturation "dome" on the higher boiling point chart. In this event, the two adjacent lower charts should be extrapolated upward to the average boiling point of the fraction.

Compression

The molal change in enthalpy and final temperature for the adiabatic compression of an ideal gas may be calculated from the following formulas:

$$\Delta H = \frac{K}{K - 1} RT_1 \left[\left(\frac{\pi_2}{\pi_1} \right)^{\frac{K-1}{K}} - 1 \right] \qquad (14)$$

$$T_2 = T_1 \left(\frac{\pi_2}{\pi_1} \right)^{\frac{K-1}{K}} \qquad (15)$$

and for isothermal compression,

$$\Delta H = RT_1 \left[ln \left(\frac{\pi_2}{\pi_1} \right) \right] \qquad (16)$$

where ΔH = enthalpy change in BTU/mole

$K = \frac{MC_P}{MC_P - R}$ at the average temperature

R = gas constant (1.99 BTU/mole)
T_1, T_2 = initial and final temperature in °R
π_1, π_2 = initial and final absolute pressures

Letting a = (K-1)/K = R/MC_P, the first two equations become:

$$\Delta H = \frac{RT_1}{a}\left[\left(\frac{\pi_2}{\pi_1}\right)^a - 1\right] \tag{17}$$

and

$$T_2 = T_1\left(\frac{\pi_2}{\pi_1}\right)^a \tag{18}$$

For a mixture of two or more components neither the individual *K*'s nor *a*'s are directly additive. However, since the molal heat capacities may be added in proportion to their mole fractions, this is also true of the reciprocal *a*'s (Mcp/R),

$$\frac{1}{a_{av}} = \frac{y_1}{a_1} + \frac{y_2}{a_2} + \ldots + \frac{y_n}{a_n} \tag{19}$$

where y_1,y_2 etc. = mole fractions of individual components
and a_1, a_2, etc. = corresponding a's at the average temperature

In terms of horsepower and millions of SCF per day of gas, n, the enthalpy equations become:

$$HP = 0.085\,\frac{nT_1}{a}\left[\left(\frac{\pi_2}{\pi_1}\right)^a - 1\right] \tag{20}$$

for adiabatic compression, and for isothermal compression:

$$HP = 0.085\,nT_1\left[ln\left(\frac{\pi_2}{\pi_1}\right)\right] \tag{21}$$

Figure 86 provides a chart for adiabatic compression exponents for light hydrocarbons and miscellaneous gases. The theoretical horsepower required to compress a million SCF per day of gas at 100 °F is given as a

function of a and the compression ratio in Figure 87. On the same chart is the compression efficiency for single stage reciprocating compressors which also applies to two-stage units without intercooling. The theoretical horsepower divided by the efficiency represents the brake horsepower of the driver (motor, steam or gas engine driven).

While these charts and equations apply only to ideal gases, they may be used with very little error for the adiabatic compression of real gases which approximate the ideal gas law at the inlet conditions. This is true for light hydrocarbons and their mixtures under the following conditions:

1. Molecular weights up to 35. For all compression ratios if the ideal gas correction factor, μ, is 0.95 or greater at the inlet temperature and pressure.

2. Molecular weights from 35 to 45. For all compression ratios if the initial μ is 0.95 or greater and the outlet pressure does not exceed 125 psia. For outlet pressures greater than 125 psia compression ratios are limited to 3:1.

3. Molecular weights from 45 to 60. For compression ratios up to 3:1 if the initial μ is 0.97 or greater.

In using these adiabatic compression equations (or horsepower chart) the enthalpy change and horsepower should always be multiplied by μ at the inlet conditions. While there is no corresponding correction which can be applied to the temperature equation, the a-curves for hydrocarbons have been adjusted to minimize the error in final temperature. These empirical values in Figure 86 are slightly higher than R/MC_p and may be used to predict the temperature rise with acceptable accuracy. Deviations average about 2% and rarely exceed 5%. While the empirical a's tend to increase the error in enthalpy change or horsepower, the effect is so small that it can be neglected.

These relations also may be used for mixtures of hydrocarbons and other gases with the limitations itemized above applying to the hydrocarbon portion of the mixture. The "effective" hydrocarbon pressures, $\pi_1(y_{HC})$ and $\pi_2(y_{HC})$ are used to determine the initial μ_{HC} and the maximum outlet pressure under assumption (2). If inert gases represent 20% or more of the mixture, the first condition may be extended up to a molecular weight of 45 and the second up to a molecular weight of 60.

The average a and μ for the entire mixture are computed as follows:

$$a_{av} = \frac{1}{\frac{y_p}{a_p} + \frac{y_0}{a_0} + \frac{y_1}{a_1} + \cdots + \frac{y_n}{a_n}} \qquad (22)$$

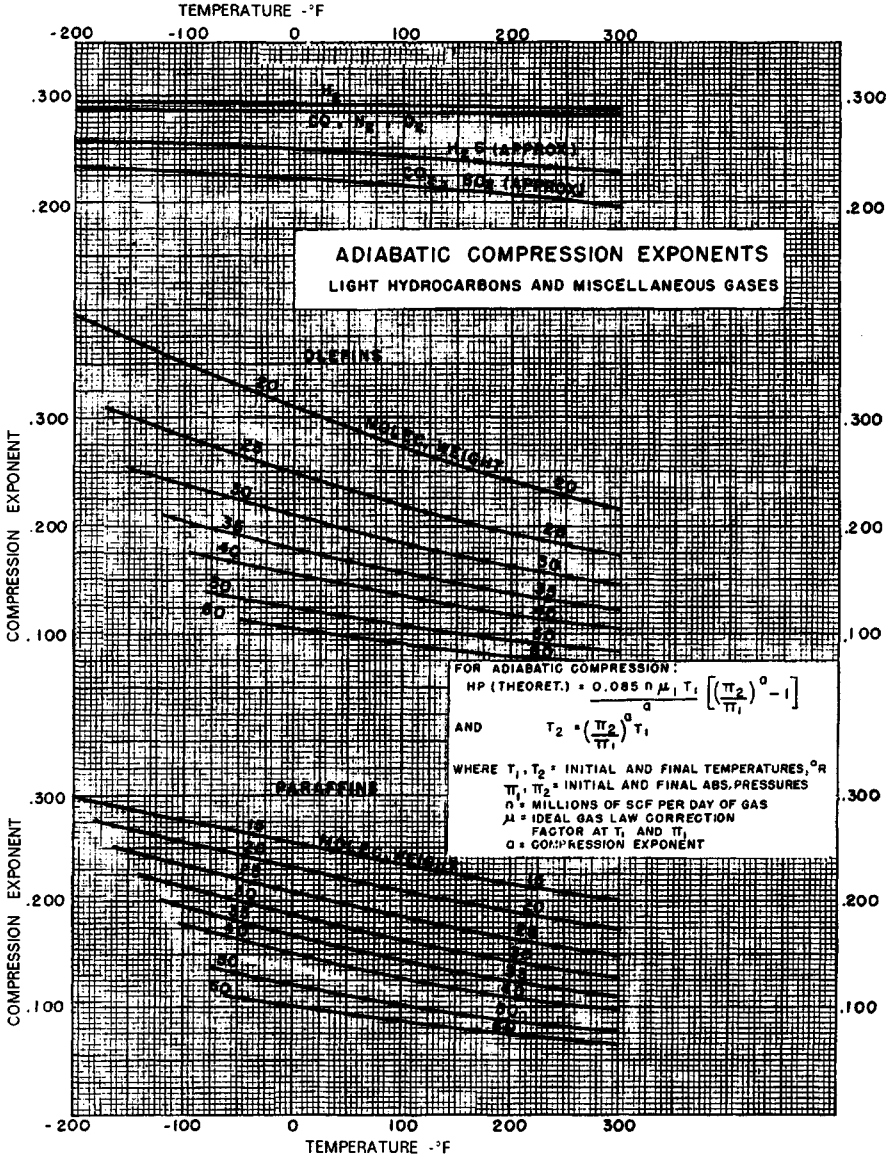


Figure 86. Chart for adiabatic compression exponents of light hydrocarbons and miscellaneous gases.

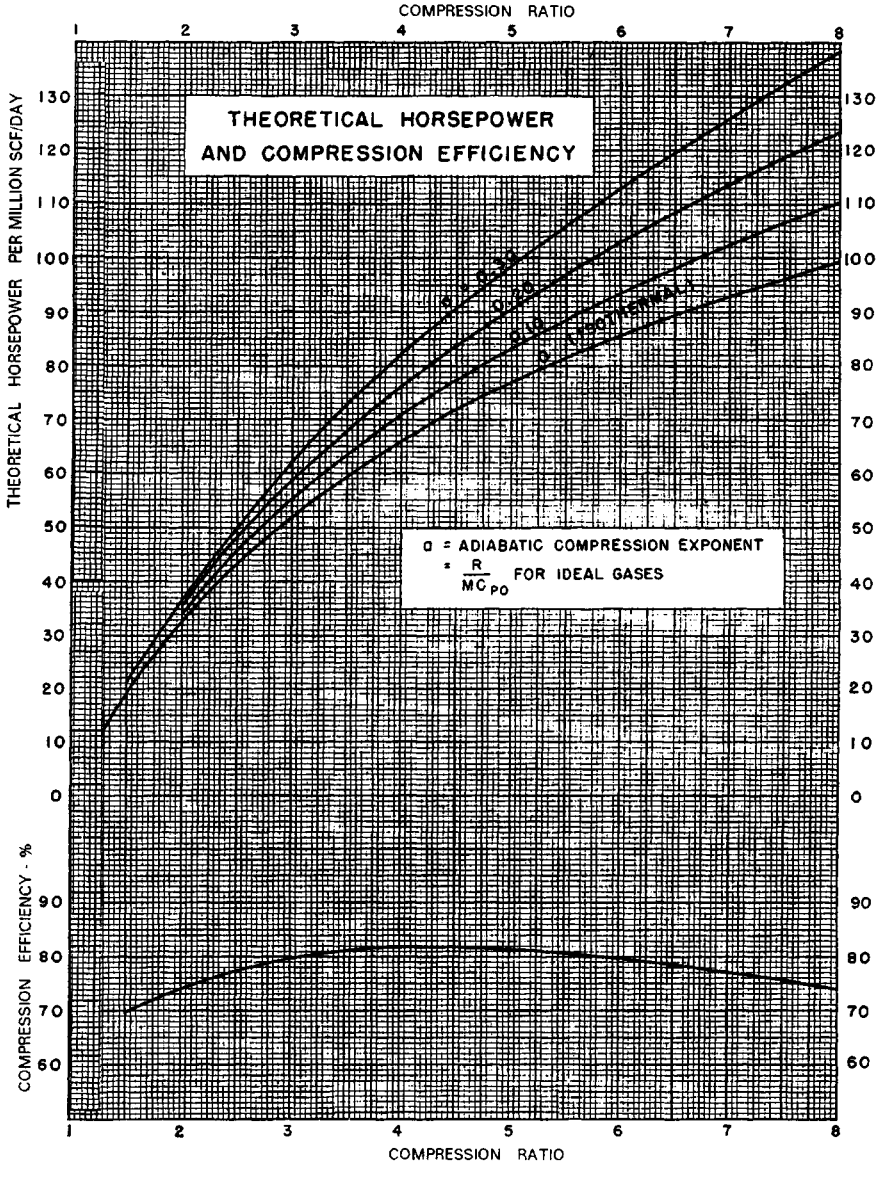


Figure 87. Chart for theoretical horsepower and compression efficiency.

where the subscript, P, refers to the paraffin and 0 to the olefin portion of the hydrocarbon fraction; the subscripts 1, ... , n refer to other gases which may be present.

To calculate the average μ there is no necessity to segregate the paraffin and olefin portions; the hydrocarbon fraction may be considered as a whole, or

$$\mu_{av} = y_{HC}\mu_{HC} + y_1\mu_1^* + \ldots + y_n\mu_n^* \qquad (23)$$

where $y_{HC} = y_P + y_o$

and $y_{HC} + y_1 + \ldots + y_n = 1.00$

Inert gases present in hydrocarbon mixtures usually are very nearly ideal and μ may be assumed to be 1.00 for this portion of the mixture. Otherwise, the inert gases should be treated individually and μ determined for each gas at its effective pressure, $\pi_1 y_n^{1/2}$.

The following examples illustrate the application of the foregoing method to mixtures of hydrocarbons both with and without other gases present.

Example: Determine the horsepower per million SCF per day and final temperature if the following mixture is compressed adiabatically from 20 psig and 80 °F to 100 psig.

Component	Mole Fraction		Average Molec. Wt.	Molal Boiling Point, °F
	Total	Olefins		
CH_4	0.050	-	0.8	-13
C_2H_4	.100	.100	2.8	-15
C_2H_6	.150	-	4.5	-19
C_3H_6	.100	.100	4.2	-5
C_3H_8	.200	-	8.8	-9
C_4H_8	.100	.100	5.6	+3
C_4H_{10}	.250	-	14.5	+8
C_5H_{12}	.050	-	3.6	+5
	1.000	0.300	44.8	-45

P_C = 42. 0 atm. (Figure 38); T_C = 460 + 210 = 670 °R (Figure 37)

$$\pi_{r1} = \frac{2.36\ atm}{42.0\ tm} = 0.056; \qquad T_{r1} = \frac{540\,^oR}{670\,^oR} = 0.805 \quad \mu_1 = 0.955$$

Assuming $t_2 = 150\ ^oF$, $a_p = 0.113$ and $a_0 = 0.120$ for 44.8 M.W. at $(80+150)/2 = 115\ ^oF$

$$a_{av} = \frac{1}{\frac{0.700}{0.113} + \frac{0.300}{0.120}} = 0.115$$

$$T_2 = \left(\frac{114.7}{34.7} \right)^{0.115} \times 540 = 620\,^oR \approx 160\,^oF$$

Recalculating,

$$a_{av}\ (120^oF) = \frac{1}{\frac{0.700}{0.112} + \frac{0.300}{0.119}} = 0.114$$

$$T_2 = (3.31)^{0.114} \times 540 = 619\,^oR \approx 159\,^oF$$

$$HP\ (theoret.) = \frac{0.955 \times 0.085 \times 540}{0.114} \left[(3.31)^{0.114} - 1 \right] =$$

$$= 56.2\ /MM\ SCF/day$$

or from the chart in Figure 87:

$$HP\ (theoret.) = \frac{0.955 \times 61.0 \times 540}{560} = 56.2\ /MM\ SCF/day$$

$$HP\ (brake) = 56.2 \times \frac{100}{80.7} = 69.5\ /MM\ SCF/day$$

Another example will help to provide further illustration.

Example: Determine the horsepower per million SCF per day and final temperature if the following mixture of CO, H_2 and light hydrocarbons is compressed adiabatically from 50 psig and 100 °F to 300 psig.

Component	Mole Fraction	Hydrocarbon Portion		
		Mole Fraction	Average Molec. Wt.	Molal Average Boiling Point, °F
CO	0.200	-	-	-
H_2	.175	-	-	-
CH_4	.125	0.200	3.2	-52
C_2H_6	.150	.240	7.2	-31
C_3H_8	.200	.320	14.1	-14
C_4H_{10+}*	.150	.240	17.3	+23
	1.000	1.000	41.8	-74

*Assumed to average C_5H_{12}.

$$\pi_{el} = \frac{64.7}{14.7}\sqrt{0.625} = 3.48\ atm; \quad \frac{\pi_2}{\pi_1} = \frac{314.7}{64.7} = 4.86$$

where π_{el} = effective initial pressure

P_c = 43.7 atm. (Figure 38); T_c = 460+169=629 °R (Figure 37)

π_{rl} = 0.080 T_c = 0.890 μ_{HC} = 0.952

μ_{av} = 0.375×1.000+0.625×0.952 = 0.970

In order to estimate values of a assume t_2 = 250 °F

$$a_{av}@\ 175^oF = \frac{1}{\frac{0.200}{0.284} + \frac{0.175}{0.290} + \frac{0.625}{0.108}} = 0.141$$

$T_2 = (4.86)^{0.141} \times 560 = 700\ °R \approx 240\ °F$

This is sufficiently close to the assumed final temperature that it is unnecessary to recalculate a_{av}.

The theoretical horsepower may be calculated by Equation 20 (or read

from the chart in Figure 87), multiplied by μ,

$$HP(theoret.) = \frac{0.970 \times 0.085 \times 560}{0.141}\left[(4.86)^{0.141} - 1\right] = 81.8 / MM\ SCF/day$$

$$HP\ (brake) = \frac{81.8 \times 100}{81.5} = 100.4 / MM\ SCF/day$$

The foregoing examples may also be solved by the use of Mollier diagrams. Furthermore, if the limiting conditions are exceeded the Mollier diagrams must be used for adiabatic compression. Empirical methods of applying these charts to light hydrocarbon mixtures are given in the following discussion.

Mollier Diagrams

The Mollier diagrams for the individual light hydrocarbons are of essentially the same type as the familiar one for steam. To minimize confusion and to make the charts as easily usable as possible, lines of constant volume are omitted and lines of constant temperature replace lines of constant superheat in the super-heated vapor region. These charts can be used principally for adiabatic compressions and expansions. Charts are given in Figures 88 through 95.

In applying the Mollier diagrams to hydrocarbon mixtures, the mixture should be treated as a single compound of the average molecular weight. An empirical study of the diagrams indicates that successive charts of the same series (paraffin or olefin) may be interpolated (or extrapolated) by assuming a linear relation exists between molecular weight and (1) is entropic change of molal enthalpy with pressure and (2) the product of the square root of the molecular weight and the isentropic change of temperature with pressure.

If both paraffins and olefins are present in the mixture, the charts of each series are interpolated (or extrapolated) to the average molecular weight of the total mixture. These values corresponding, respectively, to a 100% paraffin mixture and a 100% olefin mixture are used for linear interpolation to the actual olefin content of the mixture.

The earlier example for adiabatic compression is recalculated by this method to illustrate the application of the Mollier diagrams to a light hydrocarbon mixture. Interpolation is used between the propane and butane charts to determine the change in enthalpy and final temperature of a paraffin hydrocarbon having an average molecular weight of 44.8. The ethylene and propylene charts are extrapolated to an olefin of this same

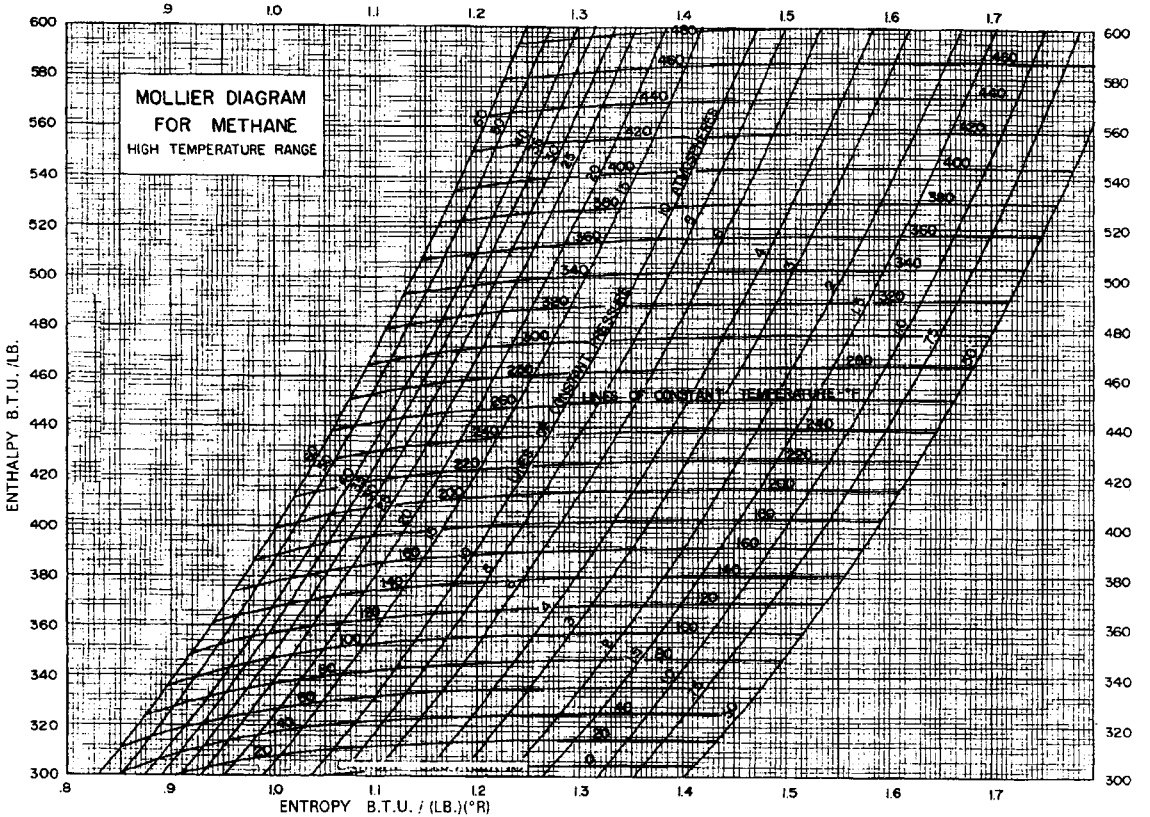


Figure 88. Chart for Mollier diagram for methane; high temperature range.

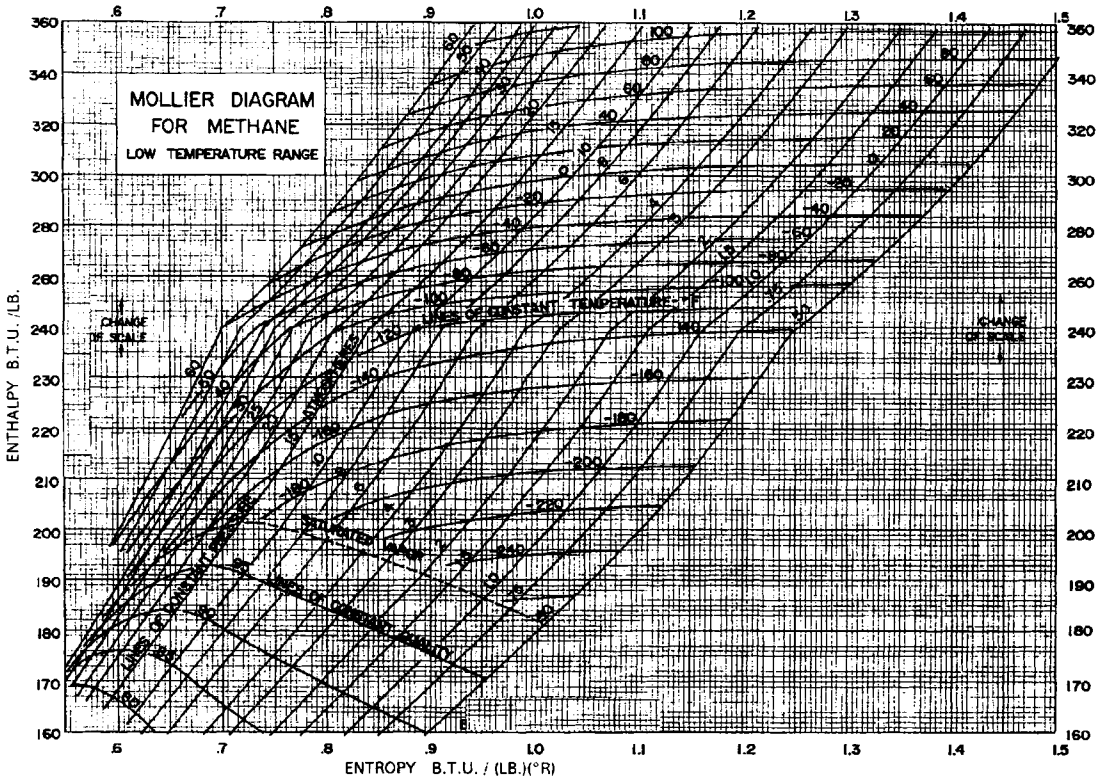


Figure 89. Chart for Mollier diagram for methane; low temperature range.

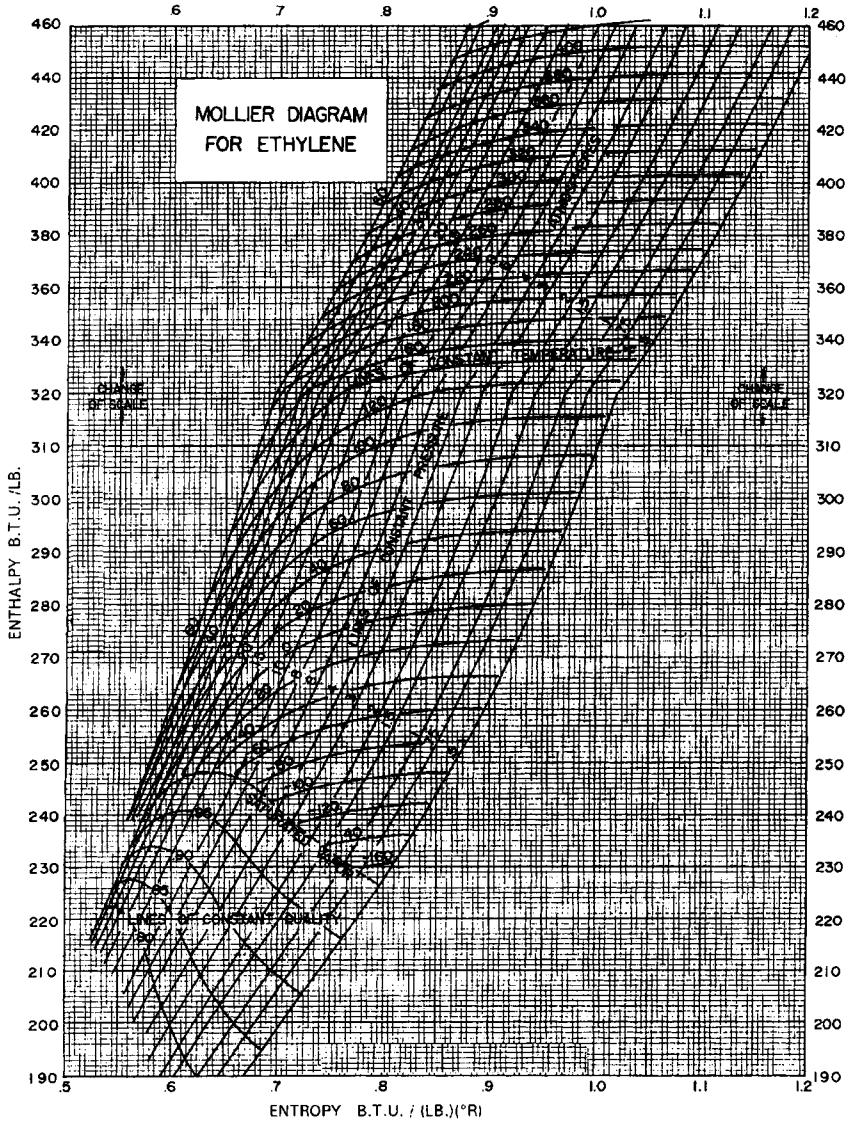


Figure 90. Chart for Mollier diagram for ethylene.

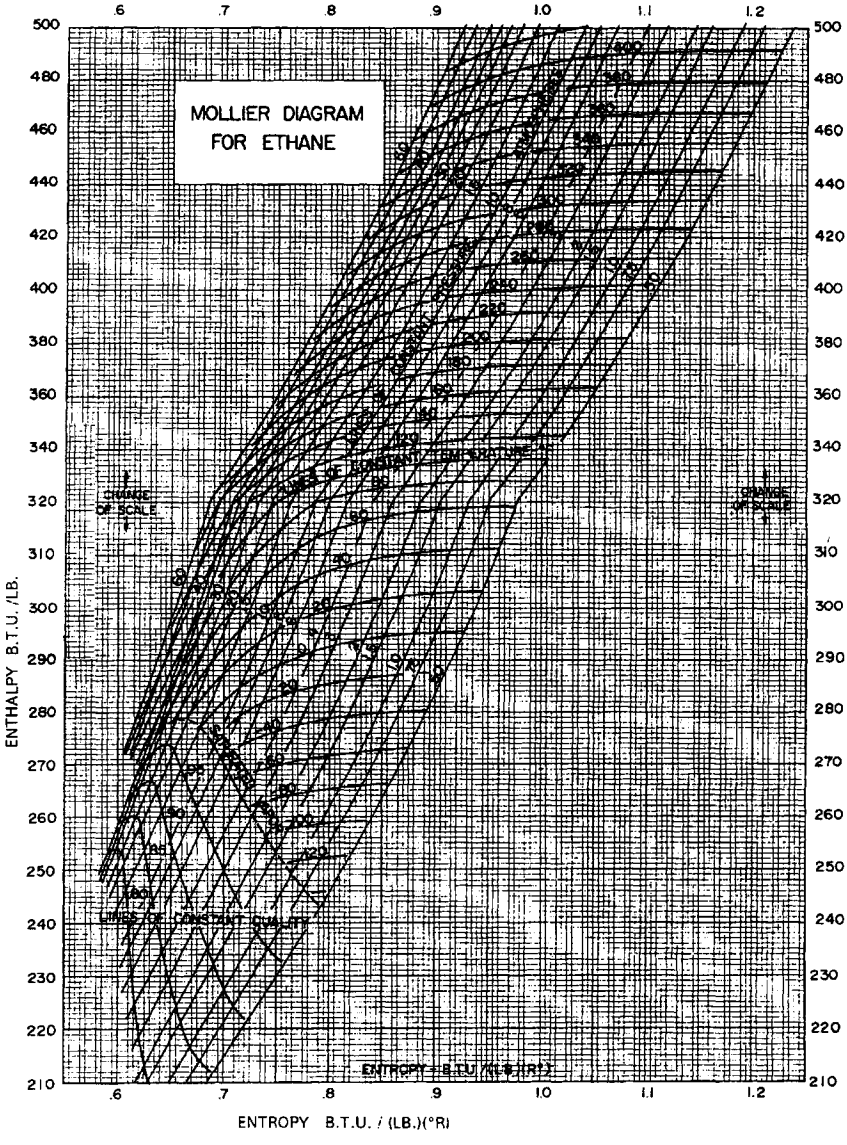


Figure 91. Chart for Mollier diagram for ethane.

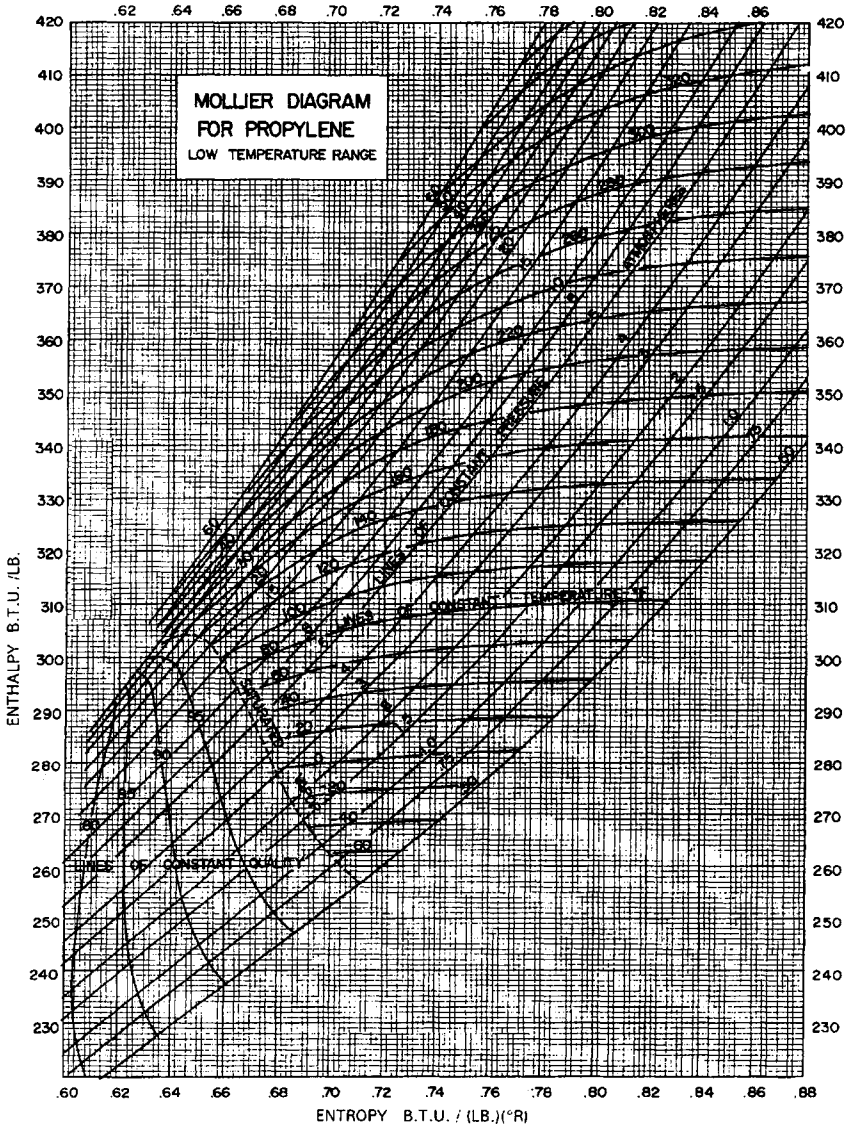


Figure 92. Chart for Mollier diagram for propylene; low temperature range.

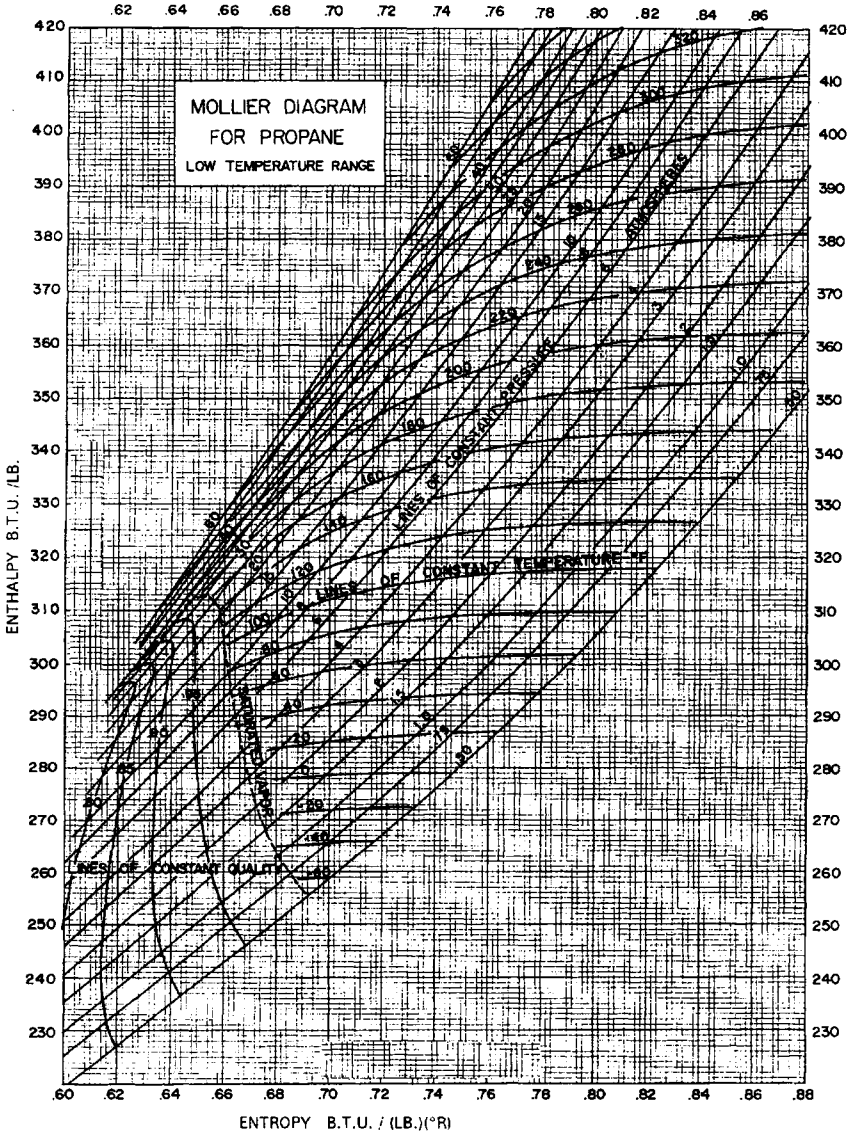


Figure 93. Chart for Mollier diagram for propane; low temperature range.

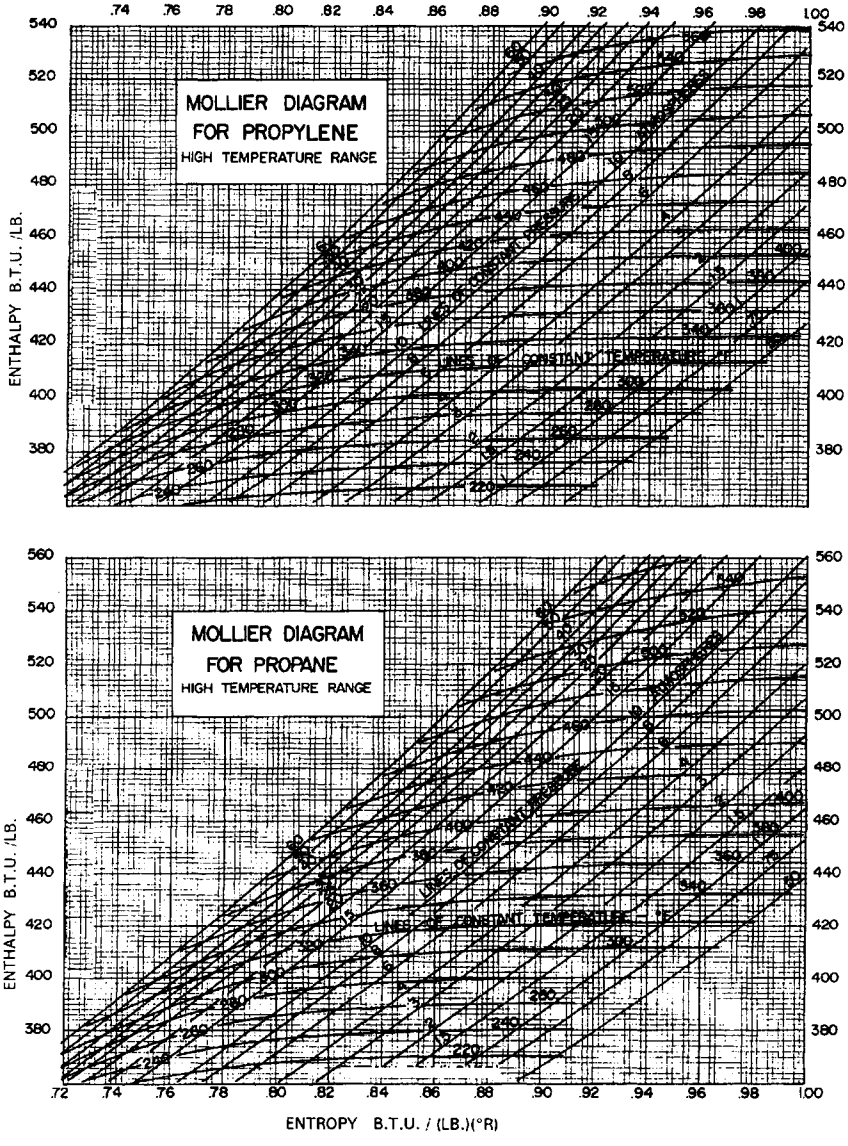


Figure 94. Charts for Mollier diagram for propylene and propane; high temperature range.

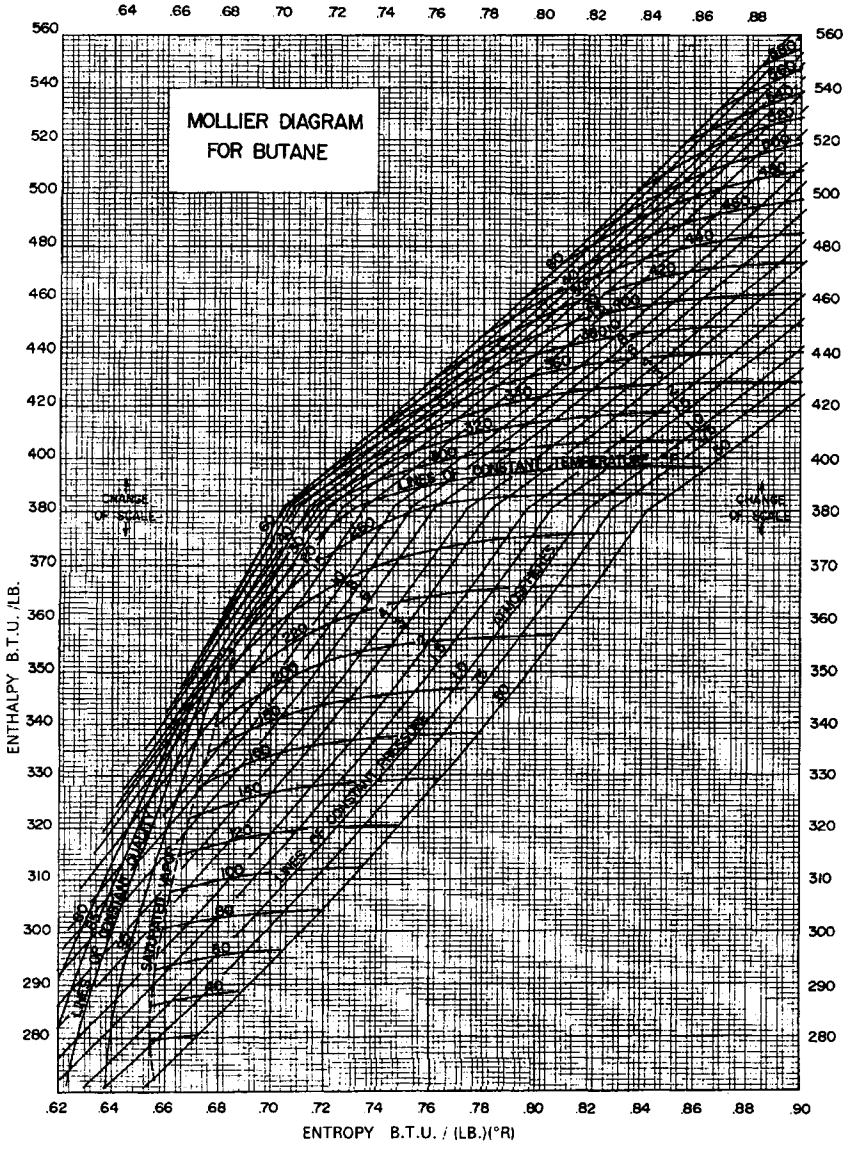


Figure 95. Chart for Mollier diagram for butane.

average molecular weight. Values corresponding to adiabatic compression from 2.36 atm and 80 °F to 7.80 atm were read from the individual charts and are tabulated below:

Compound	S	BTU /lb		t_2 °F	ΔH $M(h_2-h_1)$ BTU/mole	$\Delta t \sqrt{M}$
		h_1	h_2			
C_3H_8	0.739	308.5	337.5	159	1280	525
C_4H_{10}	0.663	300	(320.5)*	(145)*	1190	495
C_2H_4	0.885	306.5	355.5	207	1375	672
C_3H_6	0.753	308.5	339.5	168	1305	570

*Estimated. since the isentropic abscissa crosses the saturation curve into the two-phase region. As the molecular weight of the mixture is almost the same as C_3H_8 , these C_4H_{10} values have very little effect on the result. Otherwise, it would have been better to extrapolate from the C_2H_8 and C_3H_8 charts.

By interpolation, $\Delta H = 1275$ BTU/mole and $\Delta t \times M^{1/2} = 523$ for a saturated hydrocarbon mixture of 44.8 molecular wt.

By extrapolation, $\Delta H = 1291$ BTU/mole and $\Delta t \times M^{1/2} = 550$ for an unsaturated hydrocarbon mixture of 44.8 molecular wt.

By interpolation, $\Delta H = 1280$ BTU/mole and $\Delta t \times M^{1/2} = 531$ for a hydrocarbon mixture of 44.8 molecular wt. containing 30% un saturates.

ΔH(theoret.) $= 0.043 \times 1280 = 55.1$ and $t_2 = 80 + 531/(44.8)^{1/2} =$ 159 °F while the equations gave 56,2 HP and the same final temperature.

The Mollier diagrams may also be used for mixtures of light hydrocarbons and inert gases (N_2, H_2 , CO_2, etc.) by considering the latter to be paraffins with fictitious molecular weights. For this purpose diatomic gases (CO, H_2, N_2, etc.) are assumed to be the equivalent of a paraffin hydrocarbon having a molecular weight of 10. The corresponding value for the triatomic gases (CO_2, H_2O, SO_2, etc.) is a molecular weight of 16.

The average molecular weight of the entire mixture is computed by using these equivalent values for inert gases. Then, the Mollier diagrams are interpolated or extrapolated just the same as they would be for a mixture of pure hydrocarbons. The molal change in enthalpy resulting from the interpolations may be converted directly to horsepower per million SCF per day. However, if it is necessary to convert the enthalpy from BTU/mole to BTU/lb., the true molecular weight of the mixture must be the divisor.

This method is reliable for mixtures of paraffins and inert gases if the latter are not present in excess of 40 mole per cent. If the hydrocarbon portion contains only olefins, the method should not be used for mixtures

having more than 10 per cent of inert gases. If the hydrocarbon portion of the mixture contains both paraffins and olefins, the limiting percentage of inert gases will be in direct proportion to the relative quantities of these hydrocarbons. For example, if there are 70% paraffins and 30% olefins in the hydrocarbon portion, the maximum inert gas for which this method is reliable is $0.70 \times 40 + 0.30 \times 10 = 31\%$.

The previous example is recalculated to illustrate the application of the Mollier diagrams if inert gases are present.

Component	Mole Fraction	Equivalent Molec. Weight	Average Molec. Weight
CO	0.200	10.0	2.0
H_2	0.175	10.0	1.7
CH_4	0.125	16.0	2.0
C_2H_6	0.150	30.1	4.5
C_3H_8	0.200	44.1	8.8
C_4H_{10+}	0.150	72.1	10.8
	1.000		29.8

Since the equivalent molecular weight of the mixture is 29.8, the methane and ethane charts will be interpolated. However, for all practical purposes the ethane chart could be used directly by converting the enthalpy change from BTU/lb. to BTU/mole. The values tabulated below correspond to the initial conditions of 4.4 atm and 100 °F and the final pressure of 21.4 atm.

Compound	S	BTU /lb		t_2 °F	ΔH $M(h_2-h_1)$ BTU/mole	$\Delta t \sqrt{M}$
		h_1	h_2			
CH_4	1.240	355	484	318	2070	872
C_2H_6	0.860	333	395	247	1865	806

By interpolation, $\Delta H = 1870$ BTU/mole and $\Delta t M^{1/2} = 807$ ΔH(theoret.) $= 0.043 \times 1870 = 80.3$ and $t_2 = 100 + 807\ (29.8)^{1/2} = 248$ °F whereas, 81.8 HP and 240 °F were calculated by the equations.

5

Fire And Explosion Guide For Common Chemicals

INTRODUCTION

This chapter provides a listing of common chemicals and information pertinent to their stability in terms of fire, explosion and general fire fighting guidelines. The first part of the chapter provides an alphabetical listing of chemicals that are regulated by the U.S. Department of Transportation. The chemicals are listed according to their common name and not technical name. Each chemical listed has its United Nations 4-digit shipping number designation. Also, each chemical is referred to an Emergency Response Fact Sheet or Guide Number. The fact sheet is given in the second half of the chapter. The fact sheet is an Emergency Response Guide that the U.S. Department of Transportation recommends. The information fact sheet provides information on the following areas:

- Potential Hazards (Health Hazards, Fire or Explosion)
- Emergency Action for Fire, Spills or Leaks and First Aid.

ALPHABETICAL LISTING OF HIGH HAZARD CHEMICALS

From the Guide number, the reader can obtain fire hazard and emergency response information on a specific chemical by matching the number with fact sheets in the second half of this chapter. Those chemicals in the table which are boldfaced represent materials that require an initial isolation distance when involved in a spill or leak. Information and guidelines on isolation distances can be found in Chapter 7. Note that in some of the chemical shipping name designations, the abbreviation n.o.s. is used. This stands for "not otherwise specified", which refers to the fact that this material is not assigned a hazard class according to U.S. Department of

Transportation shipping regulations. The reader should refer to the book by Cheremisinoff for a detailed introduction to hazard material transportation laws (Cheremisinoff, N.P.-Transportation of Hazardous Materials: A Guide to Compliance, Noyes Publications, Westwood, New Jersey,1994).

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Accumulators, pressurized	1956	12
Acetal	1088	26
Acetaldehyde	1089	26
Acetaldehyde Ammonia	1841	31
Acetaldehyde Oxime	2332	26
Acetic Acid, Glacial	2789	29
Acetic Acid Solution, more than 10% but no more than 80% acid	2790	60
Acetic Acid Solution, more than 80% acid	2789	29
Acetic Anhydride	1715	39
Acetone, and solutions	1090	26
Acetone Cyano-hydrin, stabilized	**1541**	**55**
Acetone Oils	1091	26
Acetonitrile	1648	28
Acetyl Acetone Peroxide	2080	48
Acetyl Benzoyl Peroxide	2081	48
Acetyl Bromide	1716	60
Acetyl Chloride	1717	29
Acetyl Cyclohexane Sulfonyl Peroxide	2082	52
Acetyl Cyclohexane Sulfonyl Peroxide	2083	52
Acetylene	1001	17
Acetylene, dissolved	1001	17
Acetylene Tetrabromide	2504	58
Acetyl Iodide	1898	60
Acetyl Methyl Carbinol	2621	26
Acetyl Peroxide	2084	49
Acid, liquid, n.o.s.	1760	60
Acid, Sludge	1906	60
Acid Butyl Phosphate	1718	60
Acid Mixture, hydrofluoric and sulfuric acids	1786	59
Acid mixture, nitrating	1796	73
Acid mixture, spent, nitrating	1826	60
Acridine	2713	32
Acrolein, inhibited	**1092**	**30**
Acrolein dimer, stabilized	2607	26
Acrylamide	2074	55
Acrylic acid, inhibited	2218	29
Acrylonitrile, inhibited	1093	30
Activated carbon	1362	32
Adhesive	1133	26
Adhesives, containing flammable liquid	1133	26
Adiponitrile	2205	55
Aerosols	1950	12
Air, compressed	1002	12
Air, refrigerated liquid (cryogenic liquid)	1003	23
Air bag inflators	3268	31
Air bag inflators	1325	32
Air Bag Modules	3268	31

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Air bag inflators	1325	32
Air Bag Modules	3268	31
Air Bag Modules	1325	32
Aircraft Hydraulic Power Unit Fuel Tank	3165	28
Alcohol (beverage)	1170	26
Alcohol, denatured	1987	26
Alcohol, denatured (toxic)	1986	28
Alcohol (ethyl)	1170	26
Alcohol, nontoxic, n.o.s.	1987	26
Alcoholates Solution, n.o.s., in alcohol	3274	26
Alcoholic beverage	1170	26
Alcoholic beverages	3065	26
Alcohols, n.o.s.	1987	26
Alcohols, toxic, n.o.s.	1986	28
Aldehydes, n.o.s.	1989	26
Aldehydes, toxic, n.o.s.	1988	28
Aldol	2839	55
Aldrin and its mixtures	2761	55
Alkali Metal Alcoholates, n.o.s.	3206	38
Alkali metal Alcoholates, self-heating, corrosive, n.o.s.	3206	38
Alkali Metal Alloys, liquid, n.o.s.	1421	40
Alkali Metal Amalgams	1389	40
Alkali Metal Amides	1390	40
Alkali Metal Dispersions	1391	40
Alkaline Corrosive Liquid, n.o.s.	1719	60
Alkaline Earth Metal Alcoholates, n.o.s.	3205	37
Alkaline Earth Metal Alloys, n.o.s.	1393	40
Alkaline Earth Metal Amalgams	1392	40
Alkaline Earth Metal Dispersions	1391	40
Alkaloid Salts, liquid, n.o.s., poisonous	3140	53
Alkaloid Salts, solid, n.o.s., poisonous	1544	55
Alkaloids, liquid, n.o.s., poisonous	3140	53
Alkaloids, solid, n.o.s., poisonous	1544	55
Alkyl Phenols, liquid, n.o.s.	3145	55
Alkylamines, n.o.s.	2733	29
Alkylamines, n.o.s.	2734	29
Alkylamines, n.o.s.	2735	60
Alkylphenols, solid, n.o.s.	2430	55
Alkylsulfonic Acids, liquid with more than 5% free sulfuric acid	2584	60
Alkylsulfonic Acids, liquid with not more than 5% free sulfuric acid	2586	60
Alkylsulfonic Acids, liquid with not more than 5% free sulfuric acid	2583	60
Alkylsulfonic Acids, liquid with not more than 5% free sulfuric acid	2585	60
Alkylsulfuric Acids	2571	60
Allethrin	2902	55
Allyl Acetate	2333	28
Allyl Alcohol	**1098**	**57**
Allylamine	**2334**	**28**

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Allyl Chloro-carbonate	**1722**	**57**
Allyl Chloro-formate	**1722**	**57**
Allyl Ethyl Ether	2335	28
Allyl Formate	2336	28
Allyl Glycidil Ether	2219	29
Allyl Iodide	1723	29
Allyl Isothio-cyanate, inhibited	**1545**	**57**
Allyl Isothio-cyanate, stabilized	**1545**	**57**
Allyltrichlorosilane, stabilized	1724	29
Aluminum, molten	9260	77
Aluminum Alkyl	2845	40
Aluminum Alkyl Halides	3052	40
Aluminum Alkyl Hydrides	3076	40
Aluminum Alkyls	3051	40
Aluminum Borohydride	2870	37
Aluminum Boro-hydride in Devices	2870	37
Aluminum Bromide, anhydrous	1725	39
Aluminum Bromide, Solution	2580	60
Aluminum Carbide	1394	40
Aluminum Chloride, anhydrous	1726	39
Aluminum Chloride, Solution	2581	60
Aluminum Dross	3170	40
Aluminum Ferro-silicon, powder	1395	41
Aluminum Hydride	2463	40
Aluminum Nitrate	1438	35
Aluminum Phosphate Solution	1760	60
Aluminum Phosphide	1397	41
Aluminum Phosphide Pesticides	3048	53
Aluminum Powder, coated	1309	32
Aluminum Powder, uncoated	1396	40
Aluminum Process-ing By-Products	3170	40
Aluminum Resinate	2715	32
Aluminum Silicon Powder uncoated	1398	40
Aluminum Sulfate Solution	1760	60
Amines, flammable, corrosive, n.o.s.	2733	29
Amines, liquid, corrosive, flammable, n.o.s.	2734	29
Amines, liquid, corrosive, n.o.s.	2735	60
Amines, solid, corrosive, n.o.s.	3259	60
2-amino-4-chloro-phenol	2673	53
2-amino-5-diethyl-aminopentane	2946	31
Aminoethoxyethanol	1760	60
2-(2-aminoethoxy) ethanol	3055	60
N-Aminoethyl-piperazine	2815	60
Aminophenols (o-, m-,p-)	2512	55
Aminopropyl-diethanolamine	1760	60
N-Aminopropyl-morpholine	1760	60
N-Aminopropyl-piperazine	1760	60
Aminopyridines (o-, m-, p-)	2671	55
Ammonia	**1005**	**15**

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Ammonia Anhydrous, liquefied	**1005**	**15**
Ammonia Solutions with more than 10% but no more than 35% ammonia	2672	60
Ammonia Solutions with more than 35% but no more than 50% ammonia	2073	15
Ammonia Solutions with more than 50% ammonia	1005	15
Ammonium Arsenate	1546	53
Ammonium Bifluoride, solid	1727	60
Ammonium Bifluoride, solution	2817	60
Ammonium Bisulfite, solid	2693	60
Ammonium Bisulfite Solution	2693	60
Ammonium Carbamate	9083	31
Ammonium Carbonate	9084	31
Ammonium Dichromate	1439	35
Ammonium Dinitro-o-Cresolate	1843	42
Ammonium Fluoborate	9088	31
Ammonium Fluoride	2505	54
Ammonium Fluorosilicate	2854	53
Ammonium Hydrogendifluoride, solid	1727	60
Ammonium Hydrogendifluoride Solution	2817	60
Ammonium Hydrogendifluoride, solid	1727	60
Ammonium Hydrogendifluoride Solution	2817	60
Ammonium Hydrogen Sulfate	2506	60
Ammonium Hydrosulfide Solution	2683	28
Ammonium Hydroxide	2672	60
Ammonium Metavanadate	2859	53
Ammonium Nitrate, Liquid (hot concentrated solution)	2426	35
Ammonium Nitrate with more than 0.2 % combustible material	0222	46
Ammonium Nitrate with not more than 0.2 % combustible material	1942	43
Ammonium Nitrate, with organic coating	1942	43
Ammonium Nitrate Fertilizer	2067	43
Ammonium Nitrate Fertilizer, which is more liable to explode than ammonium nitrate with 0.2% combustible material	0223	46
Ammonium Nitrate Fertilizer with ammonium sulfate	2069	43
Ammonium Nitrate Fertilizer, with calcium carbonate	2068	43
Ammonium Nitrate Fertilizer, with not more than 0.4% of combustible material	2071	35

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Ammonium Nitrate Fertilizer, with phosphate or potash	2070	43
Ammonium Nitrate Fertilizers	2071	35
Ammonium Nitrate Fertilizers	2072	43
Ammonium Nitrate Fertilizer, n.o.s.	2072	43
Ammonium Nitrate - Fuel Oil Mixture (containing only prilled ammonium nitrate and fuel oil)	0331	46
Ammonium Nitrate - Fuel Oil Mixtures	--	46
Ammonium Nitrate Mixed Fertilizers	2069	43
Ammonium Nitrate Solution, with not less than 15% water	2426	35
Ammonium Nitrate - Sulfate Mixture	2069	43
Ammonium Oxalate	2449	54
Ammonium Perchlorate	0402	46
Ammonium Perchlorate	1442	43
Ammonium Permanganate	9190	43
Ammonium Persulfate	1444	35
Ammonium Picrate, dry or wetted with less than 10% water	0004	46
Ammonium Picrate, wetted with less than 10% water	1310	33
Ammonium Poly-sulfide Solution	2818	60
Ammonium Polyvanadate	2861	55
Ammonium Silico-fluoride, solid	2854	53
Ammonium Sulfide Solution	2863	28
Ammunition, tear-producing, non-explosive	2017	58
Ammunition, toxic, non-explosive	2016	15
Amyl Acetates	1104	26
Amyl Acid Phosphate	2819	60
Amyl Alcohols	1105	26
Amylamines	1106	68
Amyl Butyrates	2620	27
Amyl Chlorides	1107	26
n-Amylene	1108	26
Amyl Formates	1109	26
Amyl Mercaptans	1111	27
Amyl Methyl Ketone	1110	26
Amyl Nitrate	1112	26
Amyl Nitrites	1113	26
tert-Amyl Peroxy-2-Ethylhexanoate	2898	52
tert-Amyl Peroxy-Neodecanoate	2891	52
Amyltrichlorosilane	1728	29
Anhydrous Ammonia	**1005**	**15**
Aniline	1547	57
Aniline Hydro-chloride	1548	53
Ansidines	2431	55
Anisole	2222	26
Anisoyl Chloride	1729	60
Anti-Freeze	1142	26
Anti-Knock Compound	1649	56
Antimony, powder	2871	53
Antimony Chloride	1733	60
Antimony Com-pound, inorganic, n.o.s.	1549	60

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Antimony Compounds, inorganic, liquid, n.o.s.	3141	53
Antimony Compounds, inorganic, n.o.s.	1549	60
Antimony Lactate	1550	43
Antimony Pentachloride, liquid	1730	60
Antimony Pentachloride Solution	1731	60
Antimony Pentafluoride	1732	59
Antimony Potassium Tartate	1551	53
Antimony Powder	2871	53
Antimony Tribromide	1549	60
Antimony Tribromide Solution	1549	60
Antimony Trichloride	1733	60
Antimony Trichloride Solution	1733	60
Antimony Trifluoride	1549	60
Antimony Trifluoride Solution	1549	60
Argon, compressed	1006	12
Argon, refrigerated liquid (cryogenic liquid)	1951	21
Arsenic	1558	53
Arsenic, white, solid	1561	53
Arsenic Acid, liquid	1553	55
Arsenic Acid, solid	1554	53
Arsenic Bromide	1555	53
Arsenic Chloride	**1560**	**55**
Arsenic Compounds, liquid, n.o.s.	1556	55
Arsenic Compounds, solid, n.o.s.	1557	53
Arsenic Disulfide	1557	53
Arsenic Iodide, solid	1557	53
Arsenic Pentoxide	1559	53
Arsenic Sulfide	1557	53
Arsenic Trichloride	**1560**	**55**
Arsenic Trioxide	1561	53
Arsenic Trisulfide	1557	53
Arsenical Dust	1562	53
Arsenical Pesticides, liquid, flammable, toxic, n.o.s.	2760	28
Arsenical Pesticides, liquid, toxic, flammable, n.o.s	2993	28
Arsenical Pesticides, liquid, toxic, n.o.s	2994	55
Arsenical Pesticides, solid, toxic, n.o.s	2759	55
Arsine	**2188**	**18**
Articles, pressurized pneumatic or hydraulic (containing nonflammable gas)	3164	12
Arylsulfonic Acids, liquid with more than 5% free sulfuric acid	2584	60
Arylsulfonic Acids, liquid with not more than 5% free sulfuric acid	2586	60
Arylsulfonic Acids, solid, with ore than 5% free sulfuric acid	2583	60
Arylsulfonic Acids, solid with not more than 5% free sulfuric acid	2585	60
Asbestos	2212	31
Asbestos, blue or brown	2212	31
Asbestos, white	2590	31
Asphalt	1999	27
Asphalt, Cut Back	1999	27
Azinphos Methyl (Guthion)	2783	55

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
1-Aziridinyl Phosphine Oxide (This)	2501	55
Azodicarbonamide	3242	32
2,2-Azodi-(2,4-Dimethyl-4-Methoxyvaleronitrile)	2955	70
2,2-Azodi-(2,4-Dimethyl-Valeronitrile)	2953	70
1,1'-Azodi-(Hexahydrobenzonitrile)	2954	72
Azodiisobutyronitrile	2952	70
2,2'-Azodi-(2-methylbutyronitrile)	3030	70
Barium	1400	40
Barium Alloys, pyrophoric	1854	37
Barium Azide, wetted with not less than 50% water	1571	36
Barium Bromate	2719	42
Barium Chlorate	1445	42
Barium Compounds, n.o.s.	1564	55
Barium Cyanide	1565	53
Barium Hypochlorite	2741	45
Barium Nitrate	1446	42
Barium Oxide	1884	53
Barium Perchlorate	1447	42
Barium Permanganate	1448	42
Barium Peroxide	1449	42
Batteries, containing Sodium	3292	40
Batteries, dry, containing Potassium Hydroxide solid (electric storage)	2800	60
Batteries, electric storage, dry, containing Potassium Hydroxide	3028	60
Batteries, electric storage, wet, filled with acid	2794	60
Batteries, electric storage, wet, filled with alkali	2795	60
Batteries, electric storage, wet, non-spillable	2800	60
Batteries, wet, filled with acid (electric storage)	2794	60
Batteries, electric storage, wet, filled with acid wet, filled with alkali (electric storage)	2795	60
Batteries, wet, non-spillable (electric storage)	2800	60
Batteries, electric storage, dry, containing Potassium Hydroxide	1813	60
Battery Fluid, acid	2796	39
Battery Fluid, alkali	2797	60
Battery Fluid, alkali, with battery	2797	60
Battery Fluid, alkali, with electronic equipment or actuating device	2797	60
Battery-Powered Equipment (wet battery)	3171	60
Battery-Powered Vehicle (wet battery)	3171	60
Benzaldehyde	1989	26
Benzaldehyde	1990	26
Benzene	1114	27
Benzene-1,3-Disulfohydrazide	2971	72
Benzene Phosphorous Dichloride	2798	39

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Benzene Phosphorous Thiodichloride	2799	39
Benzene Sulfo-hydrazide	2970	72
Benzene Sulfonyl Chloride	2225	59
Benzidine	1885	53
Benzine	1115	26
Benzoic Derivative Pesticides, liquid, flammable toxic, n.o.s.	2770	28
Benzoic Derivative Pesticides, liquid, toxic, flammable, n.o.s	3003	28
Benzoic Derivative Pesticides, liquid, toxic, n.o.s	3004	55
Benzoic Derivative Pesticides, solid, toxic, n.o.s	2769	55
Benzonitrile	2224	55
Benzoquinone	2587	55
Benzotrichloride	2226	60
Benzotrifluoride	2338	28
Benzoyl Chloride	1736	39
Benzoyl Peroxide	2085	49
Benzoyl Peroxide	2087	49
Benzoyl Peroxide	2088	49
Benzoyl Peroxide	2089	49
Benzoyl Peroxide	2090	49
Benzyl Bromide	1737	59
Benzyl Chloride	1738	59
Benzyl Chloroformate	1739	39
Benzyldimethylamine	2619	68
4-(Benzyl(ethyl) amino)-3-ethoxy-benzene-diazonium zinc Chloride	3037	70
Benzylidene Chloride	1886	55
Benzyl Iodide	2653	53
4-(benzyl(methyl) amino)-3-Ethoxy-benzene-diazonium Zinc Chloride	3038	70
Beryllium, powder	1567	32
Beryllium Chloride	1566	53
Beryllium Compounds, n.o.s.	1566	53
Beryllium Fluoride	1566	53
Beryllium Nitrate	2464	42
Bifluorides, n.o.s.	1740	60
Biomedical Waste, n.o.s.	3291	24
Bipyridilium Pesticides, liquid, flammable, toxic, n.o.s.	2782	28
Bipyridilium Pesticides, liquid, toxic, flammable, n.o.s.	3015	28
Bipyridilium Pesticides, liquid, toxic, n.o.s.	3016	55
Bipyridilium Pesticides, solid, toxic, n.o.s.	2781	55
Bisulfates, aqueous solution	2837	60
Bisulfites, aqueous solution, n.o.s.	2693	60
Bisulfites, inorganic, aqueous solution, n.o.s.	2693	60
Blasting Agent, n.o.s.	--	46
Bleaching Powder	2208	35
Blue Asbestos	2212	31
Bombs, Smoke, Non-explosive, with corrosive liquid, without initiating device	2028	60
Borate and Chlorate Mixture	1458	35
Bordeaux Arsenite, liquid or solid	2759	55
Borneol	1312	32

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Boron Tribromide	**2692**	**59**
Boron Trichloride	**1741**	**15**
Boron Trifluoride	**1008**	**15**
Boron Trifluoride Acetic Acid Complex	1742	59
Boron Trifluoride Diethyl Etherate	2604	29
Boron Trifluoride Dihydrate	2851	59
Boron Trifluoride Dimethyl Etherate	2965	29
Boron Trifluoride Propionic Acid Complex	1743	59
Brake Fluid, hydraulic	1118	27
Bromates, inorganic, aqueous solution, n.o.s.	3213	35
Bromates, inorganic, n.o.s.	1450	42
Bromine	**1744**	**59**
Bromine Chloride	**2901**	**20**
Bromine Pentafluoride	**1745**	**44**
Bromine Solutions	**1744**	**59**
Bromine Trifluoride	**1746**	**44**
Bromoacetic Acid, solid	1938	60
Bromoacetic Acid, solution	1938	60
Bromoacetone	**1569**	**55**
Bromoacetyl Bromide	2513	60
Bromobenzene	2514	26
Bromobenzyl Cyanides	1694	58
1-Bromobutane	1226	29
2-Bromobutane	2339	27
Bromochloromethane	1887	58
2-Bromoethyl Ethyl Ether	2340	27
Bromoform	2515	58
1-Bromo-3-Methylbutane	2341	27
Bromomethylpropanes	2342	27
2-Bromo-2-Nitropropane-1,3-Diol	3241	53
2-Bromopentane	2343	27
2-Bromopropane	2344	29
3-Bromopropyne	2345	29
Bromotrifluoroethylene	2419	17
Bromotrifluoromethane	1009	12
Brown Asbestos	2212	31
Brucine	1570	53
Butadienes, inhibited	1010	17
Butane or Butane Mixtures	1011	22
Butanedione	2346	26
Butanols	1120	26
Butoxyl	2708	26
Butyl Acetates	1123	26
Butyl Acid Phosphate	1718	60
Butyl Acrylate	2348	26
Butyl Alcohol	1120	26
n-Butylamine	1125	68
N-Butylaniline	2738	55
Butyl Benzenes	2709	27
n-Butyl Bromide	1126	29
Butyl Chloride	1127	27
n-Butyl Chloroformate	**2743**	**57**
sec-Butyl Chloroformate	**2742**	**57**
tert-Butyl Cumene Peroxide	2091	48

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
tert-Butyl Cumyl Peroxide	2091	48
tert-Butylcyclohexyl Chloroformate	2747	55
n-Butyl-4,4 Di (tert-Butyl-Peroxy) Valerate	2140	48
n-Butyl-4,4 Di (tert-Butyl-Peroxy) Valerate	2141	48
Butylene	1012	22
1,2-Butylene Oxide, stabilized	3022	26
Butyl Ether	1149	26
n-Butyl Formate	1128	26
tert-Butyl Hydro-peroxide	2093	51
tert-Butyl Hydro-peroxide	2094	51
tert-Butyl Hydro-peroxide, not more than 80% in Di-tert Butyl Peroxide and/or solvent	2092	48
tert-Butyl Hypo-chlorite	3255	37
N-n Butyl Imidazole	2690	55
n-Butyl Isocyanate	**2485**	**57**
tert-Butyl Isocyanate	**2484**	**57**
tert-Butyl Isopropyl Benzene Hydro-peroxide	2091	48
Butyl Mercaptans	2347	27
n-Butyl Methacrylate	2227	26
Butyl Methyl Ether	2350	26
tert-Butyl Mono-peroxymaleate, technical pure	2099	49
Butyl Nitrites	2351	26
tert-Butyl Peroxy-acetate	2095	49
tert-Butyl Peroxya-cetate	2096	48
tert-Butyl Peroxy-benzoate	2097	48
tert-Butyl Peroxy-benzoate	2098	48
tert-Butyl Peroxy-benzoate	2890	48
tert-Butyl Peroxy-crotonate	2183	48
Butyl Peroxy-carbonate	2169	52
Butyl Peroxy-carbonate	2170	52
tert-Butyl Peroxy-diethylacetate	2144	52
tert-Butyl Peroxy-diethylacetate with tert-Butyl Peroxy-benzoate	2551	48
tert-Butyl Peroxy-2-Ethylhexanoate, not more than 50% with phlegmatizer	2888	52
tert-Butyl Peroxy-2-Ethylhexanoate, technical pure	2143	52
tert-Butyl Peroxy-2-Ethylhexanoate, with 2,2-Di(tert-Butyl-peroxy) Butane	2887	48
tert-Butyl Peroxy-2-Ethylhexanoate, with 2,2-Di(tert-Butyl-peroxy) Butane	2886	48
tert-Butyl Peroxyiso-butyrate	2562	52
tert-Butyl Peroxyiso-butyrate	2142	52
tert-Butyl Peroxyiso-nonanoate	2104	48
tert-Butyl Peroxyiso-propyl Carbonate, technical pure	2103	49
tert-Butyl Peroxy-maleate	2101	48

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
tert-Butyl Peroxy-maleate, solution or paste	2100	48
tert-Butyl Peroxy-maleate, technical pure	2099	49
tert-Butyl Peroxyneo-decanoate	2177	52
tert-Butyl Peroxyneo-decanoate	2594	52
tert-Butyl Peroxy-3-Phenylphthalide	2596	48
tert-Butyl Peroxy-phthalate	2105	48
tert-Butyl Peroxy-pivalate	2110	52
tert-Butyl Peroxy-3,5,5-Trimethyl-hexanoate	2104	48
Butyl Phenols, liquid	2228	55
Butyl Phenols, solid	2229	53
Butyl Phosphoric Acid	1718	60
Butyl Propionate	1914	27
Butyltoluenes	2667	27
Butyltrichlorosilane	1747	29
5-tert Butyl-2,4,6-Trinitro-m-Xylene	2956	32
Butyl Vinyl Ether, inhibited	2352	26
1,4-Butynediol	2716	55
Butyraldehyde	1129	26
Butyraldoxime	2840	26
Butyric Acid	2820	60
Butyric Anhydride	2739	6
Butyronitrile	2411	28
Butyril Chloride	2353	29
Cacodylic Acid	1572	53
Cadmium Compounds	2570	53
Caesium	1407	40
Caesium Hydroxide	2682	60
Caesium Hydroxide Solution	2681	60
Caesium Nitrate	1451	35
Calcium	1401	40
Calcium, metal and alloys, pyrophoric	1855	37
Calcium, Pyrophoric	1855	37
Calcium Alloy, Pyrophoric	1855	37
Calcium Arsenate	1573	53
Calcium Arsenate and Calcium Arsenite Mixtures, solid	1574	53
Calcium Arsenite	1574	53
Calcium Bisulfite Solution	2693	60
Calcium Carbide	1402	40
Calcium Chlorate	1452	35
Calcium Chlorate, aqueous solution	2429	35
Calcium Chlorite	1453	35
Calcium Cyanamide, with more than 0.1% calcium carbide	1403	40
Calcium Cyanide	1575	55
Calcium Dithionite	1923	37
Calcium Hydride	1404	40
Calcium Hydrogen Sulfite Solution	2693	60
Calcium Hydrosulfite	1923	37
Calcium Hypo-chlorite, dry, includ-ing mixtures, with more than 39% available chlorine (8.8% available oxygen)	1748	45

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Calcium Hypochlorite, hydrated, including mixtures with not less than 5.5% but not more than 10% water	2880	45
Calcium Hypochlorite Mixture, dry, with more than 10% but not more than 39% available chlorine	2208	35
Calcium Manganese Silicon	2844	40
Calcium Nitrate	1454	35
Calcium Oxide	1910	60
Calcium Perchlorate	1455	35
Calcium Permanganate	1456	35
Calcium Peroxide	1457	35
Calcium Phosphide	1360	41
Calcium Resinate	1313	32
Calcium Resinate, fused	1314	32
Calcium Silicide	1405	40
Calcium Silicon	1406	40
Camphene	9011	58
Camphor	2717	32
Camphor, synthetic	2717	32
Camphor Oil	1130	27
Caproic Acid	2829	60
Caproic Acid (Hexanoic Acid)	1760	60
Caprylyl Peroxide	2199	52
Carbamate Pesticides, liquid, flammable, toxic, n.o.s.	2758	28
Carbamate Pesticides, liquid, toxic, flammable, n.o.s.	2991	28
Carbamate Pesticides, liquid, toxic, n.o.s.	2992	55
Carbamate Pesticides, solid, toxic, n.o.s.	2757	55
Carbaryl	2757	55
Carbofuran	2757	55
Carbolic Acid	1671	55
Carbon, activated	1362	32
Carbon, animal or vegetable origin	1361	32
Carbon Bisulfide	1131	28
Carbon Dioxide	1013	21
Carbon Dioxide, refrigerated liquid (cryogenic liquid)	2187	21
Carbon Dioxide, solid	1845	21
Carbon Dioxide and Ethylene Oxide Mixture, with more than 6% ethylene oxide	1041	17
Carbon Dioxide and Ethylene Oxide Mixture, with not more than 6% ethylene oxide	1952	12
Carbon Dioxide and Ethylene Oxide Mixture, with not more than 9% ethylene oxide	1952	12
Carbon Dioxide and Nitrous Oxide Mixtures	1015	12
Carbon Dioxide and Oxygen Mixtures	1014	14
Carbon Disulfide	1131	28
Carbon Monoxide	**1016**	**18**
Carbon Monoxide, refrigerated liquid (cryogenic liquid)	**9202**	**67**
Carbon Monoxide and Hydrogen Mixture	**2600**	**18**

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Carbon Tetrabromide	2516	53
Carbon Tetrachloride	1846	55
Carbonyl Fluoride	**2417**	**15**
Carbonyl Sulfide	**2204**	**18**
Castor Beans, Meal, Pomace or Flake	2969	31
Caustic Alkali Liquids, n.o.s.	1719	60
Caustic Potash, dry, solid	1813	60
Caustic Potash, liquid or solution	1814	60
Caustic Soda, dry, solid	1823	60
Caustic Soda, solution	1824	60
Caustic Soda Solution	1824	60
Cells, containing Sodium	3292	40
Celluloid, in blocks, rods, rolls, sheets, tubes, etc, except celluloid scrap	2000	32
Celluloid scrap	2002	32
Cement, containing flammable liquid	1133	26
Cement, liquid, n.o.s.	1133	26
Cerium, slabs, ingots or rods	1333	32
Cerium, turnings or gritty powder	3078	40
Cesium	1407	40
Cesium Hydroxide	2682	60
Cesium Hydroxide Solution	2681	60
Cesium Nitrate	1451	35
Charcoal	1361	32
Chemical Ammunition, nonexplosive, with irritant	2017	58
Chemical Ammunition, nonexplosive, with poisonous material	2016	15
Chemical Kit	1760	60
Chloral, anhydrous, inhibited	2075	55
Chlorate and Borate Mixtures	1458	35
Chlorate and Magnesium Chloride Mixtures	1459	35
Chlorate of Potash	1485	35
Chlorate of Soda	1495	35
Chlorates, inorganic, aqueous solution, n.o.s.	3210	35
Chlorates, inorganic, n.o.s.	1461	35
Chlorates, flammable liquid	2762	28
Chloric Acid, aqueous solution	2626	35
Chloride of Phosphorus	**1809**	**39**
Chloride of Sulfur	**1828**	**39**
Chlorine	**1017**	**20**
Chlorine Dioxide Hydrate, frozen	9191	47
Chlorine Pentafluoride	**2548**	**44**
Chlorine Trifluoride	**1749**	**44**
Chlorite Solution with more than 5% available chlorine	1908	60
Chlorites, inorganic, n.o.s.	1462	43
Chloroacet-aldehyde	**2232**	**55**
Chloroacetic Acid, liquid	1750	59
Chloroacetic Acid, molten	3250	59
Chloroacetic Acid, solid	1751	60

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Chloroacetone, stabilized	**1695**	**59**
Chloroacetonitrile	**2668**	**57**
Chloroacetophenole	1697	55
Chloroacetyl Chloride	**1752**	**59**
Chloroanilines, liquid	2019	55
Chloroanilines, solid	2018	53
Chloroanisidines	2233	53
Chlorobenzene	1134	57
Chlorobenzotri-fluorides	2234	27
p-Chlorobenzol Peroxide	2113	48
p-Chlorobenzol Peroxide	2114	48
p-Chlorobenzol Peroxide	2115	48
Chlorobenzyl-chlorides	2235	55
1-Chloro-3-Bromo-propane	2688	58
Chlorobutanes	1127	27
3-Chloro-4-diethyl-aminobenzenediazoni um zinc chloride	3033	72
Chlorodifluoro-bromomethane	1974	12
1-Chloro-1,1-difluro-ethane	2517	22
Chlorodifluroethanes	2517	22
Chlorodifluro-methane	1018	12
Chlorodifluro-methane and Chloro-pentafluoroethane Mixture	1973	12
Chlorodifluro-methane and Chloro-pentafluoroethane Mixture	1078	12
Chlorodinitro-benzenes	1577	56
2-Chloroethanal	**2232**	**55**

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Chloroform	1888	55
Chloroformates, n.o.s.	2742	57
Chloroformates, toxic, corrosive, flammable, n.o.s.	2742	57
Chloroformates, toxic, corrosive, n.o.s.	3277	59
Chloromethyl Chloroformate	2745	55
Chloromethyl Ethyl Ether	2354	28
3-Chloro-4-methyl-phenylisocyanate	2236	55
Chloronitroanilines	2237	53
Chloronitrobenzenes	1578	55
Chloronitrotoluenes	2433	53
Chloropentafluoro-ethane	1020	12
3-Chloroperoxy-benzoic Acid	2755	49
Chlorophenates, liquid	2904	55
Chlorophenates, solid	2905	53
Chlorophenolates, liquid	2904	55
Chlorophenolates, solid	2905	43
Chlorophenols, liquid	2021	55
Chlorophenols, solid	2021	55
Chlorophenyl Trichlorosilane	1753	60
Chloropicrin	**1580**	**56**
Chloropicrin and Methyl Chloride Mixtures	**1581**	**55**
Chloropicrin and Methyl Chloride Mixtures	**1582**	**18**

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Chloropicrin and Non-Flammable Compressed Gas Mixtures	**1955**	**15**
Chloropicrin Mixture, Flammable	2929	57
Chloropicrin Mixtures, n.o.s.	**1583**	**56**
Chloropivaloyl Chloride	**9263**	**59**
Chloroplatinic Acid, solid	2507	60
Chloroprene, inhibited	1991	30
1-Chloropropane	1278	26
2-Chloropropane	2356	26
3-Chloropropanol-1	2849	53
2- Chloropropene	2456	27
alpha-Chloro-propionic Acid	2511	60
2-Chloropropionic Acid	2511	60
2-Chloropyridine	2822	54
Chlorosilanes, corrosive, flamm-able, n.o.s.	2986	29
Chlorosilanes, corrosive, n.o.s.	2987	60
Chlorosilanes, flammable, corrosive, n.o.s.	2985	29
Chlorosilanes, n.o.s. (corrosive)	2987	60
Chlorosilanes, n.o.s. (flammable, corrosive)	2985	29
Chlorosilanes, n.o.s. (flammable, corrosive)	2986	29
Chlorosilanes, n.o.s. (emits flammable gas when wet)	2988	40
Chlorosilanes, water-reactive, flammable, corrosive, n.o.s.	2988	40
Chlorosulfonic Acid	**1754**	**39**
Chlorosulfonic Acid and Sulfur Trioxide Mixture	**1754**	**39**
Chlorotetrafluoro-ethane	1021	12
Chlorotoluenes	2238	27
4-Chloro-o-Toludine Hydrochloride	1579	53
Chlorotrifluoroethane	1983	12
Chlorotrifluoro-methane	1022	12
Chlorotrifluoroethane and trifluoromethane Mixture	1078	12
Chlorpyrifos	2783	55
Chromic Acid, solid	1463	42
Chromic Acid Solution	1755	60
Chromic Anhydride	1463	42
Chromic Fluoride, solid	1756	60
Chromic Fluoride Solution	1757	60
Chromium Nitrate	2720	35
Chromium Oxychloride	1758	39
Chromium Trioxide, anhydrous	1463	42
Chromosulfuric Acid	2240	39
Cigarette, self-lighting	1867	32
Cigarette Lighter, with flammable gas	1057	17
Cigarette Lighter, with flammable liquid	1226	26
Cleaning Compound	1142	26
Cleaning Compound, liquid, corrosive	1760	60

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Clinical Waste, unspecified, n.o.s.	3291	24
Coal, ground bituminous, sea coal, etc	1361	32
Coal Facings	1361	32
Coal Gas	**1023**	**18**
Coal Tar Distillate	1137	27
Coal Tar Distillates, flammable	1136	27
Coal Tar Naphtha	2553	27
Coal Tar Oil	1136	27
Coal Tar Oil	1137	27
Coating Solution	1139	26
Cobalt Naphthenates, powder	2001	32
Cobalt Resinate, precipitated	1318	32
Coculus	1584	53
Collodion	2059	26
Combustible Liquid, n.o.s.	1993	27
Compounds, cleaning liquid (corrosive)	1760	60
Compounds, cleaning liquid (flammable)	1993	27
Compounds, Polishing, liquid, etc. (flammable)	1142	26
Compounds, Tree or Weed Killing, liquid (corrosive)	1760	60
Compounds, Tree or Weed Killing, liquid (flammable)	1993	27
Compounds, Tree or Weed Killing, liquid (poisonous)	2810	55
Compressed Gas, oxidizing, n.o.s.	3156	14
Compressed Gas, toxic, flammable, n.o.s. (Inhalation Hazard Zone A)	**1953**	**18**
Compressed Gas, toxic, flammable, n.o.s. (Inhalation Hazard Zone B)	**1953**	**18**
Compressed Gas, toxic, flammable, n.o.s. (Inhalation Hazard Zone C)	**1953**	**18**
Compressed Gas, toxic, flammable, n.o.s. (Inhalation Hazard Zone D)	**1953**	**18**
Compressed Gases, flammable, n.o.s.	**1954**	**22**
Compressed Gases, flammable, poisonous, n.o.s.	**1953**	**18**
Compressed Gases, flammable, toxic, n.o.s. (Inhalation Hazard Zone A)	**1953**	**18**
Compressed Gases, flammable, toxic, n.o.s. (Inhalation Hazard Zone B)	**1953**	**18**
Compressed Gases, flammable, toxic, n.o.s. (Inhalation Hazard Zone C)	**1953**	**18**
Compressed Gases, flammable, toxic, n.o.s. (Inhalation Hazard Zone D)	**1953**	**18**
Compressed Gases, n.o.s.	**1956**	**12**
Compressed Gases, poisonous, n.o.s.	**1955**	**15**
Compressed Gases, toxic, n.o.s. (Inhalation Hazard Zone A)	**1955**	**15**
Compressed Gases, toxic, n.o.s. (Inhalation Hazard Zone B)	**1955**	**15**

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Compressed Gases, toxic, n.o.s. (Inhalation Hazard Zone C)	**1955**	**15**
Compressed Gases, toxic, n.o.s. (Inhalation Hazard Zone D)	**1955**	**15**
Copper Acetoarsenite	1585	53
Copper Arsenite	1586	53
Copper-Based Pesticides, solid, toxic, n.o.s.	2775	53
Copper-Based Pesticides, liquid, flammable, toxic, n.o.s.	2776	28
Copper-Based Pesticides, liquid, toxic, flammable, n.o.s.	3009	28
Copper-Based Pesticides, liquid, toxic, n.o.s.	3010	55
Copper Chlorate	2721	35
Copper Chloride	2802	60
Copper Cyanide	1587	53
Copra	1363	37
Corrosive Liquid, acidic, inorganic, n.o.s.	3264	60
Corrosive Liquid, acidic, organic, n.o.s.	3265	60
Corrosive Liquid, basic, inorganic, n.o.s.	3266	60
Corrosive Liquid, self-heating, n.o.s.	3301	37
Corrosive Liquid, toxic, n.o.s.	2922	59
Corrosive Liquids, flammable, n.o.s.	2920	29
Corrosive Liquids, n.o.s.	1760	60
Corrosive Liquids, oxidizing, n.o.s.	3093	45
Corrosive Liquids, poisonous, n.o.s.	2922	59
Corrosive Liquids, water-reactive, n.o.s.	3094	39
Corrosive Liquids, which in contact with water emit Flammable Gases, n.o.s.	3094	39
Corrosive Solid, acidic, inorganic, n.o.s.	3260	60
Corrosive Solid, acidic, organic, n.o.s.	3261	60
Corrosive Solid, basic, inorganic, n.o.s.	3262	60
Corrosive Solid, basic, organic, n.o.s.	3263	60
Corrosive Solid, toxic, n.o.s.	2923	59
Corrosive Solids, flammable, n.o.s.	2921	34
Corrosive Solids, n.o.s.	1759	60
Corrosive Solids, oxidizing, n.o.s.	3084	35
Corrosive Solids, poisonous, n.o.s.	2923	59
Corrosive Solids, self-heating, n.o.s.	3095	37
Corrosive Solids, water-reactive, n.o.s.	3096	40
Corrosive Solids, which in contact with water emit Flammable Gases, n.o.s.	3096	40
Cosmetics, corrosive liquid, n.o.s.	1760	60
Cosmetics, corrosive solid, n.o.s.	1759	60
Cosmetics, flammable liquid, n.o.s.	1993	27

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Cosmetics, flammable solid, n.o.s.	1325	32
Cosmetics, oxidizer, n.o.s.	1479	35
Cotton, wet	1365	32
Cotton Waste, oily	1364	32
Coumaphos	2783	55
Coumarin Derivative Pesticides, liquid, flammable, n.o.s.	3024	28
Coumarin Derivative Pesticides, liquid, toxic, flammable, n.o.s.	3025	28
Coumarin Derivative Pesticides, liquid, toxic, n.o.s.	3026	55
Coumarin Derivative Pesticides, solid, toxic, n.o.s.	3027	55
Creosote, coal tar	1993	27
Creosote Salts	1334	32
Cresol (o-, m-, and p-)	2076	55
Creosols	2076	55
Cresylic Acid	2022	55
Crotonaldehyde, inhibited	**1143**	**28**
Crotonaldehyde, stabilized	**1143**	**28**
Crotonic Acid	2823	60
Crotonylene	1144	27
Cumene	1918	28
Cumene Hydroperoxide, technical pure	2126	51
Cupric Nitrate	1479	35
Cupriethylenediamine Solution	1761	59
Cyanide or Cyanide Mixture, dry	1588	55
Cyanide Solution, n.o.s.	1935	55
Cyanide Solutions	1935	55
Cyanides, inorganic, n.o.s.	1588	55
Cyanides, inorganic, solid, n.o.s.	1588	55
Cyanogen	**1026**	**18**
Cyanogen, liquefied	**1026**	**18**
Cyanogen Bromide	1889	55
Cyanogen Chloride, inhibited	**1589**	**55**
Cyanogen Gas	**1026**	**18**
Cyanuric Chloride	2670	60
Cyclobutane	2601	22
Cyclobutylchloroformate	2744	57
1,5,9-Cyclododecatriene	2518	59
Cycloheptane	2241	27
Cycloheptatriene	2603	28
Cycloheptene	2242	27
Cyclohexane	1145	26
Cyclohexanone	1915	26
Cyclohexanone Peroxide, not more than 72% in solution	2896	51
Cyclohexanone Peroxide, not more than 90% with not less than 10% water	2119	51
Cyclohexene	2256	29
Cyclohexenyltrichlorosilane	1762	29
Cyclohexyl Acetate	2243	27
Cyclohexylamine	2357	68
Cyclohexyl Isocyanate	**2488**	**57**
Cyclohexyl Mercaptan	3054	28
Cyclohexyltrichlorosilane	1763	60

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Cyclooctadiene Phosphines	2940	37
Cyclooctadienes	2520	27
Cyclooctatetraene	2358	27
Cyclopentane	1146	27
Cyclopentanol	2244	26
Cyclopentanone	2245	26
Cyclopentene	2246	27
Cyclopropane	1027	22
Cyclopropane, liquefied	1027	22
Cymenes	2046	27
2,4-D	2765	55
DDT	2761	55
Decarbonate	1868	34
Decahydro-naphthalene	1147	27
n-Decane	2247	27
Decanoyl peroxide, technical pure	2120	52
Denatured Alcohol	1987	26
Denatured Alcohol (toxic)	1986	28
Deuterium	1957	22
Devices, small, Hydrocarbon Gas powered, with release device	3150	22
Diacetone Alcohol	1148	26
Diacetone Alcohol Peroxide	2163	52
Diacetyl	2346	26
Diallylamine	2359	29
Diallyl Ether	2360	28
4,4-Diaminodiphenyl Methane	2651	53
Di-N-Amylamine	2841	68
Diazinon	2783	55
2-Diazo-1-Naphthol-4-Sulfochloride	3042	71
2-Diazo-1-Naphthol-5-Sulfochloride	3043	71
Dibenzyldichloro-silane	2434	60
Dibenzyl Peroxydicarbonate	2149	52
Diborane	**1911**	**18**
Diborane Mixtures	1911	18
Dibromobenzene	2711	26
1,2- Dibromobutan-3-One	2648	55
Dibromochloro-propanes	2872	58
Dibromidofluoro-methane	1941	58
1,2-Dibromoethane	**1605**	**55**
Dibromomethane	2664	74
Di-n-Butylamine	2248	68
Dibutylaminoethanol	2873	55
Di(4-tert-Butylcyclo-hexyl)Peroxydi-carbonate	2154	52
Di(4-tert-Butylcyclo-hexyl) Peroxy-dicarbonate	2894	52
Dibutyl Ethers	1149	26
Di-tert-Butyl Peroxide, technical pure	2102	48
2,2-Di(tert-Butyl-peroxy)Butane	2111	48
1,1-Di(tert-Butyl-peroxy)Cyclohexane	2179	49
1,1-Di(tert-Butyl-peroxy)Cyclohexane	2180	49
1,2-Di(tert-Butyl-peroxy)Cyclohexane	2181	48
1,1-Di(tert-Butyl-peroxy)Cyclohexane	2885	48
1,1-Di(tert-Butyl-peroxy)Cyclohexane	2897	48
Di-sec-Butyl-Peroxy-Dicarbonate	2150	52

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Di-sec-Butyl-Peroxy-Dicarbonate	2151	52
Di-(2-tert-Butyl-peroxyisopropyl) Benzene	2112	48
1,4 Di-(2-tert-Butyl-peroxyisopropyl) Benzene and 1,3-Di(2-tert-Butyl-peroxyisopropyl) Benzene	2112	48
Di-tert-Butylperoxy-phthalate	2106	48
Di-tert-Butylperoxy-phthalate	2107	48
Di-tert-Butylperoxy-phthalate	2108	48
2,2-Di(tert-Butyl-peroxy) Propane	2883	48
2,2-Di(tert-Butyl-peroxy) Propane	2884	48
1,1-Di(tert-Butyl-peroxy)-3,3,5-Tri-methylcyclohexane	2145	48
1,1-Di(tert-Butyl-peroxy)-3,3,5-Tri-methylcyclohexane	2146	48
1,1-Di(tert-Butyl-peroxy)-3,3,5-Tri-methylcyclohexane	2147	48
Dicetyl Peroxy-dicarbonate, not more than 42%	2895	42
Dicetyl Peroxy-dicarbonate, technical pure	2164	52
Dichloroacetic Acid	1764	60
1,3-Dichloroacetone	2649	55
Dichloroacetyl Chloride	1765	60
Dichloroanilines, solid or liquid	1590	55
0-Dichlorobenzene	1591	58
p-Dichlorobenzene	1592	58
2,4-Dichlorbenzoyl Peroxide	2137	48
2,4-Dichlorbenzoyl Peroxide	2138	48
2,4-Dichlorbenzoyl Peroxide	2139	48
Dichlorobutene	2920	29
Dichlorobutene	2924	29
2,2'-Dichlordiethyl Ether	1916	55
Dichlorodifluoro-ethylene	9018	74
Dichlorodifluoro-methane	1028	12
Dichlorodifluoro-methane and Dichlorotetrafluoro-ethane Mixture	1078	12
Dichlorodifluoro-methane and Difluoroethane Azeotropic Mixture	2602	12
Dichlorodifluoro-methane and Dichlorodifluoro-ethane Mixture	1078	12
Dichlorodifluoro-methane and Ethylene Oxide Mixture with not more than 12% Ethylene Oxide	3070	12
Dichlorodifluoro-methane and Tri-chlorofluoromethane Mixture	1078	12
Dichlorofluoro-methane,Trichloro-fluoromethane and Chlorodifluoro-methane Mixture	1078	12
Dichlorodifluoro-methane and Tri-chlorotrifluoroethane Mixture	1078	12

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Dichlorodifluoro-methane and Chloro-difluoromethane Mixture	1078	12
Dichlorodimethyl Ether, symmetrical	2249	55
Dichlorodiphenyl-trichloroethane, DDT	2761	55
1,1-Dichloroethane	2362	27
Dichloroethylene	1150	29
1,2-Dichloroethylene	1150	29
Dichloroethyl Ether	1916	55
1,1-Dichloro-1-Fluoroethane	9274	74
Dichlorofluoro-methane	1029	12
Dichloroisocyanuric Acid, and its salts, dry	2465	45
Dichloroisopropyl Ether	2490	59
Dichloromethane	1593	74
Dichloromonofluoro-methane	1029	12
1,1-Dichloro-1-Nitro-Ethane	2650	57
Dichloropentanes	1152	27
2,4-Dichlorphenoxy-acetic Acid	2765	55
Dichlorophenyliso-cyanates	2250	53
Dichlorophenyl-trichlorosilane	1766	60
Dichloropropanes	1279	27
1,3-Dichloro-propanol-2	2750	55
Dichloropropene	2047	29
Dichloropropene and Propylene Dichloride Mixture	2047	29
Dichloropropenes	2047	29
Dichloropropionic Acid	1760	60
2,2-Dichloro-propionic Acid	1760	60
Dichlorosilane	**2189**	**19**
Dichlorotetrafluoro-ethane	1958	12
Dichloro-S-Triazine-trione and its salts dry	2465	45
3,5-Dichloro-2,4,6-trifluoropyridine	**9264**	**55**
Dichlorvos	2783	55
Dicumyl Peroxide	2121	48
Dicycloheptadiene	2251	26
Dicyclohexylamine	2565	60
Dicyclohexyl-ammonium Nitrite	2687	53
Dicyclohexyl Peroxydicarbonate	2152	52
Dicyclohexyl Peroxydicarbonate	2153	52
Dicyclopentadiene	2048	26
2,2-Di(4,4-Di-tert-Butylperoxycyclo-hexyl) Propane	2168	48
Didymium Nitrate	1465	35
Dieldrin	2761	55
Diesel Fuel	1202	27
Diesel Fuel	1993	27
Diethoxyethane	1153	26
Diethoxymethane	2373	26
2,5-Diethoxy-4-Morpholinobenzene-diazonium Zinc Chloride	3036	72
Diethoxypropene	2374	26
Diethylamine	1154	68
Diethylaminoethanol	2686	29
Diethylaminopropyl-amine	2684	29
N,N-Diethyl Aniline	2432	57
Diethylbenzene	2049	29
Diethyl Carbonate	2366	26

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Diethyl Cellosolve	1153	26
Diethyldichlorosilane	1767	29
Diethylenetriamine	2079	29
Diethyl Ether	1155	26
N,N-Diethylethylene-diamine	2685	29
Di-(2-Ethylhexyl) Peroxydicarbonate	2122	52
Di-(2-Ethylhexyl)-Peroxydicarbonate	2123	52
Di-(2-Ethylhexyl) Phosphoric Acid	1902	60
Diethyl Ketone	1156	26
Diethyl Peroxy-dicarbonate	2175	52
Diethyl Sulfate	1594	55
Diethyl Sulfide	2375	28
Diethylthio-phosphoryl Chloride	2751	59
Diethylzinc	1366	40
1,1-Difluoroethane	1030	22
Difluorochloro-ethanes	2517	22
Difluoroethane	1030	22
Difluoroethylene	1959	22
1,1-Difluoroethylene	1959	22
Difluoromethane	3252	22
Difluorophosphoric Acid, anhydrous	1768	59
2,2-Dihydroperoxy-propane	2178	49
2,3-Dihydropyran	2376	26
Di(1-Hydroxycyclo-hexyl) Peroxide	2148	48
Diisobutylamine	2361	68
Diisobutylene, Isomeric Compounds	2050	26
Diisobutyl Ketone	1157	26
Diisobutyryl Peroxide	2182	52
DiisooctylAcid Phosphate	1902	60
Diisopropylamine	1158	68
Diisopropylbenzene Hydroperoxide	2171	48
Diisopropyl Ether	1159	26
Diisotridecylperoxy-dicarbonate	2889	52
Diketene	**2521**	**57**
1,1-Dimethoxyethane	2377	27
1,2-Dimethoxyethane	2252	27
Dimethylamine, anhydrous	1032	19
Dimethylamine Solution	1160	26
2-Dimethylamino-acetonitrile	2378	28
4-Dimethylamino-6-(2-Di-Methylamino-ethoxy)Toluene-2-Diazonium Zinc Chloride	3039	70
1,2-Di-(Dimethyl-amino)Ethane	2372	26
Dimethylamino-ethanol	2051	29
2-Dimethylamino-ethanol	2051	29
Dimethylaminoethyl Methacryalate	2522	55
N,N-Dimethylaniline	2253	57
Di(2-Methylbenzoyl) Peroxide	2593	52
2,3-Dimethylbutane	2457	27
1,3-Dimethylbutyl-amine	2379	68
Dimethylcarbamoyl Chloride	2262	60
Dimethyl Carbonate	1161	26
Dimethyl Chlorothio-phosphate	2267	59

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Dimethylcyclo-hexanes	2263	27
Dimethylcyclohexyl-amine	2264	60
2,5-Dimethyl-2,5-Di-(Benzoylperoxy) Hexane	2173	49
2,5-Dimethyl-2,5-Di-(Benzoylperoxy) Hexane, technical pure	2172	49
2,5-Dimethyl-2,5-Di(tert-Butylperoxy) Hexane	2156	48
2,5-Dimethyl-2,5-Di(tert-Butylperoxy) Hexane, technical pure	2155	48
2,5-Dimethyl-2,5-Di(tert-Butylperoxy) Hexyne-3, technical pure	2158	49
2,5-Dimethyl-2,5-Di(tert-Butylperoxy) Hexyne-3, with not more than 52% in inert solid	2159	48
Dimethyldichloro-silane	1162	29
Dimethyldiethoxy-silane	2380	26
2,5-Dimethyl-2,5-Di(2-Ethyl-hexanoyl-peroxy) Hexane, technical pure	2157	52
2,5-Dimethyl-2,5-Dihydroperoxy hexane	2174	49
Dimethyldioxanes	2707	27
Dimethyl Disulfide	2381	27
Dimethylethanol-amine	2051	29
Dimethyl Ether	1033	22
N,N-Dimethyl-formamide	2265	26
Dimethylhydrazine, symmetrical	**2382**	**57**
Dimethylhydrazine, unsymmetrical	**1163**	**57**
Dimethyl Phosphorochloridothioate	2267	59
2,2-Dimethylpropane	2044	22
Dimethyl-N-Propyl-amine	2266	29
Dimethyl Sulfate	1595	57
Dimethyl Sulfide	1164	27
Dimethyl Thiophosphoryl Chloride	2267	59
Dimethylzinc	1370	40
Dimyristyl Peroxy Dicarbonate	2595	52
Dimyristyl Peroxy Dicarbonate, not more than 42%, in water	2892	52
Dinitroanilines	1596	56
Dinitrobenzene Solution	1597	56
Dinitrobenzenes	1597	56
Dinitrochlorobenzene	1577	56
Dinitro-o-Cresol	1598	53
Dinitrocyclohexyl Phenol	9026	53
Dinitrogen Tetroxide, liquefied	**1067**	**20**
Dinitrophenol, wetted with not less than 15% water	1320	36
Dinitrophenol Solutions	1599	57
Dinitrophenolate, wetted with not less than 15% water	1321	36
Dinitroresorcinol, wetted with not less than 15% water	1322	36

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
N,N'-Dinitroso-N,N'-Dimethyl Terephthalamide	2973	71
N,N'-Dinitrosopenta-methylene Tetramine	2972	71
Dinitrotoluenes	2038	56
Dinitrotoluenes, molten	1600	56
Dioxane	1165	26
Dioxolane	1166	26
Dipentene	2052	27
Diphenylamine Chloroarsine	1698	55
Diphenylchloro-arsine, solid or liquid	1699	55
Diphenyldichloro-silane	1769	29
Diphenylmethane-4,4'-Diisocyanate (MDI)	2489	54
Diphenylmethyl Bromide	1770	60
Diphenyloxide-4,4'-Disulfohydrazide	2951	72
Dipicryl Sulfide, wetted with not less than 10% water	2852	33
Dipropylamine	2383	68
4-Dipropylamino-benzenediazonium Zinc Chloride	3034	72
Dipropyl Ether	2384	26
Dipropyl Ketone	2710	26
Di-n-Propyl Peroxy-dicarbonate, tech-nical pure	2176	52
Disinfectant, liquid, corrosive, n.o.s.	1903	60
Disinfectant, solid, toxic, n.o.s.	1601	55
Disinfectants, liquid, n.o.s., poisonous	3142	55
Disinfectants, liquid, toxic, n.o.s.	3142	55
Disinfectants, solid, n.o.s., poisonous	1601	55
Disinfectants, cor-rosive, liquid, n.o.s.	1903	60
Disodium Trioxo-silicate, pentahydrate	3253	60
Dispersant Gas, flammable, n.o.s.	1954	22
Dispersant Gas, n.o.s.	1078	12
Distearyl Peroxy-dicarbonate	2592	48
Disulfoton	2783	55
Dithiocarbamate Pesticides, liquid, flammable, toxic, n.o.s.	2772	28
Dithiocarbamate Pesticides, liquid, toxic, flammable, n.o.s.	3005	28
Dithiocarbamate Pesticides, liquid, toxic, n.o.s.	3006	55
Dithiocarbamate Pesticides, solid, toxic, n.o.s.	2771	55
Di(3,5,5-Trimethyl-1,2-Dioxolanyl-3) Peroxide	2597	52
Divinyl Ether, inhibited	1167	30
Dodecylbenzene-sulfonic Acid	2584	60
Drier, paint or var-nish, liquid, n.o.s.	1168	26
Dry Ice	1845	21
Dye, liquid, corrosive, n.o.s.	2801	60
Dye, liquid, n.o.s. (corrosive)	2801	60

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Dye, liquid, toxic, n.o.s.	1602	55
Dye, solid, corrosive, n.o.s.	3147	60
Dye, solid, n.o.s. or Dye Intermediate, solid, n.o.s., corrosive	3147	60
Dye, solid, n.o.s. or Dye Intermediate, solid, n.o.s., poisonous	3143	55
Dye, solid, toxic, n.o.s.	3143	55
Dye Intermediate, liquid, corrosive, n.o.s.	2801	60
Dye Intermediate, liquid n.o.s. (corrosive)	2801	60
Dye Intermediate, liquid, toxic, n.o.s.	1602	55
Dye Intermediate, solid, corrosive, n.o.s.	3147	60
Dye Intermediate, solid, toxic, n.o.s.	3143	55
Dye Intermediate, liquid, n.o.s. (poisonous)	1602	55
Dye Intermediate, liquid n.o.s. (poisonous)	1602	55
Electrolyte, Battery Fluid, acid	2796	39
Elevated Temperature Liquid, flammable, n.o.s., with flash point above 60.5°C, at or above its flash point	3256	27
Elevated Temperature Liquid, n.o.s., at or above 100°C and below its flash point	3257	27
Elevated Temperature Material, liquid n.o.s. (at or above 100°C (212°F) and below its flash point)	9259	27
Elevated Temperature Solid, n.o.s., at or above 240°C	3258	31
Enamel	1263	26
Endosulfan	2761	55
Endrin Mixture, dry or liquid	2761	55
Engine Starting Fluid	1960	22
Engines, internal combustion, including when fitted in machinery or vehicles	3166	27
Environmentally Hazardous Substance, liquid, n.o.s.	3082	31
Environmentally Hazardous Substance, solid, n.o.s.	3077	31
Epibromohydrin	2558	57
Epichlorohydrin	2023	30
1,2-Epoxy-3-Ethoxy-propane	2752	26
Esters, n.o.s.	3272	26
Etching Acid, liquid, n.o.s.	1790	59
Ethane, compressed	1035	22
Ethane, refrigerated liquid (cryogenic liquid)	1961	22
Ethane-Propane Mixture, refrigerated liquid (cryogenic liquid)	1961	22
Ethanol, and solutions	1170	26
Ethanolamine, and solutions	2491	60
Ether	1155	26
Ethers, n.o.s.	3271	26

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Ethion	2783	55
Ethoxyethanol	1171	26
Ethoxyethyl Acetate	1172	26
Ethyl Acetate	1173	26
Ethyl Acetylene, inhibited	2452	17
Ethyl Acrylate, inhibited	1917	26
Ethyl Alcohol, and solutions	1170	26
Ethylamine	1036	68
Ethylamine, aqueous solution with not less than 50% but not more than 70% ethylamine	2270	29
Ethyl Amyl Ketone	2271	26
2-Ethylaniline	2273	55
N-Ethylaniline	2272	55
Ethylbenzene	1175	26
N-Ethyl-N-Benzyl-aniline	2274	53
N-EthylBenzyl-toludines	2753	53
Ethyl Borate	1176	26
Ethyl Bromide	1891	58
Ethyl Bromoacetate	1603	55
2-Ethylbutanol	2275	26
2-Ethylbutyl Acetate	1177	26
Ethyl Butyl Ether	1179	26
2-Ethylbutyraldehyde	1178	26
Ethyl Butyrate	1180	26
Ethyl Chloride	1037	27
Ethyl Chloroacetate	1181	55
Ethyl Chloro-formate	**1182**	**28**
Ethyl-2-Chloro-propionate	2935	29
Ethyl Chlorothio-formate	**2826**	**59**
Ethyl Crotonate	1862	26
Ethyl Cyanoacetate	2666	55
Ethyl-3,3-Di(tert-Butylperoxy) Butyrate	2184	49
Ethyl-3,3-Di(tert-Butylperoxy) Butyrate	2598	48
Ethyl-3,3-Di(tert-Butylperoxy) Butyrate, not more than 77%	2185	48
Ethyldichloroarsine	**1892**	**55**
Ethyldichlorosilane	1183	29
Ethylene, compressed	1962	22
Ethylene, refrigerated liquid (cryogenic liquid)	1038	22
Ethylene, Acetylene and Propylene Mixture, refrigerated liquid (cryogenic liquid), containing at least 71.5% Ethylene with not more than 22.5% Acetylene and not more than 6% Propylene	3138	17
Ethylene Chlorohydrin	**1135**	**55**
Ethylene Dibromide	**1605**	**55**
Ethylene Dichloride	1184	26
Ethylene Glycol Diethyl Ether	1153	26
Ethylene Glycol Monobutyl Ether	2369	26
Ethylene Glycol Monoethyl Ether	1171	26
Ethylene Glycol Monomethyl Ether	1188	26
Ethylene Glycol Monoethyl Ether Acetate	1172	26
Ethylene Glycol Monomethyl Ether Acetate	1189	26

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Ethylene Oxide	**1040**	**69**
Ethylene Oxide and Carbon Dioxide Mixture, with more than 6% ethylene oxide	1041	17
Ethylene Oxide and Carbon Dioxide Mixture, with more than 9% but not more than 87% ethylene oxide	1041	17
Ethylene Oxide and Carbon Dioxide Mixture, with more than 87% ethylene oxide	**3300**	**18**
Ethylene Oxide and Carbon Dioxide Mixture, with not more than 6% ethylene oxide	1952	12
Ethylene Oxide and Carbon Dioxide Mixture, with not more than 9% ethylene oxide	1952	12
Ethylene Oxide and Chlorotetrafluoro-ethane Mixtures, with not more than 8.8% ethylene oxide	3297	12
Ethylene Oxide and Dichlorodifluoro-methane Mixture, with not more than 12% ethylene oxide	3070	12
Ethylene Oxide and Dichlorodifluoro-methane Mixture, with not more than 12.5% ethylene oxide	3070	12
Ethylene Oxide and Pentafluoroethane Mixtures, with not more than 7.9% ethylene oxide	3298	12
Ethylene Oxide and Propylene Oxide Mixtures	2983	26
Ethylene Oxide and Tetrafluoroethane Mixtures, with not more than 5.6% ethylene oxide	3299	12
Ethylene Oxide with nitrogen	**1040**	**69**
Ethylenediamine	1604	29
Ethyleneimine, inhibited	**1185**	**30**
Ethyl Ether	1155	26
Ethyl Fluid	1649	56
Ethyl Fluoride	2453	12
Ethyl Formate	1190	26
Ethylhexaldehydes	1191	26
2-Ethyl Hexylamine	2276	29
2-Ethylhexyl Chloroformate	2748	55
Ethyl Isobutyrate	2385	26
Ethyl Isocyanate	**2481**	**28**
Ethyl Lactate	1192	26
Ethyl Mercaptan	2363	27
Ethyl Methacrylate	2277	26
Ethyl Methyl Ether	1039	26
Ethyl Methyl Ketone	1193	26
Ethyl Methyl Ketone Peroxide	2550	51
Ethyl Nitrate	1993	27
Ethyl Nitrite, and solutions	1194	30
Ethyl Orthoformate	2524	26
Ethyl Oxalate	2525	54
Ethyl Phenyl Dichlorosilane	2435	39
Ethyl Phosphono-thioic Dichloride, anhydrous	1760	60
Ethyl Phosphono-thioic Dichloride, anhydrous	**2927**	**59**

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Ethyl Phosphonous Dichloride, anhydrous	**2845**	**40**
Ethyl Phosphoro-dichloridate	1760	60
Ethyl Phosphoro-dichloridate	**2927**	**59**
Ethyl Piperidine	2386	68
1-Ethylpiperidine	2386	68
Ethyl Propionate	1195	26
Ethyl Propyl Ether	2615	26
Ethyl Silicate	1292	29
Ethyl Sulfate	1594	55
Ethylsulfuric Acid	2571	60
N-Ethyltoludines	2754	55
Ethyltrichlorosilane	1196	29
Etiologic Agent, n.o.s.	2814	24
Explosive A	--	46
Explosive B	--	46
Explosive C	--	50
Explosives, division 1.1, 1.2, 1.3, 1.5 or 1.6	--	46
Explosives, division 1.4	--	50
Extracts, aromatic, liquid	1169	26
Extracts, flavouring, liquid	1197	26
Fabric, animal or vegetable or synthetic, with oil, n.o.s.	1373	32
Fabrics, impregnated with weakly nitrated nitrocellulose, n.o.s.	1353	32
Ferric Arsenate	1606	53
Ferric Arsenite	1607	53
Ferric Chloride, anhydrous	1773	60
Ferric Chloride Solution	2582	60
Ferric Nitrate	1466	35
Ferrocerium	1323	32
Ferrosilicon	1408	41
Ferrous Arsenate	1608	53
Ferrous Chloride, solid	1759	60
Ferrous Chloride Solution	1760	60
Ferrous Metal, borings, cuttings, shavings, or turnings	2793	32
Fertilizer Ammoniating Solution, with more than 35% free ammonia	1043	16
Fiber, animal or vegetable, burnt, wet or damp, n.o.s.	1372	32
Fiber, animal or vegetable or synthetic, with oil, n.o.s.	1373	32
Fibers, impregnated with weakly nitrated nitrocellulose, n.o.s.	1353	32
Film, Motion Picture, nitro-cellulose base	1324	32
Film, Nitrocellulose Base	1324	32
Fire Extinguisher Charges, corrosive liquid	1774	60
Fire Extinguishers, with compressed or liquefied gas	1044	12
Fire Lighters, solid with flammable liquid	2623	32
Fish Meal or Scrap, unstabilized	1374	32
Fish Meal or Scrap, stabilized	2216	31
Flammable Gas in Lighter for cigars, cigarettes, etc.	1057	17

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Flammable Gas, n.o.s.	1954	22
Flammable Liquid, toxic, corrosive, n.o.s.	3286	28
Flammable Liquid, toxic, n.o.s.	1992	28
Flammable Liquid Preparations, n.o.s.	1142	26
Flammable Liquids, corrosive, n.o.s.	2924	29
Flammable Liquids, elevated temperature material, n.o.s.	9276	27
Flammable Liquids, n.o.s.	1993	27
Flammable Liquids, poisonous, n.o.s.	1992	28
Flammable Solid, corrosive, inorganic, n.o.s.	3180	34
Flammable Solid, corrosive, n.o.s.	2925	34
Flammable Solid, corrosive, organic, n.o.s.	2925	34
Flammable Solid, inorganic, corrosive, n.o.s.	3180	34
Flammable Solid, inorganic, n.o.s.	3178	32
Flammable Solid, inorganic, poisonous, n.o.s.	3179	34
Flammable Solid, n.o.s.	1325	32
Flammable Solid, organic, molten, n.o.s.	3176	32
Flammable Solid, oxidizing, n.o.s.	3097	32
Flammable Solid, poisonous, n.o.s.	2926	34
Flammable Solid, toxic, inoprganic, n.o.s.	3179	34
Flammable Solid, toxic, organic, n.o.s.	2926	34
Flue Dust, poisonous	2811	53
Fluoboric Acid	1775	60
Fluoric Acid	1790	59
Fluorine, compressed	**1045**	**20**
Fluorine, refrigerated liquid (cryogenic liquid)	**9192**	**25**
Fluoroacetic Acid	2642	59
Fluoroanilines	2941	55
Fluorobenzene	2387	27
Fluoroboric Acid	1775	60
Flurophosphoric Acid, anhydrous	1776	59
Fluorosilicates, n.o.s.	2856	53
Fluorosilicic Acid	1778	60
Fluorosulfonic Acid	1777	39
Fluorotoluenes	2388	27
Fluorosilicic Acid	1778	60
Formaldehyde Solutions (Formalin)	2209	29
Formaldehyde Solutions (Formalin)	1198	29
Formic Acid	1779	60
Fuel, Aviation, turbine engine	1863	27
Fuel Oil	1993	27
Fumaryl Chloride	1780	60
Fungicide, corrosive, n.o.s.	1759	60
Fungicide, poisonous, n.o.s.	2902	55
Furan	2389	26
Furfural	1199	29
Furfuryl Alcohol	2874	55

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Furfurylamine	2526	28
Fusee (rail or highway)	1325	32
Fusel Oil	1201	26
Gallium	2803	60
Gallium, metal	2803	60
Gas, refrigerated liquid, n.o.s.	3158	21
Gas Drips, hydrocarbon	1864	27
Gas Identification Set	9035	15
Gasohol	1203	27
Gas Oil	1202	27
Gasoline	1203	27
Gas Sample, non-pressurized, flammable, n.o.s., not refrigerated liquid	3167	22
Gas Sample, non-pressurized, toxic, flammable, n.o.s., not refrigerated liquid	3168	18
Gas Sample, non-pressurized, toxic, n.o.s., not refrigerated liquid	3169	15
Gas Sample, non-pressurized, flammable, n.o.s., not deeply refrigerated	3167	22
Gas Sample, non-pressurized, toxic, flammable, n.o.s., not deeply refrigerated	3168	18
Gas Sample, non-pressurized, toxic, n.o.s., not deeply refrigerated	3169	15
Genetically Modified Microorganisms	3245	31
Genetically Modified Organisms	9278	31
Germane (germanium hydride)	**2192**	**18**
Glycerol-alpha-Monochlorohydrin	2869	55
Glyceril Trinitrate Solution	1204	26
Glicidaldehyde	2622	28
Grenade, tear gas	2017	58
Grenade, without bursting charge, with poisonous gas	2016	15
Guanidine Nitrate	1467	43
Guthion	2783	55
Hafnium powder, dry	2545	40
Hafnium powder, wetted with not less than 25% water	1326	32
Halogenated Irritating Liquids, n.o.s.	1610	58
Hay, Straw or Bhusa, wet damp or contaminated with oil	1327	32
Hazardous Substance, liquid or solid, n.o.s.	9188	31
Hazardous Waste, liquid or solid, n.o.s.	9189	31
Hazardous Waste, liquid, n.o.s.	3082	31
Hazardous Waste, solid, n.o.s.	3077	31
Heating Oil, light	1202	27
Helium, compressed	1046	12
Helium, refrigerated liquid (cryogenic liquid)	1963	21
Helium-Oxygen Mixture	1980	14
Heptafluoropropane	3296	12
n-Heptaldehyde	3056	26
Heptanes	1206	27
n-Heptene	278	27

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Hexachloroacetone	2661	54
Hexachlorobenzene	2729	53
Hexachlorobutadiene	2279	55
Hexachlorocyclo-pentadiene	**2646**	**55**
Hexachloroethane	9037	53
Hexachlorophene	2875	53
Hexadecyltrichloro-silane	1781	60
Hexadienes	2458	29
Hexaethyl Tetra-phosphate	1611	55
Hexaethyl Tetra-phosphate and Compressed Gas Mixtures	**1612**	**15**
Hexaethyl Tetra-phosphate Mixture	2783	55
Hexafluoroacetone	**2420**	**15**
Hexafluoroacetone Hydrate	2552	55
Hexafluoroethane	2193	12
Hexafluoro-phosphoric Acid	1782	59
Hexafluoropropylene	1858	12
Hexafluoropropylene Oxide	1956	12
Hexaldehyde	1207	26
Hexamethylene-diamine, solid	2280	60
Hexamethylene-diamine Solution	1783	60
Hexamethylene Diisocyanate	2281	53
Hexamethyleneimine	2493	29
Hexamethylene-tetramine	1328	32
3,3,6,6,9,9-Hexa-methyl-1,2,4,5-Tetraoxocyclononane	2166	48
3,3,6,6,9,9-Hexa-methyl-1,2,4,5-Tetra-oxocyclononane	2167	48
3,3,6,6,9,9-Hexa-methyl-1,2,4,5-Tetra-oxocyclononane, technical pure	2165	49
Hexamine	1328	32
Hexanes	1208	27
Hexanoic Acid	1760	60
Hexanols	2282	26
1-Hexene	2370	27
Hexyltrichlorosilane	1784	29
Hydrazine, Anhydrous	2029	28
Hydrazine Aqueous Solution with not less than 37% but not more than 64% hydrazine	2030	59
Hydrazine Aqueous Solution with not more than 64% hydrazine	2030	59
Hydrazine Aqueous Solutions, with more than 64% hydrazine	2029	28
Hydrazine Aqueous Solutions, with not more than 37% hydrazine	3293	53
Hydrazine Hydrate	2030	59
Hydrazine Hydrate with not less than 37% but not more than 64% hydrazine	2030	59
Hydrazine Solution, with not more than 64% hydrazine	2030	59
Hydrides , metal, n.o.s.	1409	40
Hydriodic Acid, and Solutions	1787	60
Hydrobromic Acid and Solutions	1788	60

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Hydrocarbon Gas Mixtures, compressed, n.o.s.	1964	22
Hydrocarbon Gas Mixtures, liquefied, n.o.s.	1965	22
Hydrocarbon Gas Refills for small devices, with release device	3150	22
Hydrocarbon Gases, compressed, n.o.s.	1964	22
Hydrocarbon Gases, liquefied, n.o.s.	1965	22
Hydrochloric Acid, anhydrous	**1050**	**15**
Hydrochloric Acid Solution	1789	60
Hydrocyanic Acid	**1051**	**13**
Hydrocyanic Acid, aqueous solution, with less than 5% hydrocyanic acid	1613	55
Hydrocyanic Acid, aqueous solution, with not less than 5% hydrocyanic acid	1613	55
Hydrocyanic Acid, aqueous solution, with not more than 20% hydrogen cyanide	**1613**	**55**
Hydrofluoric Acid, anhydrous	**1052**	**15**
Hydrofluoric Acid Solution	1790	59
Hydrofluoric and Sulfuric Acid Mixtures	1786	59
Hydrofluosilicic Acid	1778	60
Hydrogen, compressed	1049	22
Hydrogen, refrigerated liquid (cryogenic liquid)	1966	22
Hydrogen and Methane Mixtures, compressed	2034	22
Hydrogen Bromide, anhydrous	**1048**	**15**
Hydrogen Bromide Solution	1788	60
Hydrogen Chloride, anhydrous	**1050**	**15**
Hydrogen Chloride, refrigerated liquid (cryogenic liquid)	**2186**	**15**
Hydrogen Chloride Solution	1789	60
Hydrogen Cyanide, anhydrous, stabilized	**1051**	**13**
Hydrogen Cyanide, anhydrous, stabilized (absorbed)	**1614**	**57**
Hydrogen Cyanide, aqueous solution, with not more than 20% hydrogen cyanide	**1613**	**55**
Hydrogen Cyanide, solution in alcohol with not more than 45% hydrogen cyanide	**3294**	**28**
Hydrogen Cyanide, stabilized, containing less than 3% water	**1051**	**13**
Hydrogen Cyanide, stabilized, containing less than 3% water (absorbed in porous inert material)	**1614**	**57**
Hydrogendifluorides, n.o.s., solid or solution	1740	60
Hydrogen Fluoride, anhydrous	**1052**	**15**

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Hydrogen Fluoride Solution	1790	59
Hydrogen Iodide, anhydrous	**2197**	**15**
Hydrogen Iodide Solution	1787	60
Hydrogen Peroxide, stabilized	2015	47
Hydrogen Peroxide Aqueous Solutions, stabilized with more than 60% hydrogen peroxide	2015	47
Hydrogen Peroxide Aqueous Solutions with not less than 8% but less than 20% peroxide	2984	45
Hydrogen Peroxide Aqueous Solutions, with not less than 20% but not more than 60% peroxide	2014	45
Hydrogen Peroxide-Peroxyacetic Acid Mixtures, with acid(s), water and not more than 5% Peroxyacetic acid, stabilized	3149	45
Hydrogen Selenide, anhydrous	**2202**	**13**
Hydrogen Sulfide	**1053**	**13**
Hydrogen Sulfide, liquefied	**1053**	**13**
Hydroquinone	2662	53
Hydrosilicofluoric Acid	1778	60
3-(2-Hydroxy-ethoxy)-4-Pyrrolidin-1-Yl benzene Diazonium Zinc Chloride	3035	70
Hydroxylamine Sulfate	2865	60
Hypochlorite Solution with more than 5% available chlorine	1791	60
Hypochlorites, inorganic, n.o.s.	3212	35
Hyrocarbons, Liquid, n.o.s.	3295	27
Iminobispropylamine	2269	60
3,3'-Iminodipropyl-amine	2269	60
Infectious Substances, affecting animal only	2900	24
Infectious Substances, affecting humans	2814	24
Ink, printer's, flammable	1210	26
Insecticide, dry, n.o.s.	2588	55
Insecticide, liquid, n.o.s.	1993	27
Insecticide, liquid, poisonous, n.o.s.	2902	55
Insecticide Gases, n.o.s.	1968	12
Insecticide Gases, toxic, n.o.s.	**1967**	**15**
Iodine Monochloride	1792	59
Iodine Pentafluoride	2495	44
2-Iodobutane	2390	26
IPDI	2290	53
Iron Chloride, solid	1773	60
Iron Chloride Solution	2582	60
Iron Oxide, spent	1376	37
Iron Pentacarbonyl	**1994**	**57**
Iron Sponge, spent	1376	37
Irritating Agent	1693	58
Isoamyl Alcohol	1105	26
Isobutane or Isobutane Mixtures	1969	22

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Isobutanol	1212	26
Isobutyl Acetate	1213	26
Isobutyl Acrylate	2527	27
Isobutyl Alcohol	1212	26
Isobutyl Aldehyde	2045	26
Isobutylamine	1214	68
Isobutyl Chloroformate	**2742**	**57**
Isobutylene	1055	22
Isobutyl Formate	2393	29
Isobutyl Isobutyrate	2528	26
Isobutyl Isocyanate	**2486**	**57**
Isobutyl Methacrylate	2283	27
Isobutyl Propionate	2394	26
Isobutyraldehyde	2045	26
Isobutyric Acid	2529	29
Isobutyric Anhydride	2530	29
Isobutyronitrile	2284	28
Isobutyryl Chloride	2395	29
Isocyanate Solution, flammable, toxic, n.o.s.	2478	28
Isocyanate Solution, toxic, n.o.s.	2206	55
Isocyanate Solutions, n.o.s.	3080	28
Isocyanate Solutions, toxic, flammable, n.o.s.	3080	28
Isocyanates and solutions, n.o.s., b.p. less than 300°C	2206	55
Isocyanates and solutions, n.o.s., b.p. not less than 300°C	2207	55
Isocyanates and solutions, n.o.s., (flammable)	2478	28
Isocyanates, flammable, toxic, n.o.s.	2478	28
Isocyanates, n.o.s.	3080	28
Isocyanates, toxic, flammable, n.o.s.	3080	28
Isocyanates, toxic, n.o.s.	2206	55
Isocyanatobenzotrifluorides	2285	55
Isoheptenes	2287	27
Isohexenes	2288	28
Isononanoyl Peroxide, technical pure or in solution	2128	52
Isooctane	1262	27
Isooctenes	1216	27
Isopentane	1265	27
Isopentanoic Acid	1760	60
Isopentenes	2371	27
Isophoronediamine	2289	60
Isophorone Diisocyanate	2290	53
Isoprene, inhibited	1218	27
Isopropanol	1219	26
Isopropenyl Acetate	2403	26
Isopropenylbenzene	2303	27
Isoprop yl Acetate	1220	26
Isopropyl Acid Phosphate	1793	60
Isopropyl Alcohol	1219	26
Isopropylamine	1221	68
Isopropylbenzene	1918	28
Isopropyl Butyrate	2405	26
Isopropyl Chloroacetate	2947	29
Isopropyl Chloroformate	**2407**	**57**
Isopropyl 2-Chloropropionate	2934	29
Isopropyl Ether	1159	26
Isopropyl Formate	2408	27
Isopropyl Isobutyrate	2406	28

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Isopropyl Isocyanate	**2483**	**28**
Isopropyl Mercaptan	2402	27
Isopropyl Nitrate	1222	27
Isopropyl Peroxy-dicarbonate	2133	52
Isopropyl propionate	2409	27
Isosorbide Dinitrate Mixture	2907	32
Isosorbide-5-Mono-nitrate	3251	32
Kerosene	1223	27
Ketones, liquid, n.o.s.	1224	26
Krypton, compressed	1056	12
Krypton, refrigerated liquid (cryogenic liquid)	1970	21
Lacquer	1263	26
Lacquer Base, dry	2557	32
Lacquer Base, liquid	1263	26
Lauroyl Peroxide, not more than 42%	2893	48
Lauroyl Peroxide, technical pure	2124	48
Lead Acetate	1616	53
Lead Arsenates	1617	53
Lead Arsenites	1618	53
Lead Chloride	2291	53
Lead Compounds, soluble, n.o.s.	2291	53
Lead Cyanide	1620	53
Lead Dioxide	1872	42
Lead Fluoborate	2291	53
Lead Fluoride	2811	53
Lead Nitrate	1469	42
Lead Percholate, solid or solution	1470	42
Lead Peroxide	1872	42
Lead Phosphite, dibasic	2989	32
Lead Sulfate, with more than 3% free acid	1794	60
Life-Saving Appli-ances Not Self-Inflating	3072	31
Lighter, for cigars, cigarettes, etc. with flammable liquid	1226	26
Lighter Fluid	1226	26
Lighter Refills, cigarettes, containing flammable gas	1057	17
Lighters, cigarettes, containing flammable gas	1057	17
Lindane	2761	55
Liquefied Gas, flammable, n.o.s.	1954	22
Liquefied Gas, flammable, n.o.s.	3161	22
Liquefied Gas, non-flammable, charged with nitrogen, carbon dioxide or air	1058	12
Liquefied Gas, n.o.s.	1956	12
Liquefied Gas, n.o.s.	3163	12
Liquefied Gas, oxidizing, n.o.s.	3157	14
Liquefied Gas, toxic, flammable, n.o.s.	**3160**	**18**
Liquefied Gas, toxic, n.o.s.	**3162**	**15**
Liquefied Gases, flammable, poisonous, n.o.s.	**1953**	**18**
Liquefied Gases, flammable, toxic, n.o.s. (Inhalation Hazard Zone A)	**1953**	**18**
Liquefied Gases, flammable, toxic, n.o.s. (Inhalation Hazard Zone B)	**1953**	**18**

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Liquefied Gases, flammable, toxic, n.o.s. (Inhalation Hazard Zone C)	**1953**	**18**
Liquefied Gases, flammable, toxic, n.o.s. (Inhalation Hazard Zone D)	**1953**	**18**
Liquefied Gases, poisonous, n.o.s.	**1955**	**15**
Liquefied Gases, toxic, n.o.s. (Inhalation Hazard Zone A)	**1955**	**15**
Liquefied Gases, toxic, n.o.s. (Inhalation Hazard Zone B)	**1955**	**15**
Liquefied Gases, toxic, n.o.s. (Inhalation Hazard Zone C)	**1955**	**15**
Liquefied Gases, toxic, n.o.s. (Inhalation Hazard Zone D)	**1955**	**15**
Liquefied Natural Gas	1972	22
Liquefied Non-flammable Gas charged with nitrogen, carbon dioxide or air	1058	12
Liquefied Petroleum Gas	1075	22
Lithium	1415	40
Lithium Acetylide-Ethylenediamine Complex	2813	40
Lithium Alkyls	2445	40
Lithium Alluminium Hydride	1410	40
Lithium Alluminium Hydride, ethereal	1411	40
Lithium Amide	1412	40
Lithium Batteries, contained in equipment	3091	40
Lithium Batteries, packed with equipment	3091	40
Lithium Battery	3090	40
Lithium Borohydride	1413	40
Lithium Ferrosilicon	2830	41
Lithium Hydride	1414	40
Lithium Hydride, fused, solid	2805	40
Lithium Hydroxide, solid	2680	60
Lithium Hydroxide Monohydrate	2680	60
Lithium Hydroxide Solution	2679	60
Lithium Hypochlorite, dry, including mixtures with more than 39% available chlorine	1471	45
Lithium Metal	1415	40
Lithium Nitrate	2722	35
Lithium Nitride	2806	37
Lithium Peroxide	1472	47
Lithium Silicon	1417	40
LNG, liquefied natural gas	1972	22
London Purple	1621	53
LPG, liquefied petroleum gas	1075	22
Magnesium, pellets, turnings or ribbon	1869	76
Magnesium, powder	1418	76
Magnesium Alkyls	3053	40
Magnesium Alloy, with more than 50% magnesium, pellets, turnings or ribbon	1869	76
Magnesium Alloy, with more than 50% magnesium, powder	1418	76

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Magnesium Aluminum Phosphide	1419	41
Magnesium Arsenate	1622	53
Magnesium Bromate	1473	35
Magnesium Chlorate	2723	35
Magnesium Diamide	2004	37
Magnesium Diphenyl	2005	40
Magnesium Fluorosilicate	2853	53
Magnesium Granules,coated	2950	40
Magnesium Hydride	2010	40
Magnesium Nitrate	1474	35
Magnesium Perchlorate	1475	35
Magnesium Peroxide	1476	35
Magnesium Phosphide	2011	41
Magnesium Silicide	2624	40
Magnetized Material	2807	31
Malathion	2783	55
Maleic Acid	2215	60
Maleic Anhydride	2215	60
Malononitrile	2647	53
Maneb, or Maneb Preparation(s), stabilized against self-heating	2968	37
Maneb, or Maneb Preparation(s) with 50% or more Maneb	2210	37
Manganese Nitrate	2724	35
Manganese Resinate	1330	32
Matches, fusee	2254	32
Matches, safety	1944	32
Matches, strike anywhere	1331	32
Matches, wax (Vesta)	1945	32
Medical Waste, n.o.s.	3291	24
Medicines, corrosive, liquid, n.o.s.	1760	60
Medicines, corrosive, solid, n.o.s.	1759	60
Medicines, flammable, liquid, n.o.s.	1993	27
Medicines, flammable, solid, n.o.s.	1325	32
Medicines, liquid, flammable, poisonous, n.o.s.	3248	28
Medicines, liquid, flammable, toxic, n.o.s.	3248	28
Medicines, liquid, poisonous, n.o.s.	1851	55
Medicines, liquid, toxic, n.o.s.	1851	55
Medicines, oxidizing substance, solid, n.o.s.	1479	35
Medicines, poisonous, liquid, n.o.s.	2810	55
Medicines, poisonous, solid, n.o.s.	2811	53
Medicines, solid, poisonous, n.o.s.	3249	55
Medicines, solid, toxic, n.o.s.	3249	55
Menthane Hydroperoxide, para, technical pure	2125	51
Mercaptan Mixture, aliphatic	1228	28
Mercaptan Mixture, liquid, flammable, toxic, n.o.s.	1228	28
Mercaptan Mixture, liquid, toxic, flammable, n.o.s.	3071	28
Mercaptan Mixtures, liquid, n.o.s.	3071	28
Mercaptans, liquid, flammable, toxic, n.o.s.	1228	28

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Mercaptans, liquid, n.o.s.	3071	28
Mercaptans, liquid, toxic, flammable, n.o.s.	3071	28
Mercaptans and Mixtures, liquid, n.o.s.	1228	28
Mercuric Acetate	1629	53
Mercuric Arsenate	1623	53
Mercuric Bromide	1634	53
Mercuric Chloride	1624	53
Mercuric Cyanide	1636	53
Mercuric Nitrate	1625	42
Mercuric Oxycyanide	1642	53
Mercuric Potassium Cyanide	1626	53
Mercuric Sulfate	1645	53
Mercurol	1639	53
Mercurous Acetate	1629	53
Mercurous Bromide	1634	53
Mercurous Nitrate	1627	42
Mercurous Sulfate	1628	53
Mercury	2809	60
Mercury Acetate	1629	53
Mercury Ammonium Chloride	1630	53
Mercury-based Pesticides, liquid, flammable, toxic, n.o.s.	2778	28
Mercury-based Pesticides, liquid, toxic, flammable, n.o.s.	3011	28
Mercury-based Pesticides, liquid, toxic, n.o.s.	3012	55
Mercury-based Pesticides, solid, toxic, n.o.s.	2777	55
Mercury Benzoate	1631	53
Mercury Bisulfate	1633	53
Mercury Bromides	1634	53
Mercury Compounds, liquid, n.o.s.	2024	53
Mercury Compounds, solid, n.o.s.	2025	53
Mercury Cyanide	1636	53
Mercury Gluconate	1637	53
Mercury Iodide	1638	53
Mercury Metal	2809	60
Mercury Nucleate	1639	53
Mercury Oleate	1640	53
Mercury Oxide	1641	53
Mercury Oxycyanide, desensitized	1642	53
Mercury Potassium Iodide	1643	53
Mercury Salicylate	1644	53
Mercury Sulfate	1645	53
Mercury Thiocyanate	1646	53
Mesityl Oxide	1229	26
Metal Alkyl Halides, n.o.s.	3049	40
Metal Alkyl Hydrides, n.o.s.	3050	40
Metal Alkyl Solution, n.o.s.	9195	40
Metal Alkyls, n.o.s.	2003	40
Metal Carbonyls, toxic, n.o.s.	3281	55
Metal Catalyst, dry	2881	37
Metal Catalyst, finely divided, activated or spent, wet with not less than 40% water or other suitable liquid	1378	32
Metaldehyde	1332	32
Metal Hydrides, flammable, n.o.s.	3182	32

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Metal Hydrides, water-reactive, n.o.s.	1409	40
Metallic Substance, water-reactive, n.o.s.	3208	40
Metallic Substance, water-reactive, self-heating, n.o.s.	3209	40
Metal Powder, flammable, n.o.s.	3089	32
Metal Powder, self-heating, n.o.s.	3189	37
Metal Salts of Organic Compounds, flammable, n.o.s.	3181	32
Methacrylaldehyde	2396	28
Methacrylic Acid, inhibited	2531	60
Methacrylonitrile, inhibited	**3079**	**28**
Methallyl Alcohol	2614	26
Methane, compressed	1971	17
Methane, refrigerated liquid (cryogenic liquid)	1972	22
Methanesulfonyl Chloride	**3246**	**59**
Methanol	1230	28
Methoxymethyl Isocyanate	**2605**	**57**
1-Methoxy-4-Methyl-Pentan-2-One	2293	27
Methoxy-2-Propanol	3092	26
Methyl Acetate	1231	26
Methyl Acetone	1232	26
Methyl Acetylene and Propadiene Mixture, stabilized	1060	17
Methyl Acrylate, inhibited	1919	26
Methylal	1234	26
Methyl Alcohol	1230	28
Methyl Allyl Chloride	2554	26
Methylamine, anhydrous	1061	19
Methylamine, aqueous solution	1235	68
Methyl Amyl Acetate	1233	26
Methyl Amyl Alcohol	2053	26
Methyl Amyl Ketone	1110	26
N-Methylaniline	2294	57
Methyl Benzoate	2938	31
Methylbenzyl Alcohol (alpha)	2937	55
Methyl Bromide	**1062**	**55**
Methyl Bromide and Chloropicrin Mixtures	**1581**	**55**
Methyl Bromide and Ethylene Dibromide Mixtures, liquid	**1647**	**55**
Methyl Bromide and Non-flammable Compressed Gas Mixture	**1955**	**15**
Methyl Bromoacetate	2643	58
3-Methyl-2-Butanone	2397	26
Methylbutene	2460	26
2-Methyl-1-Butene	2459	26
2-Methyl-2-Butene	2460	26
3-Methyl-1-Butene	2561	26
N-Methylbutylamine	2945	29
Methyl tert-Butyl Ether	2398	26
Methyl butyrate	1237	26
Methyl Chloride	1063	18
Methyl Chloride and Chloropicrin Mixtures	**1582**	**18**
Methyl Chloride and Methylene Chloride Mixtures	1912	22
Methyl Chloroacetate	2295	57

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Methyl Chloro-carbonate	**1238**	**28**
Methyl Chloroform	2831	74
Methyl Chloro-formate	**1238**	**28**
Methyl Chloro-methylether	**1239**	**57**
Methyl 2-Chloro-propionate	2933	29
Methyl Chlorosilane	**2534**	**18**
Methyl Cyanide	1648	28
Methyl Cyclohexane	2296	27
Methyl Cyclohexanol	2617	26
Methyl Cyclo-hexanols, flammable	2617	26
Methyl Cyclo-hexanone	2297	26
Methyl Cyclopentane	2298	26
Methyl Dichloro-acetate	2299	60
Methyl Dichloro-arsine	**1556**	**55**
Methyldichlorosilane	1242	29
Methylene Bis(4-Phenyl-isocyanate) (MDI)	2489	54
Methylene Chloride	1593	74
Methyl Ethyl Ether	1039	26
Methyl Ethyl Ketone	1193	26
Methyl Ethyl Ketone Peroxide	2550	51
2-Methyl-5-Ethyl-piridine	2300	60
Methyl Fluoride	2454	22
Methyl Formate	1243	26
2-Methylfuran	2301	26
5-Methylhexan-2-one	2302	26
Methylhydrazine	**1244**	**57**
Methyl Iodide	**2644**	**55**
Methyl Isobutyl Carbinol	2053	26
Methyl Isobutyl Ketone	1245	26
Methyl Isobutyl Ketone Peroxide	2126	51
Methyl Isocyanate	**2480**	**26**
Methyl Isopropenyl Ketone, inhibited	1246	26
Methyl Isothio-cyanate	**2477**	**28**
Methyl Isovaleriate	2400	27
Methyl Magnesium Bromide in Ethyl Ether	1928	37
Methyl Mercaptan	**1064**	**13**
Methyl Methacrylate, monomer, inhibited	1247	26
Methylmorpholine	2535	29
Methyl Nitrite	2455	17
Methyl Orthosilicate	**2606**	**57**
Methyl Parathion, liquid	2783	55
Methyl Parathion Mixture, dry	2783	55
Methyl Parathion and Compressed Gas Mixture	**1967**	**15**
Methylpentadienes	2461	26
Methylpentane	2462	26
2-Methylpentan-2-Ol	2560	26
Methylphenyldichloro silane	2437	29
Methyl Phosphonic Dichloride	**9206**	**39**
Methyl Phosphono-thioic Dichloride	1760	60
Methyl Phosphon-ous Dichloride	**2845**	**40**
Methylpiperidine	2399	68
1-Methylpiperidine	2399	68

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Methyl Propionate	1248	26
Methyl Propyl Ether	2612	26
Methyl Propyl Ketone	1249	26
Methyl Sulfate	**1595**	**57**
Methyl Sulfide	1164	27
Methyltetrahydro-furan	2536	26
Methyl Trichloro-acetate	2533	53
Methyltrichlorosilane	1250	29
Methylvaleraldehyde (alpha)	2367	27
Methyl Vinyl Ketone	**1251**	**28**
Meviphos	2783	55
Mexacarbate	2757	55
Mining Reagent, liquid	2022	55
Mixed Acid	1796	73
Mixed Acid, spent	1826	60
Molybdenium Penta-chloride	2508	60
Monochloroacetic Acid, liquid	1750	59
Monochloroacetone, inhibited	**1695**	**59**
Monochloroacetone, stabilized	**1695**	**59**
Monochloroethylene	1086	17
Monoethanolamine	2491	60
Monofluoro-phosphoric Acid	1776	59
Monomethylamine, anhydrous	1061	19
Monomethylamine, aqueous solution	1235	68
Monopropylamine	1277	68
Mono-(Trichloro)-Tetra-(mono-potassium Dichloro)-Penta-S-Triazine-trione, dry	2468	45
Morpholine	2054	29
Morpholine, aqueous, mixture	1760	60
Motor Fuel Anti-Knock Compound	1649	56
Motor Fuel Anti-Knock Mixtures	1649	56
Motor Spirit	1203	27
Muriatic Acid	1789	60
Musk Xylene	2956	32
Naphtha	2553	27
Naphtha, petroleum	1255	27
Naphtha, solvent	1256	27
Naphthalene, crude or refined	1334	32
Naphthalene, molten	2304	32
Naphthylamine (alpha)	2077	55
Naphthylamine (beta)	1650	55
Naphthylthiourea	1651	53
Naphthylurea	1652	53
Natural Gas, compressed with high Methane content	1971	17
Natural Gas, refrigerated liquid (cryogenic liquid) with high Methane content	1972	22
Natural Gas with high Methane con-tent, compressed	1971	17
Natural gasoline	1257	27
Neohexane	1208	27
Neon, compressed	1065	12
Neon, refrigerated liquid (cryogenic liquid)	1913	21
Nickel Carbonyl	**1259**	**57**
Nickel Catalyst, dry	2881	37
Nickel Cyanide	1653	53

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Nickel Nitrate	2725	35
Nickel Nitrite	2726	35
Nicotine	1654	55
Nicotine Compound, liquid, n.o.s.	3144	55
Nicotine Compounds, solid, n.o.s.	1655	55
Nicotine Hydrochloride and solutions	1656	55
Nicotine Preparations, liquid, n.o.s.	3144	55
Nicotine Preparations, solid, n.o.s.	1655	55
Nicotine Salicylate	1657	53
Nicotine Sulfate, liquid	1658	55
Nicotine Sulfate, solid	1658	55
Nicotine Tartrate	1659	53
Nitrates, inorganic, aqueous solution, n.o.s.	3218	35
Nitrates, inorganic, n.o.s.	1477	35
Nitrating Acid	1796	73
Nitrating Acid, mixtures	1796	73
Nitrating Acid Mixtures, spent	1826	60
Nitric Acid, fuming	**2032**	**44**
Nitric Acid, other than fuming, with more than 40% acid	2031	44
Nitric Acid, other than fuming, with not more than 40% acid	1760	60
Nitric Acid, red fuming	**2032**	**44**
Nitric Acid, other than red fuming with more than 70% nitric acid	2031	44
Nitric Acid, other than red fuming with not more than 70% nitric acid	2031	44
Nitric Oxide	**1660**	**20**
Nitric Oxide and Dinitrogen Tetroxide Mixtures	**1975**	**20**
Nitric Oxide and Nitrogen Dioxide Mixtures	**1975**	**20**
Nitric Oxide and Nitrogen Tetroxide Mixtures	**1975**	**20**
Nitriles, flammable, toxic, n.o.s.	3273	28
Nitriles, toxic, flammable, n.o.s.	**3275**	**57**
Nitriles, toxic, n.o.s. (liquid)	3276	55
Nitriles, toxic, n.o.s. (solid)	3276	55
Nitrites, inorganic, aqueous solutions, n.o.s.	3219	35
Nitrites, inorganic, n.o.s.	2627	35
Nitroanilines	1661	55
Nitroanisole	2730	55
Nitrobenzene	1662	55
Nitrobenzenesulfonic Acid	2305	60
Nitrobenzotrifluorides	2306	54
Nitrobromobenzenes	2732	55
Nitrocellulose, solution in a flammable liquid	2059	26
Nitrocellulose, wet with more than 40% flammable liquid	2059	26
Nitrocellulose, wet with not less than 20% water	2555	33

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Nitrocellulose, wet with not less than 25% alcohol	2556	33
Nitrocellulose, with not more than 12.6% nitrogen, by dry mass, mixture, with or without plasticizer or with pigment	2557	32
Nitrocellulose, with plasticizing substance	2557	32
Nitrocellulose Membrane Filters	3270	32
Nitrochlorobenzene, liquid	1578	55
Nitrochlorobenzene, solid	1578	55
3-Nitro-4-Chloro-benzotrifluoride	2307	54
Nitrocresols	2446	55
Nitroethane	2842	26
Nitrogen, compressed	1066	12
Nitrogen, refrigerated liquid (cryogenic liquid)	1977	21
Nitrogen Dioxide, liquefied	**1067**	**20**
Nitrogen Peroxide	**1067**	**20**
Nitrogen Tetroxide	**1067**	**20**
Nitrogen Trifluoride	2451	15
Nitrogen Trioxide	**2421**	**20**
Nitroglycerin Solution in Alcohol, not more than 1% nitroglycerin	1204	26
Nitroglycerin Solution in Alcohol, with more than 1% but not more than 5% nitroglycerin	3064	26
Nitroguanidine, wetted with not less than 20% water	1336	33
Nitrohydrochloric Acid	1798	60
Nitromethane	1261	26
Nitromuriatic Acid	1798	60
Nitronaphthalene	2538	32
Nitrophenols	1663	55
Nitropropanes	2608	26
p-Nitrosodimethyl-aniline	1369	32
Nitrostarch, wet with not less than 20% water	1337	33
Nitrostarch, wet with not less than 30% solvent	1337	33
Nitrosyl Chloride	**1069**	**16**
Nitrosylsulfuric Acid	2308	60
Nitrotoluenes	1664	55
Nitrotoludines (mono)	2660	55
Nitrous Oxide, compressed	1070	14
Nitrous Oxide, refrigerated liquid (cryogenic liquid)	2201	23
Nitroxylenes	1665	55
Nitroxylol	1665	55
Nonanes	1920	27
Nonflammable Gas, n.o.s.	1956	12
Nonyltrichlorosilane	1799	60
2,5-Norbornadiene	2251	26
Octadecyltrichloro-silane	1800	39
Octadiene	2309	27
Octafluorobut-2-Ene	2422	12
Octafluorocyclo-butane	1976	12
Octafluoropropane	2424	12
Octanes	1262	27
Octanoyl Peroxide	2129	52
Octyl Aldehydes	1191	26

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
tert-Octyl Mercaptan	**3023**	**57**
Octyltrichlorosilane	1801	60
Oil, n.o.s., flash point not less than 93°C	9277	31
Oil, petroleum, n.o.s.	1270	27
Oil Gas	**1071**	**18**
Oleum, with less than 30% free sulfur trioxide	1831	39
Oleum, with not less than 30% free sulfur trioxide	**1831**	**39**
ORM-A, n.o.s.	1693	58
ORM-B, n.o.s.	1760	60
ORM-E, liquid or solid, n.o.s.	9188	31
Organic Peroxide, liquid or solution, n.o.s.	9183	52
Organic Peroxide, n.o.s. (including trial quantities)	2899	52
Organic Peroxide, sample, n.o.s.	2255	48
Organic Peroxide, solid, n.o.s.	9187	52
Organic Peroxide Mixture	2756	52
Organic Peroxide Type B, liquid	3101	49
Organic Peroxide Type B, liquid, temperature controlled	3111	52
Organic Peroxide Type B, solid	3102	49
Organic Peroxide Type B, solid, temperature controlled	3112	52
Organic Peroxide Type C, liquid	3103	48
Organic Peroxide Type C, liquid, temperature controlled	3113	52
Organic Peroxide Type C, solid	3104	48
Organic Peroxide Type C, solid, temperature controlled	3114	52
Organic Peroxide Type D, liquid	3105	48
Organic Peroxide Type D, liquid, temperature controlled	3115	52
Organic Peroxide Type D, solid	3106	48
Organic Peroxide Type D, solid, temperature controlled	3116	52
Organic Peroxide Type E, liquid	3107	48
Organic Peroxide Type E, liquid, temperature controlled	3117	52
Organic Peroxide Type E, solid	3108	48
Organic Peroxide Type E, solid, temperature controlled	3118	52
Organic Peroxide Type F, liquid	3109	48
Organic Peroxide Type F, liquid, temperature controlled	3119	52
Organic Peroxide Type F, solid	3110	48
Organic Peroxide Type F, solid, temperature controlled	3120	52
Organic Phosphate Compound, and mixtures, liquid	2783	55
Organic Phosphate Compound, and mixtures, solid	2783	55

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Organic Phosphate, mixed with Compressed Gas	**1955**	**15**
Organic Phosphate Compound, mixed with Compressed Gas	**1955**	**15**
Organic Phosphorous Compound, mixed with Compressed Gas	**1955**	**15**
Organoarsenic Compound, toxic, n.o.s.	3280	55
Organochlorine Pesticides, liquid, flammable, toxic, n.o.s.	2762	28
Organochlorine Pesticides, liquid, toxic, flammable, n.o.s.	2995	28
Organochlorine Pesticides, liquid, toxic, n.o.s.	2996	55
Organochlorine Pesticides, solid, toxic, n.o.s.	2761	55
Organometallic Compounds, toxic, n.o.s.	3282	55
Organometallic - Compounds, water-reactive, flammable, n.o.s.	3207	40
Organometallic Dispersion, water-reactive, flammable, n.o.s.	3207	40
Organometallic Solution, water-reactive, flammable, n.o.s.	3207	40
Organophosphorous Compound, toxic, flammable, n.o.s.	**3279**	**28**
Organophosphorous Compound, toxic, n.o.s.(liquid)	3278	55
Organophosphorous Compound, toxic, n.o.s.(solid)	3278	55
Organophosphorous Pesticides, liquid, flammable, toxic, n.o.s.	2784	28
Organophosphorous Pesticides, liquid, toxic, flammable, n.o.s.	3017	28
Organophosphorous Pesticides, liquid, toxic, n.o.s.	3018	55
Organophosphorous Pesticides, solid, toxic, n.o.s.	2783	55
Organotin Compounds, liquid, n.o.s.	2788	55
Organotin Compounds, solid, n.o.s.	3146	55
Organotin Pesticides, liquid, flammable, toxic, n.o.s.	2787	28
Organotin Pesticides, liquid, toxic, n.o.s.	3020	55
Organotin Pesticides, solid, toxic, n.o.s.	2786	55
Osmium Tetroxide	2471	55
Other Regulated Substances, liquid, n.o.s.	3082	31
Other Regulated Substances, solid, n.o.s.	3077	31
Oxalates, water soluble	2449	54
Oxidizer, corrosive liquid, n.o.s.	9193	45
Oxidizer, corrosive solid, n.o.s.	9194	45
Oxidizer, n.o.s.	1479	35

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Oxidizer, poisonous liquid, n.o.s.	9199	44
Oxidizer, poisonous solid, n.o.s.	9200	42
Oxidizing Liquid, corrosive, n.o.s.	3098	45
Oxidizing Liquid, poisonous, n.o.s.	3099	44
Oxidizing Liquid, toxic, n.o.s.	3099	44
Oxidizing Material, n.o.s.	1479	35
Oxidizing Solid, corrosive, n.o.s.	3085	42
Oxidizing Solid, n.o.s.	1479	35
Oxidizing Solid, self-heating, n.o.s.	3100	43
Oxidizing Solid, toxic, n.o.s.	3087	44
Oxidizing Solid, water-reactive, n.o.s.	3121	43
Oxidizing Substances, liquid, corrosive, n.o.s.	3098	45
Oxidizing Substances, liquid, n.o.s.	3139	35
Oxidizing Substances, solid, corrosive, n.o.s.	3085	42
Oxidizing Substances, solid, flammable, n.o.s.	3137	35
Oxidizing Substances, solid, n.o.s.	1479	35
Oxidizing Substances, solid, poisonous, n.o.s.	3087	44
Oxidizing Substances, solid, self-heating, n.o.s.	3100	43
Oxidizing Substances, solid, which in contact with water emit Flammable Gases, n.o.s.	3121	43
Oxygen, compressed	1072	14
Oxygen, refrigerated liquid (cryogenic liquid)	1073	23
Oxygen Difluoride	**2190**	**20**
Paint, corrosive liquid	1760	60
Paint, corrosive liquid	3066	60
Paint, flammable liquid	1263	26
Paint Related Material, corrosive liquid	1760	60
Paint Related Material, corrosive liquid	3066	60
Paint Related Material, flammable liquid	1263	26
Paper, treated with unsaturated oil	1379	32
Paraformaldehyde	2213	32
Paraldehyde	1264	26
Paramenthane Hydroperoxide	2125	51
Parathion and Compressed Gas Mixture	**1967**	**15**
Parathion Mixture, liquid or dry	2783	55
PCBs	2315	31
Pelargonyl Peroxide	2130	52
Pentaborane	**1380**	**75**
Pentachloroethane	1669	55
Pentachlorophenol	3155	15
Pentafluoroethane	3220	12
Pentamethylheptane	2286	27
Pentan-2,4-Dione	2310	26
n-Pentane	1265	27

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
1-Pentene	1108	26
1-Pentol	2705	60
Peracetic Acid, solution	2131	51
Peracarbonates, inorganic, n.o.s.	3217	35
Perchlorates, inorganic, aqueous solution, n.o.s.	3211	35
Perchlorates, inorganic, n.o.s.	1481	35
Perchloric Acid, more than 50% but not more than 72% acid, by weight	1873	47
Perchloric Acid, not more than 50% acid, by weight	1802	45
Perchloroethylene	1897	74
Perchlormethyl Mercaptan	**1670**	**55**
Perchloryl Fluoride	**3083**	**20**
Perfluoroethylvinyl Ether	3154	22
Perfluoromethylvinyl Ether	3153	22
Perfumery Products, with flammable solvent	1266	26
Permanganates, inorganic, n.o.s.	1482	35
Permanganates, inorganic, aqueous solution, n.o.s.	3214	35
Peroxide, inorganic, n.o.s.	1483	35
Peroxyacetic Acid, solution	2131	51
Permanganates, inorganic, aqueous solution, n.o.s.	3216	35
Permanganates, inorganic, n.o.s.	3215	35
Pesticide, water reactive, containing manganese ethylene-bisdithiocarbamate (maneb)	2210	37
Pesticides, liquid, flammable, toxic, n.o.s.	3021	28
Pesticides, liquid, toxic, flammable, n.o.s.	2903	28
Pesticides, liquid, toxic, n.o.s.	2902	55
Pesticides, solid, toxic, n.o.s.	2588	55
Petrol	1203	27
Petroleum Crude Oil	1267	27
Petroleum Distillates, n.o.s.	1268	27
Petroleum Ether	1271	26
Petroleum Gases, liquefied	1075	22
Petroleum Naphtha	1255	27
Petroleum Oil	1270	27
Petroleum Products, n.o.s.	1268	27
Petroleum Spirit	1271	26
Phenacyl Bromide	2645	55
Phenitidines	2311	55
Phenol, molten	2312	55
Phenol, solid	1671	55
Phenol Solutions	2821	55
Phenolsulfonic Acid, liquid	1803	60
Phenoxy Pesticides, liquid, flammable, toxic, n.o.s.	2766	28
Phenoxy Pesticides, liquid, toxic, flammable, n.o.s.	2999	28
Phenoxy Pesticides, liquid, toxic, n.o.s.	3000	55

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Phenoxy Pesticides, solid, toxic, n.o.s.	2765	55
Phenylacetonitrile, liquid	2470	55
Phenylacetyl Chloride	2577	60
Phenylcarbylamine Chloride	**1672**	**55**
Phenyl Chloroformate	2746	55
Phenyldichloroarsine	1556	55
Phenylenediamines	1673	53
Phenylhydrazine	2572	53
Phenyl Isocyanate	**2487**	**55**
Phenyl Mercaptan	**2337**	**57**
Phenylmercuric Acetate	1674	55
Phenylmercuric Compounds, solid, n.o.s.	2026	53
Phenylmercuric Hydroxide	1894	53
Phenylmercuric Nitrate	1895	53
Phenyl Phosphorous Dichloride	2798	39
Phenyl Phosphorous Thiodichloride	2799	39
Phenyltrichlorosilane	1804	39
Phenyl Urea Pesticides, liquid, flammable,toxic, n.o.s.	2768	28
Phenyl Urea Pesticides, liquid, toxic, flammable, n.o.s.	3001	28
Phenyl Urea Pesticides, liquid, toxic, n.o.s.	3002	55
Phosgene	**1076**	**15**
9-Phosphabicyclononanes	2940	37
Phosphine	**2199**	**18**
Phosphoric Acid	1805	60
Phosphoric Acid Triethyleneimine	2501	55
Phosphoric Anhydride	1807	39
Phosphorous Acid	2834	60
Phosphorous Acid, ortho	2834	60
Phosphorus, amorphous, red	1338	32
Phosphorus, white, molten	2447	38
Phosphorus, white or yellow, dry or under water or in solution	1381	38
Phosphorus Heptasulfide, free from yellow or white phosphorus	1339	32
Phosphorus Oxybromide, molten	2576	39
Phosphorus Oxybromide, solid	1939	39
Phosphorus Oxychloride	**1810**	**39**
Phosphorus Pentabromide	2691	39
Phosphorus Pentachloride	1806	39
Phosphorus Pentafluoride	**2198**	**15**
Phosphorus Pentasulfide, free from yellow or white phosphorus	1341	41
Phosphorus Pentoxide	1807	39
Phosphorus Sesquisulfide, free from yellow or white phosphorus	1341	41
Phosphorus Tribromide	1808	39
Phosphorus Trichloride	**39**	**1809**
Phosphorus Trioxide	2578	60

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Phosphorus Trisulfide, free from yellow or white phosphorus	1343	41
Phosphoryl Chloride	**1810**	**39**
Phthalic Anhydride	2214	60
Phthalimide Derivative Pesticides, liquid, flammable, toxic, n.o.s.	2774	28
Phthalimide Derivative Pesticides, liquid, toxic, flammable, n.o.s.	3007	28
Phthalimide Derivative Pesticides, liquid, toxic, n.o.s.	3008	55
Phthalimide Derivative Pesticides, solid, toxic, n.o.s.	2773	55
Picolines	2313	27
Picric Acid, wet with not less than 10% water	1344	33
Picrite, wetted with not less than 20% water	1336	33
Pinane Hydroperoxide, technical pure	2162	51
Pinene (alpha)	2368	26
Pine Oil	1272	26
Piperazine	2579	60
Piperidine	2401	29
Plastic Moulding Material, evolving flammable vapor	2211	32
Plastics, nitrocellulose-based, spontaneously combustible, n.o.s.	2006	37
Poison B, Liquid, n.o.s.	2810	55
Poison B, Solid, n.o.s.	2811	53
Poisonous Liquids, corrosive, n.o.s.	2927	59
Poisonous Liquids, corrosive, n.o.s. (Inhalation Hazard Zone A)	**2927**	**59**
Poisonous Liquids, corrosive, n.o.s. (Inhalation Hazard Zone B)	**2927**	**59**
Poisonous Liquids, flammable, n.o.s.	2929	57
Poisonous Liquids, flammable, n.o.s. (Inhalation Hazard Zone A)	**2929**	**57**
Poisonous Liquids, flammable, n.o.s. (Inhalation Hazard Zone B)	**2929**	**57**
Poisonous Liquids, n.o.s.	2810	55
Poisonous Liquids, n.o.s. (Inhalation Hazard Zone A)	**2810**	**55**
Poisonous Liquids, n.o.s. (Inhalation Hazard Zone B)	**2810**	**55**
Poisonous Liquids, oxidizing, n.o.s.	3122	44
Poisonous Liquids, oxidizing, n.o.s. (Inhalation Hazard Zone A)	**3122**	**44**
Poisonous Liquids, oxidizing, n.o.s. (Inhalation Hazard Zone B)	**3122**	**44**
Poisonous Liquids, water-reactive, n.o.s.	3123	40
Poisonous Liquids, which in contact with water emit Flammable Gases, n.o.s.	3123	40

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Poisonous Liquids, which in contact with water emit Flammable Gases, n.o.s. (Inhalation Hazard Zone A)	**3123**	**40**
Poisonous Liquids, which in contact with water emit Flammable Gases, n.o.s. (Inhalation Hazard Zone B)	**3123**	**40**
Poisonous Solids, corrosive, n.o.s.	2928	59
Poisonous Solids, flammable, n.o.s.	2930	34
Poisonous Solids, n.o.s.	2811	53
Poisonous Solids, oxidizing, n.o.s.	3086	42
Poisonous Solids, self-heating, n.o.s.	3124	34
Poisonous Solids, water-reactive, n.o.s.	3125	34
Poisonous Solids, which in contact with water emit Flammable Gases, n.o.s.	3125	34
Polish, liquid	1263	26
Polyalkylamines, corrosive, flammable, n.o.s.	2734	29
Polyalkylamines, corrosive, n.o.s.	2735	60
Polyalkylamines,flammable, corrosive, n.o.s.	2733	29
Polyalkylamines, n.o.s.	2733	29
Polyalkylamines, n.o.s.	2734	29
Polyalkylamines, n.o.s.	2735	60
Polyamines, flammable, corrosive, n.o.s.	2733	29
Polyamines, liquid, corrosive, flammable, n.o.s.	2734	29
Polyamines, liquid, corrosive, n.o.s.	2735	60
Polyamines, solid, corrosive, n.o.s	3259	60
Polychlorinated Biphenyls	2315	31
Polyester Resin Kit	3269	26
Polyester Resin Kits	2255	48
Polyhalogenated Biphenyls, liquid	3151	31
Polyhalogenated Biphenyls, solid	3152	31
Polyhalogenated Terphenyls,liquid	3151	31
Polyhalogenated Terphenyls, solid	3152	31
Polymeric Beads, expandable, evolving flammable vapour	2211	32
Polystyrene Beads, expandable, evolving flammable vapour	2211	32
Potassium	2257	40
Potassium, Metal, alloy	1420	40
Potassium, metal, liquid alloy	1420	40
Potassium Arsenate	1677	53
Potassium Arsenite	1678	54
Potassium Bifluoride	1811	59
Potassium Bisulfate	2509	60
Potassium Bisulfite Solution	2693	60
Potassium Borohydride	1870	40
Potassium Bromate	1484	35
Potassium Chlorate	1485	35
Potassium Chlorate, aqueous solution	2427	31

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Potassium Cuprocyanide	1679	53
Potassium Cyanide, solid	1680	55
Potassium Cyanide Solution	1680	55
Potassium Dichloro-S-Triazinetrione	2465	45
Potassium Dichromate	1479	35
Potassium Dithionite	1929	32
Potassium Fluoride	1812	54
Potassium Fluoro-acetate	2628	53
Potassium Fluoro-silicate, solid	2655	53
Potassium Hydrogen-difluoride, solid or solution	1811	59
Potassium Hydrogen Fluoride	1811	59
Potassium Hydrogen Sulfate	2509	60
Potassium Hydrosulfite	1929	32
Potassium Hydr-oxide, dry, solid	1813	60
Potassium Hydroxide Solution	1814	60
Potassium Hypo-chlorite Solution	1791	60
Potassium Metal	2257	40
Potassium Metavanadate	2864	53
Potassium Monoxide	2033	60
Potassium Nitrate	1486	35
Potassium Nitrate and Sodium Nitrite Mixture	1487	35
Potassium Nitrite	1488	35
Potassium Perchlorate	1489	35
Potassium Permanganate	1490	35
Potassium Peroxide	1491	47
Potassium Persulfate	1492	35
Potassium Phosphide	2012	41
Potassium Sodium Alloys	1422	40
Potassium Sulfide, anhydrous or with less than 30% of hydration	1382	32
Potassium Sulfide, hydrated, with not less than 30% water of hydration	1847	60
Potassium Superoxide	2466	47
Printing Ink, flammable	1210	26
Propadiene	2200	22
Propadiene, inhibited	2200	22
Propane	1978	22
Propane Mixtures	1978	22
Propanethiols	2402	27
Propanoic Acid	1848	60
n-Propanol	1274	26
Propargyl Alcohol	1986	28
Propionaldehyde	1275	26
Propionic Acid	1848	60
Propionic Anhydride	2496	29
Propionitrile	2404	28
Propionyl Chloride	1815	29
Propionyl Peroxide	2132	52
n-Propyl Acetate	1276	26
Propyl Alcohol	1274	26
Propylamine	1277	68
n-Propylbenzene	2364	26
Propyl Chloride	1278	26
n-Propyl Chloro-formate	**2740**	**57**
Propylene	1077	22
Propylene Chlorohydrin	2611	57

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
1,2-Propylene-diamine	2258	29
Propylene Dichloride	1279	27
Propylene Oxide	1280	26
Propylene Tetramer	2850	27
Propyleneimine, inhibited	1921	30
Propyl Formates	1281	26
n-Propyl Isocyanate	**2482**	**28**
Propyl Mercaptan	2402	27
n-Propyl Nitrate	1865	30
Propyltrichlorosilane	1816	29
Pyridine	1282	26
Pyrophoric Liquid, inorganic, n.o.s.	3194	37
Pyrophoric Liquid, organic, n.o.s.	2845	40
Pyrophoric Liquid, n.o.s.	2845	40
Pyrophoric Metals or Alloys, n.o.s.	1383	37
Pyrophoric Organo-metallic Compounds, n.o.s.	3203	37
Pyrophoric Solid, inorganic, n.o.s.	3200	37
Pyrophoric Solid, organic, n.o.s.	2846	37
Pyrosulfuryl Chloride	1817	39
Pyroxylin Plastic, rod, sheet, roll, tube or scrap	1325	32
Pyrrolidine	1922	29
Quinoline	2656	29
Radioactive Material, articles manufactured from natural or depleted uranium or natural thorium	2909	61
Radioactive Material, empty package - articles manufactured from natural or depleted uranium or thorium	2910	61
Radioactive Material, excepted package - articles manufactured from natural or depleted uranium or natural thorium	2910	61
Radioactive Material, excepted package - empty packaging	2910	61
Radioactive Material, excepted package - instruments or articles	2910	61
Radioactive Material, excepted package-limited quantity of material	2910	61
Radioactive Material, fissile, n.o.s.	2918	65
Radioactive Material, instruments and articles	2911	61
Radioactive Material, limited quantity, n.o.s.	2910	61
Radioactive Material, low specific (LSA), n.o.s.	2912	62
Radioactive Material, n.o.s.	2982	63
Radioactive Material, special form, n.o.s.	2974	64
Radioactive Material, surface contaminated objects (SCO)	2913	62
Rare Gases and Nitrogen Mixtures	1981	12
Rare Gases and Oxygen Mixtures	1980	14
Rare Gases, Mixtures	1979	12

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Receptacles, small, with flammable gas	2037	17
Red Phosphorus	1338	32
Reducing Liquid	1142	26
Refrigerant Gases, flammable, n.o.s.	1954	22
Refrigerant Gases, n.o.s.	1078	12
Refrigerating Machine	1993	27
Refrigerating Machines, containing flammable, non-poisonous, liquefied gas	1954	22
Refrigerating Machines, containing non-flammable, non-poisonous, liquefied gas	2857	21
Refrigerating Machines, containing non-flammable, non-toxic, liquefied gas or ammonia solutions (2073)	2857	21
Regulated Medical Waste, n.o.s.	3291	24
Regulated Medical Waste, n.o.s	9275	24
Removing Liquid	1142	26
Resin Solution, flammable	1866	26
Resin Solution (resin compound), liquid	1866	26
Resorcinol	2876	55
Road Asphalt, liquid	1999	27
Rosin Oil	1286	26
Rubber Scrap, powdered or granulated	1345	32
Rubber Shoddy, powedered or granulated	1345	32
Rubber Solution	1287	26
Rubidium	1423	40
Rubidium Hydroxide, solid	2678	60
Rubidium Hydroxide Solution	2677	60
Rubidium Metal	1423	40
Sea Coal	1361	32
Sea-Belt Modules	3268	31
Sea-Belt Pretensioners	3268	31
Seed cake, with more than 1.5% oil and not more than 11% moisture	1368	31
Seed cake, with not more than 1.5% oil and not more than 11% moisture	2217	31
Selenates and Selenites	2630	53
Selenic Acid	1905	59
Selenium, powder	2658	53
Selenium Compound, toxic, n.o.s.	3283	55
Selenium Disulfide	2657	55
Selenium Hexafluoride	**2194**	**15**
Selenium Oxide	2811	53
Selenium Oxychloride	2879	59
Self-Heating Liquid, corrosive, inorganic, n.o.s.	3188	38
Self-Heating Liquid, corrosive, organic, n.o.s.	3185	38
Self-Heating Liquid, inorganic, corrosive, n.o.s.	3188	38
Self-Heating Liquid, inorganic, n.o.s.	3186	37
Self-Heating Liquid, inorganic, poisonous, n.o.s.	3187	38

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Self-Heating Liquid, organic, corrosive, n.o.s.	3185	38
Self-Heating Liquid, organic, n.o.s.	3183	37
Self-Heating Liquid, organic, poisonous n.o.s.	3184	38
Self-Heating Liquid, toxic, inorganic, n.o.s.	3187	38
Self-Heating Liquid, toxic, organic, n.o.s.	3184	38
Self-Heating Metal Powder, n.o.s.	3189	37
Self-Heating Solid, corrosive, inorganic, n.o.s.	3192	38
Self-Heating Solid, corrosive, organic, n.o.s.	3126	47
Self-Heating Solid, inorganic, corrosive, n.o.s.	3192	38
Self-Heating Solid, inorganic, n.o.s.	3190	37
Self-Heating Solid, inorganic, poisonous, n.o.s.	3191	38
Self-Heating Solid, organic, n.o.s.	3088	37
Self-Heating Solid, organic, poisonous, n.o.s.	3128	34
Self-Heating Solid, oxidizing, n.o.s.	3127	47
Self-Heating Solid, toxic, inorganic, n.o.s.	3191	38
Self-Heating Solid, toxic, organic, n.o.s.	3128	34
Self-Heating Substance, solid, corrosive, n.o.s.	3126	47
Self-Heating Substance, solid, oxidizing, n.o.s.	3127	47
Self-Heating Substance, solid, poisonous, n.o.s.	3128	34
Self-Heating Substances, solid, n.o.s.	3088	37
Self-Reactive Liquid Type B	3221	49
Self-Reactive Liquid Type B, temperature controlled	3231	52
Self-Reactive Liquid Type C	3223	49
Self-Reactive Liquid Type C, temperature controlled	3233	52
Self-Reactive Liquid Type D	3225	48
Self-Reactive Liquid Type D, temperature controlled	3235	52
Self-Reactive Liquid Type E	3227	48
Self-Reactive Liquid Type E, temperature controlled	3237	52
Self-Reactive Liquid Type F	3229	48
Self-Reactive Liquid Type F, temperature controlled	3239	52
Self-Reactive Solid Type B	3222	49
Self-Reactive Solid Type B, temperature controlled	3232	52
Self-Reactive Solid Type C	3224	49
Self-Reactive Solid Type C, temperature controlled	3234	52
Self-Reactive Solid Type D	3226	48

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Self-Reactive Solid Type D, temperature controlled	3236	52
Self-Reactive Solid Type E	3228	48
Self-Reactive Solid Type E, temperature controlled	3238	52
Self-Reactive Solid Type F	3230	48
Self-Reactive Solid Type F, temperature controlled	3240	52
Self-Reactive Substances, samples, n.o.s.	3031	71
Self-Reactive Substances, trial quantities, n.o.s.	3032	71
Shale Oil	1288	27
Silane	2203	17
Silicofluoric Acid	1778	60
Silicon Chloride	1818	39
Silicon Powder, amorphous	1346	32
Silicon Tetrachloride	1818	39
Silicon Tetrafluoride	**1859**	**16**
Silver Arsenite	1683	53
Silver Cyanide	1684	53
Silver Nitrate	1493	45
Silver Picrate, wetted with not less than 30% water	1347	33
Sludge Acid	1906	60
Smokeless Powder, small arms	1325	32
Soda Lime	1907	60
Sodium	1428	40
Sodium Aluminate, solid	2812	60
Sodium Aluminate Solution	1819	60
Sodium Aluminum Hydride	2835	40
Sodium Ammonium Vanadate	2863	53
Sodium Arsanilate	2473	53
Sodium Arsenate	1685	53
Sodium Arsenite, aqueous solutions	1686	54
Sodium Arsenite, solid	2027	53
Sodium Azide	1687	56
Sodium Bifluoride, solid	2439	60
Sodium Bifluoride Solution	2439	60
Sodium Bisulfate Solution	2837	60
Sodium Bisulfite Solution	2693	60
Sodium Borohydride	1426	32
Sodium Bromate	1494	42
Sodium Cacodylate	1688	53
Sodium Chlorate	1495	35
Sodium Chlorate, aqueous solution	2428	31
Sodium Chlorite	1496	43
Sodium Chlorite Solution with more than 5% available chlorine	1908	60
Sodium Chloroacetate	2659	53
Sodium Cuprocyanide, solid	2316	53
Sodium Cuprocyanide Solution	2317	54
Sodium Cyanide	1689	55
Sodium 2-Diazo-1-Naphthol-4-Sulfonate	3040	72
Sodium 2-Diazo-1-Naphthol-5-Sulfonate	3041	72
Sodium Dichloroisocyanurate	2465	45

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Sodium Dichloro-S-Triazinetrione	2465	45
Sodium Dichromate	1479	35
Sodium Dinitro-ortho-Cresolate, wetted with not less than 155 water	1348	36
Sodium Dithionite	1384	37
Sodium Fluoride, solid	1690	54
Sodium Fluoride Solution	1690	54
Sodium Fluoroacetate	2629	53
Sodium Fluoro-silicate	2674	53
Sodium Hydrate	1824	60
Sodium Hydride	1427	40
Sodium Hydrogen Fluoride	2439	60
Sodium Hydrogen Sulfate, solid	1821	60
Sodium Hydrogen Sulfate Solution	2837	60
Sodium Hydrogen Difluoride	2439	60
Sodium Hydro-sulfide, solid with less than 25% of water crystallization	2318	34
Sodium Hydro-sulfide, with not less than 25% of water crystallization	2949	59
Sodium Hydrosulfide Solution	2922	59
Sodium Hydrosulfide Solution	2949	59
Sodium Hydrosulfite	1384	37
Sodium Hydroxide, dry, solid	1823	60
Sodium Hydroxide Solution	1824	60
Sodium Hypochlorite Solution	1791	60
Sodium Metal	1428	40
Sodium Methylate, dry	1431	40
Sodium Methylate, solutions in alcohol	1289	29
Sodium Methylate Solutions in alcohol	1289	29
Sodium Monoxide	1825	60
Sodium Nitrate	1498	35
Sodium Nitrate and Potassium Nitrate Mixtures	1499	35
Sodium Nitrite	1500	35
Sodium Nitrite and Potassium Nitrate Mixtures	1487	35
Sodium Pentachloro-phenate	2567	53
Sodium Percarbonate	2467	35
Sodium Perchlorate	1502	35
Sodium Permanganate	1503	35
Sodium Peroxide	1504	47
Sodium Peroxo-borate, Anhydrous	3247	35
Sodium Persulfate	1505	35
Sodium Phenolate, solid	2497	60
Sodium Phosphide	1432	41
Sodium Picramate, wetted with not less than 20% water	1349	33
Sodium Potassium Alloys	1422	40
Sodium Selenite	2630	53
Sodium Sulfide, anhydrous or with less than 30% water of crystallization	1385	34

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Sodium Sulfide, hydrated, with not less than 30%	1849	60
Sodium Sulfide Solution	1849	60
Sodium Superoxide	2547	47
Solids Containing Corrosive Liquid, n.o.s.	3244	60
Solids Containing Flammable Liquid, n.o.s.	3175	32
Solids Containing Poisonous Liquid, n.o.s.	3243	55
Solids Containing Toxic Liquid, n.o.s.	3243	55
Spirits of Nitroglycerine	1204	26
Stannic Chloride, anhydrous	1827	39
Stannic Chloride, hydrated	2440	60
Stannic Phosphide	1433	41
Stannous Chloride, solid	1759	60
Stibine	**2676**	**18**
Strontium Arsenite	1691	53
Strontium Chlorate, solid or solution	1506	35
Strontium Nitrate	1507	35
Strontium Perchlorate	1508	35
Strontium Peroxide	1509	47
Strontium Phosphide	2013	41
Strychnine, and salts	1692	53
Styrene Monomer, inhibited	2055	27
Substances which in contact with water emit Flammable Gases, liquid, corrosive, n.o.s.	3129	39
Substances which in contact with water emit Flammable Gases, liquid, n.o.s.	3148	40
Substances which in contact with water emit Flammable Gases, liquid, poisonous, n.o.s.	3130	39
Substances which in contact with water emit Flammable Gases, solid, corrosive, n.o.s.	3131	40
Substances which in contact with water emit Flammable Gases, solid, flammable, n.o.s.	3132	40
Substances which in contact with water emit Flammable Gases, solid, oxidizing, n.o.s.	3133	40
Substances which in contact with water emit Flammable Gases, solid, poisonous, n.o.s.	3134	40
Substances which in contact with water emit Flammable Gases, solid, self-heating, n.o.s.	3135	40
Substances which in contact with water emit Flammable Gases, solid, n.o.s.	2813	40
Substituted Nitrophenol Pesticides, liquid, flammable, toxic, n.o.s.	2780	28
Substituted Nitrophenol Pesticides, liquid, toxic, flammable, n.o.s.	3013	28
Substituted Nitrophenol Pesticides, liquid, toxic, n.o.s.	3014	55

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Substituted Nitrophenol Pesticides, solid, toxic, n.o.s.	2779	53
Succinic Acid Peroxide, technical pure	2135	49
Sulfamic Acid	2967	60
Sulfur	1350	32
Sulfur, molten	2448	32
Sulfur Chlorides	**1828**	**39**
Sulfur Dioxide	**1079**	**16**
Sulfur Dioxide, liquefied	**1079**	**60**
Sulfur Hexafluoride	1080	12
Sulfur Tetrafluoride	**2418**	**15**
Sulfur Trioxide	**1829**	**39**
Sulfur Trioxide, inhibited	**1829**	**39**
Sulfur Trioxide, uninhibited	**1829**	**39**
Sulfuric Acid	1830	39
Sulfuric Acid, fuming, with less than 30% free sulfur trioxide	1831	39
Sulfuric Acid, spent	1832	39
Sulfuric Acid with not more than 51% acid	2796	39
Sulfuric and Hydrofluoric Acid Mixture	1786	59
Sulfuric Anhydride	**1829**	**39**
Sulfurous Acid	1833	60
Sulfuryl Chloride	**1834**	**39**
Sulfuryl Fluoride	**2191**	**15**
2,4,5-T	2765	55
Tars, liquid	1999	27
TDE (1,1-Dichloro-2,2-bis-(p-chlorophenyl)ethane)	2761	55
Tear Gas Candles	1700	58
Tear Gas Devices	1693	58
Tear Gas Substances, liquid or solid, n.o.s.	1693	58
Tellurium Compound, toxic, n.o.s.	3284	55
Tellurium Hexafluoride	**2195**	**15**
Terpene Hydrocarbons, n.o.s.	2319	27
Terpinolene	2541	27
Tetrabromoethane	2504	58
Tetrachloroethane	1702	55
1,12,2-Tetrachloroethane	1702	55
Tetrachloroethylene	1897	74
Tetraethylammonium Perchlorate, dry	1325	32
Tetraethyl Dithiopyrophosphate compressed gas mixture	**1703**	**15**
Tetraethyl Dithiopyrophosphate and gases, mixtures, or in solution (LC50 more than 200ppm but not more than 5000ppm)	**1703**	**15**
Tetraethyl Dithiopyrophosphate and gases, mixtures, or in solution (LC50 not more than 200ppm)	**1703**	**15**
Tetraethyl Dithiopyrophosphate, dry, liquid or mixture	1704	55
Tetraethylenepentamine	2320	60
Tetraethyl Lead, liquid	1649	56
Tetraethyl Pyrophosphate and compressed gas mixture	**1705**	**15**

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Tetraethyl Pyrophosphate and compressed gas mixtures (LC50 more than 200ppm but not more than 5000ppm)	**1705**	**15**
Tetraethyl Pyrophosphate and compressed gas mixtures (LC50 not more than 200ppm)	**1705**	**15**
Tetraethyl Pyrophosphate, liquid	3018	55
Tetraethyl Pyrophosphate, solid	2783	55
Tetraethyl Silicate	1292	29
Tetrafluoroethane	3159	12
1,1,2,2-Tetrafluoroethane	3159	12
Tetrafluoroethylene, inhibited	1081	17
Tetrafluoromethane	1982	12
1,2,3,6-Tetrahydrobenzaldehyde	2498	29
Tetrahydrofuran	2056	26
Tetrahydrofurfurylamine	2943	26
Tetrahydrophthalic Anhydrides	2698	60
1,2,3,6-Tetrahydropyridine	2410	26
Tetrahydrothiophene	2412	26
Tetralin Hydroperoxide, technical pure	2136	48
Tetramethyl Ammonium Hydroxide	1835	60
1,1,3,3-Tetramethylbutyl Hydroperoxide, technical pure	2160	48
1,1,3,3-Tetramethylbutylperoxy-2-Ethyl Hexanoate, technical pure	2161	52
Tetramethylmethylenediamine	9069	29
Tetramethyl Silane	2749	29
Tetranitromethane	**1510**	**47**
Tetrapropyl-ortho-Titanate	2413	27
Textile Treating Compound	1760	60
Thallium Chlorate	2573	42
Thallium Compound, n.o.s.	2573	42
Thallium Nitrate	2727	42
Thallium Salt, n.o.s.	1707	53
Thallium Sulfate, solid	1707	53
Thia-4-Pentanal	2785	55
Thioacetic Acid	2436	26
Thioglycol	2966	53
Thioglycolic Acid	1940	60
Thionyl Chloride	1836	39
Thiophene	2414	27
Thiophosgene	**2474**	**55**
Thiophosphoryl Chloride	1837	60
Thiram	2771	55
Thorium Metal, pyrophoric	2975	61
Thorium Nitrate, solid	2976	61
Tin Chloride, fuming	1827	39
Tin Tetrachloride	1827	39
Tinctures, medicinical	1293	26
Titanium, metal, powder, dry	2546	37
Titanium, metal, powder, wet with not less than 20% water	1352	32
TitaniumDisulfide	3174	37
Titanium Hydride	1871	32
Titanium Powder, dry	2546	37

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Titanium Powder, wetted with not less than 25% water	1352	32
Titanium Sponge, granules or powder	2878	32
Titanium Sulfate Solution	1760	60
Titanium Tetrachloride	**1838**	**39**
Titanium Trichloride, pyrophoric	2441	37
Titanium Trichloride Mixtures	2869	60
Titanium Trichloride Mixtures, pyrophoric	2441	37
Toe Puff, nitrocellulose base	1353	32
Toluene	1294	27
2,4-Toluenediamine	1709	53
Toluene Diisocyanate (T.D.I.)	2078	54
Toluene Sulfonic Acid, liquid with more than 5% free sulfuric acid	2584	60
Toluene Sulfonic Acid, liquid with not more than 5% free sulfuric acid	2586	60
Toluene Sulfonic Acid, solid with more than 5% free sulfuric acid	2583	60
Toluene Sulfonic Acid, solid with more than 5% free sulfuric acid	2585	60
Toludines	1708	55
2,4-Toluyenediamine	1709	53
Toxaphene	2761	55
Toxic Liquid, corrosive, inorganic, n.o.s.	**3289**	**59**
Toxic Liquid, corrosive, organic, n.o.s	**2927**	**59**
Toxic Liquid, flammable, inorganic, n.o.s	**2929**	**57**
Toxic Liquid, inorganic, n.o.s	3287	55
Toxic Liquid, organic, n.o.s	**2810**	**55**
Toxic Liquid, oxidizing, n.os.	**3122**	**44**
Toxic Liquid, water-reactive, n.o.s	**3123**	**40**
Toxic Solid, corrosive, inorganic, n.o.s.	3290	59
Toxic Solid, corrosive, organic, n.o.s.	2928	59
Toxic Solid, flammable, organic, n.o.s.	2930	34
Toxic Solid, inorganic, n.o.s.	3288	53
Toxic Solid, organic, n.o.s.	2811	53
Toxic Solid, oxidizing, n.o.s.	3086	42
Toxic Solid, self-heating, n.o.s.	3124	34
Toxic Solid, water-reactive, n.o.s.	3125	34
Toxins, extracted from living sources, n.o.s.	3172	55
2,4,5-TP	2765	55
Triallyl Borate	2609	55
Triallylamine	2610	29
Triazine Pesticides, liquid, flammable, toxic, n.o.s.	2764	28

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Triazine Pesticides, liquid, toxic, flammable, n.o.s.	2997	28
Triazine Pesticides, liquid, toxic, n.o.s.	2998	55
Triazine Pesticides, solid, toxic, n.o.s.	2763	55
Tri(1-Aziridinyl) phosphine Oxide	2501	55
Tributylamine	2542	68
Tributylphosphane	3254	37
Trichlorfon	2783	55
Trichloroacetic Acid	1839	59
Trichloroacetic Acid Solution	2564	59
Trichloroacetyl Chloride	**2442**	**59**
Trichlorobenzenes, liquid	2321	54
Trichlorobutene	2322	54
1,1,1-Trichloro-ethane	2831	74
Trichloroethylene	1710	74
Trichloroisocyanuric Acid dry	2468	45
Trichlorophenol	2020	53
2,4,5-Trichloro-phenoxyacetic	2765	55
2,4,5-Trichloro-phenoxypropionic Acid	2765	55
Trichlorosilane	1295	38
Trichloro-S-triazine-trione, dry	2468	45
Tricresylphosphate	2574	5
Triethylamine	1296	68
Triethyl Phosphite	2323	26
Triethylene Tetramine	2259	60
Trifluoroacetic Acid	2699	60
Trifluoroacetyl Chloride	**3057**	**16**
Trifluorochloro-ethylene	**1082**	**18**
Trifluorochloro-ethylene, inhibited	**1082**	**18**
Trifluorochloro-methane	1022	12
Trifluorochloro-ethane, compressed	2035	22
Trifluoromethane refrigerated liquid (cryogenic liquid)	3136	21
Trifluoromethane and Chlorotrifluorometha ne Mixture	2599	12
2-Trifluoromethyl-aniline	2942	55
3-Trifluoromethyl-aniline	2948	55
Triisobutylene	2324	27
Triisocyanatoiso-cyanurate of Iso-phoronediisocyanate, 70% solution	2906	26
Triisopropyl Borate	2616	26
Trimethoxysilane	**9269**	**57**
Trimethylacetyl Chloride	**2438**	**29**
Trimethylamine, anhydrous	1083	19
Trimethylamine, aqueous solution	1297	29
1,3,5-Trimethyl-benzene	2325	26
Trimethyl Borate	2416	26
Trimethylchloro-silane	1298	29
Trimethylcyclohexyl-amine	2326	29
Trimethylhexa-methylenediamines	2327	60
Trimethylhexa-methylenediiso-cyanate	2328	53

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Trimethyl Phosphite	2329	26
Trinitrobenzene, wet	1354	33
Trinitrobenzene, wetted with not less than 30% water	1354	33
Trinitrobenzoic Acid, wet	1355	33
Trinitrobenzoic Acid, wetted with not less than 30% water	1355	33
Trinitrophenol, wet	1344	33
Trinitrophenol, wetted with not less than 30% water	1344	33
Trinitrotoluene, wet	1356	33
Trinitrotoluene, wetted with not less than 30% water	1356	33
Tripropylamine	2260	68
Tripropylene	2057	27
Tris(1-Aziridinyl) phosphine Oxide	2501	55
Tungsten Hexafluoride	**2196**	**15**
Turpentine	1299	27
Turpentine Substitute	1300	27
Undecane	2330	27
Uranium Hexafluoride, fissile (containing more than 1.0% U-235)	2977	66
Uranium Hexafluoride, fissile excepted or non-fissile	2978	66
Uranium Hexafluoride, low specific activity	2978	66
Uranium Metal, pyrophoric	2979	61
Uranium Nitrate Hexahydrate Solution	2980	61
Uranyl Acetate	9180	62
Uranyl Nitrate, solid	2981	61
Urea Hydrogen Peroxide	1511	35
Urea Nitrate, wet	1357	33
Urea Nitrate, wetted with not less than 20% water	1357	33
Urea Peroxide	1511	35
Valeraldehyde	2058	26
Valeric Acid, (n-Pentanoic Acid)	1760	60
Valeryl Chloride	2502	29
Vanadium Compound, toxic, n.o.s.	3285	55
Vanadium Oxytrichloride	2443	39
Vanadium Oxytrichloride and Titanium Tetra-chloride Mixture	2443	29
Vanadium Pentoxide	2862	53
Vanadium Tetrachloride	2444	39
Vanadium trichloride	2475	60
Vanadium Sulfate	2931	55
Vinyl Acetate	1301	26
Vinyl Acetate, inhibited	1301	26
Vinyl Bromide, inhibited	1085	26
Vinyl Butyl Ether	1304	26
Vinyl Butyrate, inhibited	2838	26
Vinyl Chloride	1086	17
Vinyl Chloride, inhibited	1086	17
Vinyl Chloride, stabilized	1086	17
Vinyl Chloroacetate	2589	57
Vinyl Ethyl Ether	1302	26
Vinyl Ethyl Ether, inhibited	1302	26

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Vinyl Fluoride, inhibited	1860	17
Vinyldene Chloride, inhibited	1303	26
Vinyl Isobutyl Ether	1304	26
Vinyl Isobutyl Ether, inhibited	1304	26
Vinyl Methyl Ether	1087	17
Vinyl Methyl Ether, inhibited	1087	17
Vinyl Pyridines, inhibited	3073	57
Vinyl Toluene, inhibited	2618	27
Vinyl Trichlorosilane	1305	29
Water-Reactive Liquid, corrosive, n.o.s.	3129	39
Water-Reactive Liquid, n.o.s.	3148	40
Water-Reactive Liquid, poisonous, n.o.s.	3130	39
Water-Reactive Liquid, toxic, n.o.s.	3130	39
Water-Reactive Solid, corrosive, n.o.s.	3131	40
Water-Reactive Solid, flammable, n.o.s.	3132	40
Water-Reactive Solid, n.o.s.	2813	40
Water-Reactive Solid, oxidizing, n.o.s.	3133	40
Water-Reactive Solid, poisonous, n.o.s.	3134	40
Water-Reactive Solid, self-heating, n.o.s.	3135	40
Water-Reactive Solid, toxic, n.o.s.	3134	40
Wheelchair, Electric with batteries	3171	60
White Asbestos	2590	31
White Phosphorus, dry	1381	38
White Phosphorus, wet	1381	38
Wood Preservatives, liquid	1306	26
Xenon	2036	12
Xenon, refrigerated liquid (cryogenic liquid)	2591	21
Xylenes, (Xylol)	1307	27
Xylenols	2261	55
Xylidines	1711	55
Xylyl Bromide	1701	55
Yellow Phosphorus, dry	1381	38
Yellow Phosphorus, wet	1381	38
Zinc Ammonium Nitrite	1512	35
Zinc Arsenate	1712	53
Zinc Arsenate and Zinc Arsenite Mixtures	1712	53
Zinc Arsenite	1712	53
Zinc Ashes	1435	40
Zinc Bromate	2469	35
Zinc Chlorate	1513	35
Zinc Chloride, anhydrous	2331	60
Zinc Chloride Solution	1840	60
Zinc Cyanide	1713	53
Zinc Dithionite	1931	32
Zinc Fluorosilicate	2855	53
Zinc Hydrosulfite	1931	332
Zinc Metal, powder or dust	1436	76
Zinc Nitrate	1514	35
Zinc Permanganate	1515	35
Zinc Peroxide	1516	47
Zinc Phosphide	1714	41

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Zinc Picramate, wetted with not less than 20% water	1517	33
Zinc Powder, wetted with not less than 25% water	1358	32
Zinc Powder or Dust	1436	76
Zinc Resinate	2714	32
Zirconium, dry, wire, sheet, or strips	2009	37
Zirconium, dry, wire, sheet, or strips (thinner than 254 microns but not thinner than 18 microns)	2858	32
Zirconium Hydride	1437	40
Zirconium Metal, liquid suspension	1308	26
Zirconium Metal, powder, dry	2008	37
Zirconium Metal, powder, wet	1358	32
Zirconium Nitrate	2728	35
Zirconium Picramate, wet	1517	33
Zirconium Powder, dry	2008	37
Zirconium Powder, wet	1358	32
Zirconium Scrap	1932	32
Zirconium Sulfate	9163	31
Zirconium Suspended in a liquid	1308	26
Zirconium Tetrachloride	2503	39

EMERGENCY RESPONSE FACT SHEETS

The following are Guides on the potential hazards and emergency response actions for a generic class of chemicals. The Guide number (recommended by the U.S. Department of Transportation) corresponds to the chemicals listed in the previous section. For example, if we were dealing with the chemical Zirconium Sulfate (UN designation 9163), the chemical's fact sheet is Guide number 31, which provides appropriate emergency response information.

GUIDE 11

POTENTIAL HAZARDS

Fire or Explosion Hazards

Flammable/combustible material; may be ignited by heat, sparks or flames.
May ignite other combustible materials (wood, paper, oil, etc.).
Container may explode in heat or fire.
Reaction with fuels may be violent.

Runoff to sewer may create fire or explosion hazard.

Health Hazards
May be fatal if inhaled, swallowed or absorbed through skin.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Do not touch or walk through spilled material.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike far ahead of liquid spill for later disposal.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 12

POTENTIAL HAZARDS

Fire or Explosion Hazards
Some of these materials may burn, but none of them ignites readily.
Cylinder may explode in heat or fire.

Health Hazards
Vapors may cause dizziness or suffocation.
Contact with liquid may cause frostbite.
Fire may produce irritating or poisonous gases.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

Fire
Small fires: Dry chemical or CO_2.
Large fires: Water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire. Some of these materials, if spilled, may evaporate leaving a flammable residue

Spill or leak
Stop leak if you can do it without risk.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.

GUIDE 13

POTENTIAL HAZARDS

Health Hazards
Poison: **extremely hazardous.**
May be fatal if inhaled or absorbed through skin.
Initial odor may be irritating, foul or absent and may deaden your sense of smell.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
Some of these materials are **extremely flammable.**
May be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Cylinder may explode in heat or fire.
Vapor explosion and poison hazard indoors, outdoors or in sewers.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
See Chapter 7 which provides information on Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

Fire
Small fires: Let burn unless leak can be stopped immediately.
Large fires: Water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.
Cool container with water using unmanned device until well after fire is out.
Isolate area until gas has dispersed.
Hydrogen Cyanide Fires: Let burn unless leak can be stopped immediately.

Spill or leak
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Shut off ignition sources; no flares, smoking or flames in hazard area.
Use water spray to reduce vapor; **do not** put water directly on leak or spill area.
Isolate area until gas has dispersed.

For **hydrogen cyanide,** consider igniting spill or leak to eliminate toxic gas concerns.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 14

POTENTIAL HAZARDS

Fire or Explosion
May ignite other combustible materials (wood, paper, oil, etc.).
Mixture with fuels may explode.
Cylinder may explode in heat or fire.
Vapor explosion hazard indoors, outdoors or in sewers.

Health Hazards
Contact with liquid may cause frostbite.
Vapors may cause dizziness or suffocation.
Fire may produce irritating or poisonous gases.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.

Fire
Small fires: Dry chemical or CO_2.
Large fires: Water spray, fog or regular foam.

Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak
Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Stop leak if you can do it without risk.
Isolate area until gas has dispersed.

First aid
Move victim to fresh air; call emergency medical core.
Keep victim quiet and maintain normal body temperature.

GUIDE 15

POTENTIAL HAZARDS

Health Hazards
Poisonous; may be fatal if inhaled or absorbed through skin.
Contact may cause burns to skin and eyes.
Contact with liquid may cause frostbite.
Clothing frozen to the skin should be thawed before being removed.
Run off from fire control or dilution water may cause pollution.

Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
Cylinder may explode in heat or fire.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.

Fire
Small fires: Dry chemical or CO_2.
Large fires: Water spray, fog or regular foam.
Do not get water inside container.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
Isolate area until gas has dispersed.

Spill or leak
Stop leak if you can do it without risk.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Use water spray to reduce vapor; do not put water directly on leak or spill area.
Small spills: flush area with flooding amounts of water.
Large spills: dike far ahead of liquid spill for later disposal.
Do not get water inside container.
Isolate area until gas has dispersed.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 16

POTENTIAL HAZARDS

Health Hazards
May be poisonous if inhaled.
Vapor **extremely irritating.**
Contact may cause burns to skin and eyes.
Contact with liquid may cause frostbite.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
Cylinder may explode in heat or fire.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed space before entering.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.

Fire
Small fires: Dry chemical or CO_2.
Large fires: Water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
Isolate area until gas has dispersed.

Spill or leak
Stop leak if you can do it without risk.
Use water spray to reduce vapor; **do not** put water directly on leak or spill area.
Isolate area until gas has dispersed.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 17

POTENTIAL HAZARDS

Fire or Explosion
Extremely flammable.
May be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode violently in heat or fire.
Vapor explosion hazard indoors, outdoors or in sewers.

Health Hazards
May be poisonous it inhaled.
Contact may cause burns lo skin and eyes.
Vapors may cause dizziness or suffocation.
Contact with liquid may cause frostbite.
Fire may produce irritating or poisonous gases.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

Fire
Let tank, tank car or tank truck burn unless leak can be slopped; with smaller tanks or cylinders, extinguish/isolate from other flammables.
Small fires: dry chemical or CO_2.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.
Cool container with water using unmanned device until well after fire is out.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Stop leak if you can do it without risk.
Water spray may reduce vapor; but it may not prevent ignition in closed spaces.
Isolate area until gas has dispersed.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of frostbite, thaw frosted parts with water.
Keep victim quiet and maintain normal body temperature.

GUIDE 18

POTENTIAL HAZARDS

Health Hazards
Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.
Contact causes burns to skin and eyes.
Contact with liquid may cause frostbite.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
Extremely flammable; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat or fire.
Vapor explosion and poison hazard indoors, outdoors or in sewers.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: let burn unless leak can be stopped immediately.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Fully encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Stop leak if you can do it without risk.
Use water spray to reduce vapors; isolate area until gas has dispersed.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 19

POTENTIAL HAZARDS

Fire or Explosion
Extremely flammable; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat or fire.
Vapor explosion hazard indoors, outdoors or in sewers.

Health Hazards
May be poisonous if inhaled.
Vapor **extremely irritating;** contact causes burns to skin and eyes.
Contact with liquid may cause frostbite.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing may provide limited protection.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
If water pollution occurs, notify the appropriate authorities.

Fire
Let tank, tank car or tank truck burn unless leak can be stopped; with smaller tanks or cylinders, extinguish/isolate from other flammables.
Small fires: dry chemical or CO_2.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Stop leak if you con do it without risk.
Use water spray to reduce vapors; isolate area until gas has dispersed.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 20

POTENTIAL HAZARDS

Health Hazards
Poisonous; may be fatal if inhaled.
Contact may cause burns to skin and eyes.
Contact with liquid may cause frostbite.
Runoff from fire control or dilution water may cause pollution

Fire or Explosion
May ignite other combustible materials (wood, paper, oil, etc.).
Mixture with fuels may explode.
Cylinder may explode in heat of fire.
Vapor explosion and poison hazard indoors, outdoors or in sewers.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: **water only; no dry chemical, CO_2 or halon.**
Contain and let burn. If fire must be fought, water spray or fog is recommended.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Stop leak if you can do it without risk.
Water spray may be used to reduce or direct vapors.
Isolate area until gas has dispersed.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation

GUIDE 21

POTENTIAL HAZARDS

Fire or Explosion
Cannot catch fire.
Container may explode in heat of fire.

Health Hazards
Vapors may cause dizziness or suffocation.
Contact with liquid may cause frostbite.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

Fire
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

Spill or leak
Do not touch or walk through spilled material.
Stop leak if you can do it without risk.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of frostbite, thaw frosted parts with water.
Keep victim quiet and maintain normal body temperature.

GUIDE 22

POTENTIAL HAZARDS

Fire or Explosion
Extremely flammable; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.

Container may explode in heat of fire.
Vapor explosion hazard indoors, outdoors or in sewers.

Health Hazards
Vapors may cause dizziness or suffocation.
Contact will cause severe frostbite.
Fire may produce irritating or poisonous gases.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

Fire
Let tank, tank car or tank truck burn unless leak can be stopped; with smaller tanks or cylinders, extinguish/isolate from other flammables.
Small fires: dry chemical or CO_2.
Large fires: water spray or fog.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Use water spray to reduce vapors; isolate area until gas has dispersed.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of frostbite, thaw frosted parts with water.
Keep victim quiet and maintain normal body temperature.

GUIDE 23

POTENTIAL HAZARDS

Fire or Explosion
May ignite other combustible materials (wood, paper, oil, etc.).
Mixture with fuels may explode.
Container may explode in heat of fire.
Vapor explosion hazard indoors, outdoors or in sewers.

Health Hazards
Vapors may cause dizziness or suffocation.
Contact will cause severe frostbite.
Fire may produce irritating or poisonous gases.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

Fire
Small fires: dry chemical or CO_2.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak
Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Do not touch or walk through spilled material.
Stop leak if you can do it without risk.
Isolate area until gas has dispersed.

First aid
Move victim to fresh air; call emergency medical care.
Remove and isolate contaminated clothing and shoes at the site.
In case of frostbite, thaw frosted parts with water.
Keep victim quiet and maintain normal body temperature.

GUIDE 24

POTENTIAL HAZARDS

Health Hazards
Contact with material may cause infection and disease.
If inhaled, may be harmful.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
May be ignited if carrier liquid is flammable.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: dry chemical, soda ash, lime or sand.
Use extinguishing agent suitable for type of surrounding fire.
Move container from fire area if you can do it without risk.
Do not scatter spilled material with high-pressure water streams.

Spill or leak
Do not touch or walk through spilled material.
Do not touch damaged containers or spilled material.
Damage to outer container may not affect primary inner container.
If inner container damaged or leaking, cover with damp towel or rag and keep wet with liquid bleach.
Spills: dike for later disposal; do not apply water unless directed to do so.
Cleanup only under supervision of an expert.

First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.
Effects of exposure (inhalation, ingestion or skin contact) to material may be delayed.

GUIDE 25

POTENTIAL HAZARDS

Health Hazards
Poisonous; may be fatal if inhaled.
Vapor **extremely irritating.**
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
May ignite other combustible materials (wood, paper, oil, etc.).
Mixture with fuels may explode.
Container may explode in heat of fire.
Vapor explosion and poison hazard indoors, outdoors or in sewers.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection. Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action. If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: dry chemical, soda ash, lime or sand.
Large fires: water spray, fog (flooding amounts).
Do not get solid stream of water on spilled material.
Do not get water inside container.
Move container from fire area if you can do it without risk.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak
If you have not donned special protective clothing approved for this material, do not expose yourself to any risk of this material touching you.
Stop leak if you can do it without risk.
Use water spray to reduce vapor; do not put water directly on leak or spill area.

Isolate area until gas has dispersed.
A fine water spray remotely directed to the edge of the spill pool can be used to direct and maintain a hot flare fire which will burn the spilled material in a controlled manner.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 26

POTENTIAL HAZARDS

Fire or Explosion
Flammable/combustible material; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat of fire.
Vapor explosion hazard indoors, outdoors or in sewers.
Runoff to sewer may create fire or explosion hazard.

Health Hazards
May be poisonous if inhaled or absorbed through skin.
Vapors may cause dizziness or suffocation.
Contact may irritate or burn skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may give off poisonous gases and cause water pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: dry chemical, CO_2, water spray or alcohol-resistant foam.
Do not use dry chemical extinguishers to control fires involving nitromethane or nitroethane.
Large fires: water spray, fog or alcohol-resistant foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Stop leak if you can do it without risk.
Water spray may reduce vapor; but it may not prevent ignition in closed spaces.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike far ahead of liquid spill for later disposal.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 27

POTENTIAL HAZARDS

Fire or Explosion
Flammable/combustible material; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat of fire.
Vapor explosion hazard indoors, outdoors or in sewers.
Runoff to sewer may create fire or explosion hazard.
Material may be transported hot.

Health Hazards
May be poisonous if inhaled or absorbed through skin.
Vapors may cause dizziness or suffocation.
Fire may produce irritating or poisonous gases.

Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.
Stop leak if you can do it without risk.
Water spray may reduce vapor; but it may not prevent ignition in closed spaces.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike far ahead of liquid spilt for later disposal.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 28

POTENTIAL HAZARDS

Health Hazards
Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
Flammable/combustible material; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat of fire.
Vapor explosion and poison hazard indoors, outdoors or in sewers.
Runoff to sewer may create fire or explosion hazard.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection
Structural firefighters' protective clothing is not effective for these materials.
See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

Fire
Small fires: dry chemical, CO_2, water spray or alcohol-resistant foam.
Large fires: water spray, fog or alcohol -resistant foam.
Move container from fire area if you can do it without risk.
Dike fire control water for later disposal; do not scatter the material.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Do not touch or walk through spilled material; stop leak if you can do it without risk.

Water spray may reduce vapor; but it may not prevent ignition in closed spaces.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike far ahead of liquid spill for later disposal.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 29

POTENTIAL HAZARDS

Fire or Explosion
Flammable/combustible material; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat of fire.
Vapor explosion hazard indoors, outdoors or in sewers.
Runoff to sewer may create fire or explosion hazard.

Health Hazards
May be poisonous if inhaled.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
If water pollution occurs, notify the appropriate authorities.

Fire
Some of these materials may react violently with water.
Small fires: dry chemical, H_2O, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Do not get water inside container.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Use water spray to reduce vapor; do not get water inside container.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike far ahead of liquid spill for later disposal.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 30

POTENTIAL HAZARDS

Health Hazards
Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
Extremely flammable; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode violently in heat of fire.
Vapor explosion and poison hazard indoors, outdoors or in sewer
Runoff to sewer may create fire or explosion hazard.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

Fire

Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Do not get water inside container.
Apply cooling water to sides of containers that are exposed to after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Do not touch or walk through spilled material.
Small spills: flush area with flooding amounts of water.
Large spills: dike far ahead of liquid spill for later disposal.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 31

POTENTIAL HAZARDS

Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
Material may be transported hot.

Health Hazards
Contact may cause burns lo skin and eyes.
Inhalation of asbestos dust may have a damaging effect on the lungs.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Do not scatter spilled material with high-pressure water streams.
Dike fire control water for later disposal.

Spill or leak
Stop leak if you can do it without risk.
Avoid inhalation of asbestos dust.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike far ahead of liquid spill for later disposal.
Cover powder spill with plastic sheet or tarp to minimize spreading.

First aid
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 32

POTENTIAL HAZARDS

Fire or Explosion

Flammable/combustible material; may be ignited by heat, sparks or flames.
May burn rapidly with flare-burning effect.
Material may be transported in a molten form.

Health Hazards

Fire may produce irritating or poisonous gases.
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: dry chemical, sand, earth, water spray or regular foam
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles.
Magnesium fires: use dry sand, sodium chloride powder or graphite powder.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: wet down with water and dike for later disposal.

First aid

Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.

Removal of solidified molten material from skin requires medical assistance.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 33

POTENTIAL HAZARDS

Fire or Explosion
Flammable/combustible material; may be ignited by heat, sparks or flames.
Dried out material may explode if exposed to heat, flame or shock; keep material wet with water or treat it as an explosive (refer to Guide 46).
Runoff to sewer may create fire or explosion hazard.

Health Hazards
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire
Tire fires: flood with water; if no water is available, use dry chemical or dirt. Caution: tire fires may start again.
Do not move cargo or vehicle if cargo has been exposed to heat.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
Small spills: flush area with flooding amounts of water.
Large spills: wet down with water and dike for later disposal.

First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 34

POTENTIAL HAZARDS

Fire or Explosion
Flammable/combustible material; may be ignited by heat, sparks or flames.
May burn rapidly with flare-burning effect.

Health Hazards
Poisonous if swallowed.
Skin contact poisonous.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: dry chemical, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Dike fire control water for later disposal; do not scatter the material.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: wet down with water and dike for later disposal.

First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 35

POTENTIAL HAZARDS

Fire or Explosion
May ignite other combustible materials (wood, paper, oil, etc.).
These materials will accelerate burning when they are involved in a fire; some may react violently with fuels.
Runoff to sewer may create fire or explosion hazard.

Health Hazards
Contact may cause burns to skin and eyes.
Vapors or dust may be irritating.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: water only; no dry chemical, CO_2 or halon
Large fires: flood fire area with water from a distance.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers exposed to flames until well after fire is out.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak
Do not touch or walk through spilled material.
Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Small liquid spills: take up with sand, earth or other noncombustible absorbent material.
Large spills: dike far ahead of liquid spill for later disposal.

First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 36

POTENTIAL HAZARDS

Fire or Explosion
Flammable/combustible material; may be ignited by heat, sparks or flames.
Dried out material may explode if exposed to heat, flame or shock; keep material wet with water or treat it as an explosive (refer to Guide 46).
Runoff to sewer may create fire or explosion hazard.

Health Hazards
Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing may provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire
Tire fires: flood with water; if no water is available, use dry chemical or dirt. Caution: tire fires may start again.
Do not move cargo or vehicle if cargo has been exposed to heat.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
Small spills: flush area with flooding amounts of water.
Large spills: wet down with water and dike for later disposal.

First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 37

POTENTIAL HAZARDS

Fire or Explosion
Flammable/combustible material.
May ignite itself if exposed to air.
May re-ignite after fire is extinguished.
May burn rapidly with flare-burning effect.
Runoff to sewer may create fire or explosion hazard.

Health Hazards
If inhaled, may be harmful.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire
Some of these materials may react violently with water.
Hydrosulfite fires: use flooding quantities of water for any size fire.
Small fires: dry chemical, soda ash, lime or sand.
Large fires: flood fire area with water from a distance.
Do not get water inside container.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak
Do not touch or walk through spilled material; stop leak if you can do if without risk.
Do not get water inside container.
Small spills: flush area with flooding amounts of water.
Large spills: dike liquid spill for later disposal.

First aid
Move victim lo fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 38

POTENTIAL HAZARDS

Fire or Explosion
Extremely flammable; will ignite itself if exposed to air.
Will re-ignite itself after fire is extinguished.
Burns rapidly, releasing dense, white, irritating fumes.
Runoff to sewer may create fire or explosion hazard.
Material may be transported in a molten form.

Health Hazards
Poisonous if swallowed or if fumes from fire are inhaled repeatedly.
Contact causes burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing may provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: dry chemical, sand, earth or water spray.
Large fires: water spray or fog.
Do not scatter spilled material with high-pressure water streams.
Move container from fire area if you can do it without risk.
Apply cooling wafer to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak
Do not touch or walk through spilled material; stop leak if you can do it without risk.

Water spray may reduce vapor; but it may not prevent ignition in closed spaces.
Small spills: cover with water, sand or earth. Shovel into metal container and keep material under water.
Large spills: dike for later disposal and cover with wet sand or earth.
Cleanup only under supervision of an expert.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, keep exposed skin areas immersed in water or covered with wet bandages until medical attention is received.
Remove and isolate contaminated clothing and shoes at the site and place in metal container filled with water. Fire hazard if allowed to dry.
Effects may be delayed; keep victim under observation.

GUIDE 39

POTENTIAL HAZARDS

Health Hazards
Poisonous if inhaled or swallowed.
Contact causes severe burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
May ignite other combustible materials (wood, paper, oil, etc.).
Violent reaction with water.
Flammable/poisonous gases may accumulate in tanks and hopper cars.
Runoff to sewer may create fire or explosion hazard.
Material may be transported in a molten form.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in oil directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If

you find the ID Number and the name of the material there, begin protective action.

Fire
Do not get water inside container.
Small fires: dry chemical or CO_2.
Large fires: flood fire area with water from a distance.
Do not get solid stream of water on spilled material.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

Spill or leak
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Use water spray to reduce vapor; do not put water directly on leak, spill area or inside container.
Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Spills: dike for later disposal; do not apply water unless directed to do so.
Cleanup only under supervision of an expert.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Speed in removing material from skin is of extreme importance.
Removal of solidified molten material from skin requires medical assistance.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 40

POTENTIAL HAZARDS

Fire or Explosion
May ignite itself if exposed to air.
May re-ignite after fire is extinguished.
May ignite in presence of moisture.
Violent reaction with water produces flammable gas.
Runoff to sewer may create fire or explosion hazard.

Health Hazards
May be poisonous if inhaled.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing may provide limited protection.
See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
If water pollution occurs, notify the appropriate authorities.

Fire
Do not use water or foam.
Small fires: dry chemical, soda ash, lime or sand.
Large fires: withdraw from area and let fire burn.
Magnesium fires: use dry sand, sodium chloride powder or graphite powder.
Lithium fires: use dry sand, sodium chloride powder, graphite powder or copper powder.
Move container from fire area if you can do it without risk.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material; stop leak if you can do it without risk.
No water on spilled material; do not get water inside container.
Small dry spills: with clean shovel place material info clean, dry container and cover loosely; move containers from spill area.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike liquid spill for later disposal.
Cover powder spill with plastic sheet or tarp to minimize spreading.

First aid
Move victim to fresh air; call emergency medical care.
Wipe material from skin immediately; flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 41

POTENTIAL HAZARDS

Fire or Explosion
May ignite in presence of moisture.
Contact with water produces flammable gas.
Runoff to sewer may create fire or explosion hazard.

Health Hazards
Contact with water produces poisonous gas.
Skin contact poisonous.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
If water pollution occurs, notify the appropriate authorities.

Fire
Do not use water or foam.
Small fires: dry chemical, soda ash, lime or sand.
Large fires: withdraw from area and let fire burn.
Move container from fire area if you can do it without risk.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Do not touch or walk through spilled material.
No water on spilled material; do not get water inside container.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: dike liquid spill for later disposal.
Cover powder spill with plastic sheet or tarp to minimize spreading.
Cleanup only under supervision of an expert.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.

In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 42

POTENTIAL HAZARDS

Health Hazards
Poisonous if swallowed.
Inhalation of dust poisonous.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
May burn rapidly.
May ignite other combustible materials (wood, paper, oil, etc.)
These materials will accelerate burning when they are involved in a fire; some may react violently with fuels.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: water only; no dry chemical, CO_2 or halon
Large fires: flood fire area with water from a distance.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles.

Spill or leak
Do not touch or walk through spilled material.
Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: dike far ahead of liquid spill for later disposal.

First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 43

POTENTIAL HAZARDS

Fire or Explosion
May ignite other combustible materials (wood, paper, oil, etc.).
Mixture with fuels may explode.
Container may explode in heat of fire.
May explode from heat or contamination.
Runoff to sewer may create fire or explosion hazard.

Health Hazards
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is **not** effective for these materials.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: **water only;** no dry chemical, CO_2 or halon.
Large fires: flood fire area with water from a distance.
Do not move cargo or vehicle if cargo has been exposed to heat.
Apply cooling water to sides of containers exposed to flames until well after fire is out.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak
Keep combustibles (wood, paper, oil, etc.) away from spilled material.

Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Use water spray to reduce vapors.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike liquid spill for later disposal.

First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 44

POTENTIAL HAZARDS

Health Hazards
Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
May ignite other combustible materials (wood, paper, oil, etc.).
Violent reaction with water.
Reaction with fuels may be violent.
Flammable/poisonous gases may accumulate in tanks and hopper cars.
Runoff to sewer may create fire or explosion hazard.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: water, dry chemical or soda ash.
Large fires: flood fire area with water.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak
Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Fully-encapsulating, vapor-protective clothing should be worn for spills leaks with no fire.
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Use water spray to reduce vapor; do not get water inside container.
Small spills: flush area with flooding amounts of water.
Large spills: dike far ahead of liquid spill for later disposal.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 45

POTENTIAL HAZARDS

Fire or Explosion
May ignite other combustible materials (wood, paper, oil, etc.).
These materials will accelerate burning when they are involved in a fire; some may react violently with fuels.
Flammable/poisonous gases may accumulate in tanks and hopper cars.
Runoff to sewer may create fire or explosion hazard.

Health Hazards
If inhaled, may be harmful.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: **water only;** no dry chemical, CO_2 or halon.
Large fires: flood fire area with water.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Use water spray to reduce vapor; do not get water inside container.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Small spills: flush area with flooding amounts of water.
Large spills: dike far ahead of liquid spill for later disposal.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 46

POTENTIAL HAZARDS

Fire or Explosion

May explode and throw fragments 1 mile or more if fire reaches cargo.

Health Hazards

Fire may produce irritating or poisonous gases.

EMERGENCY ACTION

IF FIRE REACHES CARGO, DO NOT FIGHT FIRE.
If you know or suspect that heavily-encased explosives, such as bombs or artillery projectiles are involved, stop all traffic and begin to evacuate all persons, including emergency responders, from the area in all directions for 5000 feet (1 mile) for rail car or 4000 feet (3/4 mile) for tractor/trailer. When heavily-encased explosives are not involved, the area for 2500 feet (½ mile) in all directions.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.

Fire
Cargo Fires: **DO NOT FIGHT FIRE WHEN IT REACHES CARGO**
Withdraw from area and let fire burn.
Truck and Equipment Fires: Try to prevent fire from reaching the explosive cargo compartment. Flood with water; if no water is available use Halon, dry chemical or earth.
Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. First, move people out of line-of-sight of the scene and away from windows. Then, obtain more information and specific guidance from competent authorities listed on the shipping papers.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.

First aid
Call emergency medical care.
Use first aid treatment according to the nature of the injury.

GUIDE 47

POTENTIAL HAZARDS

Fire or Explosion
May ignite other combustible materials (wood, paper, oil, etc.).
Mixture with fuels may explode.
Flammable/poisonous gases may accumulate in tanks and hopper cars.
Container may explode in heat of fire.
May explode from friction, heat or contamination.
Runoff to sewer may create fire or explosion hazard.

Health Hazards
May be poisonous if inhaled.

Contact causes severe burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: water only; no dry chemical, CO_2 or halon.
Large fires: flood fire area with water from a distance.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Use water spray to reduce vapors.
Small spills: flush area with flooding amounts of water.
Large spills: dike liquid spill for later disposal.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 48

POTENTIAL HAZARDS

Fire or Explosion
May be ignited by heat, sparks or flames.
Container may explode in heat of fire.
May explode from heat or contamination.
Runoff to sewer may create fire or explosion hazard.

Health Hazards
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: flood fire area with water.
Apply cooling water to sides of containers that are exposed to after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Small spills: take up with inert, damp noncombustible material; move containers from spill area.
Large spills: wet down with water and dike for later disposal.

First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 49

POTENTIAL HAZARDS

Fire or Explosion
May be ignited by heat, sparks or flames.
May burn rapidly with flare-burning effect.
Container may explode in heat of fire.
May explode from friction, heat or contamination.
Runoff to sewer may create fire or explosion hazard.

Health Hazards
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: flood fire area with water from a distance.
Do not move cargo or vehicle if cargo has been exposed to heat.
If fire can be controlled, cool container with water from unmanned hose holder or monitor nozzles until well after fire is out.
If this is impossible, withdraw from area and let fire burn.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Small spills: take up with inert, damp noncombustible material; move containers from spill area.
Large spills: wet down with water and dike for later disposal.

First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush eyes with running water

for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 50

POTENTIAL HAZARDS

Fire or Explosion
May explode and throw fragments 1 /3 mile or more if fire reaches cargo.

Health Hazards
Fire may produce irritating or poisonous gases.

EMERGENCY ACTION

IF FIRE REACHES CARGO, DO NOT FIGHT FIRE -Stop all traffic and begin to evacuate all persons. Including emergency responders, from the area for 1500 feet (1/3 mile) in all directions.
Positive pressure self-contained breathing apparatus (SCBA) firefighters' protective clothing will provide limited protection.

Fire
Cargo Fires: **DO NOT FIGHT FIRE WHEN IT REACHES CARGO.**
Withdraw from area and let fire burn.
Truck and Equipment Fires: Try to prevent fire from reaching the explosive cargo compartment. Flood with water; if no water is available use Halon, dry chemical or earth.
Promptly isolate the scene by removing all persons from incident if there is a fire. First, move people out of line-of-sight of the scene and away from windows. Then, obtain more information and guidance from competent authorities listed on the shipping papers.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.

First aid
Call emergency medical care.
Use first aid treatment according to the nature of the injury.

SUPPLEMENTAL INFORMATION

Packages bearing the 1.4S label contain explosive substances or articles that are designed or packaged in such a manner that when involved in a fire, may burn vigorously with localized detonations and projection of fragments; effects are usually confined to immediate vicinity of packages.
If fire threatens cargo area containing packages bearing 1.4S label, consider initial isolation of at least 50 feet in all directions. Fight fire with normal precaution from a reasonable distance.

GUIDE 51

POTENTIAL HAZARDS

Fire or Explosion
May be ignited by heat, sparks or flames.
Container may explode in heat of fire.
May explode from heat or contamination.
Runoff to sewer may create fire or explosion hazard.

Health Hazards
Vapor **extremely irritating.**
Contact of material or its vapor with eyes may cause blindness.
Poisonous if swallowed.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: flood fire area with water.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles.
If fire can be controlled, cool container with water from unmanned hose holder or monitor nozzles until well after fire is out.
If this is impossible, withdraw from area and let fire burn.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
Stop leak if you can do it without risk.
Small spills: take up with inert, damp noncombustible material; move containers from spill area.
Large spills: wet down with water and dike for later disposal.

First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 52

POTENTIAL HAZARDS

Fire or Explosion
May ignite itself if exposed to air.
May be ignited by heat, sparks or flames.
May burn rapidly with flare-burning effect.
May explode from heat, contamination or loss of temperature control.
Runoff to sewer may create fire or explosion hazard.

Health Hazards
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Loss of cooling
Specified control temperature of material must be maintained. Obtain liquid nitrogen, dry ice or ice for cooling. If none can be obtained, evacuate area.

Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: flood fire area with water from a distance.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles.
If fire can be controlled, cool container with water from unmanned hose holder or monitor nozzles until well after fire is out.
If this is impossible, withdraw from area and let fire burn.

Spill or leak
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Shut off ignition sources; no flares, smoking or flames in hazard area.
Small spills: take up with sand or other noncombustible material; move containers from spill area.
Large spills: dike liquid spill for later disposal.

First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 53

POTENTIAL HAZARDS

Health Hazards
Poisonous if swallowed.
Inhalation of dust or mist may be poisonous.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
Some of these materials may burn, but none of them ignites readily.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.

Spill or leak
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: dike far ahead of liquid spill for later disposal.

First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 54

POTENTIAL HAZARDS

Health Hazards
Poisonous if swallowed.
May be poisonous if inhaled.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
Some of these materials may burn, but none of them ignites readily.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: dry chemical, CO_2, water spray or regular foam.

Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.

Spill or leak
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Small spills: take up with sand or other noncombustible material and place into containers for later disposal.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: dike far ahead of liquid spill for later disposal.

First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 55

POTENTIAL HAZARDS

Health Hazards
Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may give off poisonous gases and cause water pollution.
Fire may produce irritating or poisonous gases.

Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
Container may explode violently in heat of fire.
Material may be transported in a molten form.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is **not** effective for these materials.
See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.

Remove and isolate contaminated clothing at the site.

Fire
Small fires: dry chemical, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Fight fire from maximum distance. Stay away from ends of tanks.
Dike fire control water for later disposal; do not scatter the material.

Spill or leak
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Use water spray to reduce vapors.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: dike far ahead of liquid spill for later disposal.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Speed in removing material from skin is of extreme importance.
Removal of solidified molten material from skin requires medical assistance.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 56

POTENTIAL HAZARDS

Health Hazards
Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
May explode from friction, heat or contamination.
Material may be transported in a molten form.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.

Fire

Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Do not touch or walk through spilled material; stop leak if you can do it without risk.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Use water spray to reduce vapors.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: dike far ahead of liquid spill for later disposal.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Speed in removing material from skin is of extreme importance.
Removal of solidified molten material from skin requires medical assistance.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 57

POTENTIAL HAZARDS

Health Hazards
Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
May be ignited by heat, sparks or flames.
Container may explode in heat of fire.
Vapor explosion and poison hazard indoors, outdoors or in sewers.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.

Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Cool container with water using unmanned device until well after fire is out.
Fight fire from maximum distance. Stay away from ends of tanks.
Dike fire control water for later disposal; do not scatter the material.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Water spray may reduce vapor; but it may not prevent ignition in closed spaces.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Small dry spills: with clean shovel place material into clean, dry container

and cover loosely; move containers from spill area.
Large spills: dike far ahead of liquid spill for later disposal.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Speed in removing material from skin is of extreme importance.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 58

POTENTIAL HAZARDS

Health Hazards
Inhalation of vapor or dust is **extremely irritating.**
May cause burning of eyes and flow of tears.
May cause coughing, difficult breathing and nausea.
Brief exposure effects last only a few minutes.
Exposure in an enclosed area may be very harmful.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
Some of these materials may burn, but none of them ignites readily.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.

Spill or leak
Do not touch or walk through spilled material; stop leak if you can do it

without risk.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike far ahead of liquid spill for later disposal.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Effects should disappear after individual has been exposed to fresh air for approximately 10 minutes.

GUIDE 59

POTENTIAL HAZARDS

Health Hazards
Poisonous if inhaled or swallowed.
Skin contact poisonous.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
Some of these materials may ignite combustibles (wood, paper, oil, etc.
Material may be transported in a molten form.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.

Fire
Some of these materials may react violently with water.
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

Spill or leak
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Use water spray to reduce vapors.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike liquid spill for later disposal.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Any contact with hydrogen fluoride or hydrofluoric acid solution requires immediate and specialized medical attention.
Removal of solidified molten material from skin requires medical assistance.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 60

POTENTIAL HAZARDS

Health Hazards
Contact causes burns to skin and eyes.
If inhaled, may be harmful.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
Flammable/poisonous gases may accumulate in tanks and hopper cars.
Some of these materials may ignite combustibles (wood, paper, oil, etc.).

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire

Some of these materials may react violently with water.
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

Spill or leak

Do not touch or walk through spilled material; stop leak if you can do it without risk.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: dike far ahead of liquid spill for later disposal.

First aid

Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 61

POTENTIAL HAZARDS

Health Hazards

Radiation presents minimal risk to lives of persons during transportation accidents.
Low-level radioactive materials; very little radiation hazard to people.
Some radioactive materials cannot be detected by commonly available instruments.
Packages do not have RADIOACTIVE I, II, or III labels. Some may have EMPTY labels or be marked with the word "Radioactive".

Fire or Explosion
Radioactivity does not change flammability or other properties of the materials.
Some of these materials may burn, but none of them ignites readily.

EMERGENCY ACTION

Priority response actions may be performed before taking radiation measurements.
Priorities are life saving, control of fire and other hazards, and first aid.
Keep unnecessary people away; isolate hazard area and deny entry.
Notify Radiation Authority of accident conditions.
Uninjured persons or equipment with suspected contamination should be detained or isolated; delay cleanup until instructions are received from Radiation Authority.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide adequate protection.
Pollution from cargo fire control runoff is not expected; if any radioactive contamination occurs, it will be extremely low hazard.

Fire
Do not move damaged packages; move undamaged packages out of fire zone.
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog (flooding amounts).

Spill or leak
Do not touch damaged packages or spilled material.
Small liquid spills: cover with sand, earth or other noncombustible absorbent material.
Cover powder spill with plastic sheet or tarp to minimize spreading.

First aid
Use first aid treatment according to the nature of the injury.
If persons have contacted released material, use standard hazmat procedures for care of contaminated persons, for transport of the injured, and for notifications to authorities.

GUIDE 62

POTENTIAL HAZARDS

Health Hazards
Radiation presents minimal risk to lives of persons during transportation accidents.
Low radiation hazard when material is inside container. If material is

released from package or bulk container, hazard will vary from little to moderate depending on the type and amount of radioactivity, the kind of material it is in, and/or the surfaces it is on.
Full-load shipments and packages often do not have "RADIOACTIVE" labels.
Occasionally, packages may have a "RADIOACTIVE" label and a second hazard label; usually the second hazard is greater than the radiation hazard.
Some radioactive materials cannot be detected by commonly available instruments.
Spilled radioactive materials usually will be visible if packaging fails.
Runoff from control of cargo fire may cause low-level pollution.

Fire or Explosion
Some of these materials may burn, but most do not ignite readily.
Radioactivity does not change flammability or other properties of the materials.

EMERGENCY ACTION

Priority response actions may be performed before taking radiation measurements.
Priorities are life saving, control of fire and other hazards, and first aid.
Isolate hazard area and deny entry. Notify Radiation Authority of accident conditions.
Keep unnecessary people at least 150 feet upwind of spill; greater distances may be necessary for people downwind, or if advised by Radiation Authority.
Uninjured persons or equipment with suspected contamination should be detained or isolated; delay cleanup until instructions are received from Radiation Authority.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide adequate protection.
If water pollution occurs, notify the appropriate authorities.

Fire
Do not move damaged packages; move undamaged packages out of fire zone.
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.

Spill or leak
Do not touch damaged containers or spilled material.
Small liquid spills: cover with sand, earth or other noncombustible absorbent material.
Dike to collect large liquid spills or cargo fire control water.
Cover powder spill with plastic sheet or tarp to minimize spreading.

First aid
Use first aid treatment according to the nature of the injury.
If persons have contacted released material, use standard hazmat procedures for care of contaminated persons, for transport of the injured, and for notifications to authorities.

GUIDE 63

POTENTIAL HAZARDS

Health Hazards
Radiation presents minimal risk to lives of persons during transportation accidents.
Undamaged packages are safe; damaged packages or released material can cause external radiation exposure; released material entering or contaminating the body can cause internal radiation exposure.
Type A packages (cartons, boxes, drums, articles, etc.) identified as "Type A" by marking on packages or by shipping papers contain non-life endangering amounts. Partial releases might be expected if packages are damaged in moderately severe accidents.
Type B packages (large and small, usually metal) identified as "Type B" by marking on packages or by shipping papers contain potentially life endangering amounts. Because of design, evaluation, and testing of packages, life endangering releases are not expected in accidents except those of utmost severity.
Some radioactive materials cannot be detected by commonly available instruments.
Water from control of cargo fire may cause pollution.

Fire or Explosion
Some of these materials may burn, but most do not ignite readily.
Radioactivity does not change flammability or other properties of the materials.
Type B packages are designed to withstand temperatures of 1475°F (800°C).

EMERGENCY ACTION

Priority response actions may be performed before taking radiation measurements.
Priorities are life saving, control of fire and other hazards, and first aid.
Isolate hazard area and deny entry. Notify Radiation Authority of accident conditions.
Keep unnecessary people at least 150 feet upwind of spill; greater distances may be necessary for people downwind, or if advised by Radiation

Authority.
Uninjured persons or equipment with suspected contamination should be detained or isolated; delay cleanup until instructions are received from Radiation Authority.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide adequate protection against internal radiation exposure, but not external exposure.
If water pollution occurs, notify the appropriate authorities.

Fire
Do not move damaged packages; move undamaged packages out of fire zone.
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog (flooding amounts).

Spill or leak
Do not touch damaged packages or spilled material.
Slightly damaged or damp outer surfaces seldom indicate failure of inner container.
Small liquid spills: cover with sand, earth or other noncombustible absorbent material.
Dike to collect cargo fire control water.

First aid
Use first aid treatment according to the nature of the injury.
If persons have contacted released material, use standard hazmat procedures for care of contaminated persons, for transport of the injured, and for notification to authorities.

GUIDE 64

POTENTIAL HAZARDS

Health Hazards
Radiation presents minimal risk to lives of persons during transportation accidents.
Undamaged packages are safe; damaged packages or materials released from packages can cause external radiation hazards. Contamination is not expected.
Type A packages (cartons, boxes, drums, articles, etc.) identified as "Type A" by marking on packages or by shipping papers contain non-life endangering amounts. Radioactive sources may be released if packages are damaged in moderately severe accidents.
Type B packages (large and small, usually metal) identified as "Type B" by marking on packages or by shipping papers contain potentially life endangering amounts. Because of design, evaluation, and testing packages,

life endangering releases are not expected in accidents except those of utmost severity.
Commonly available instruments can detect most of these materials.
Water from cargo fire control is not expected to cause pollution.

Fire or Explosion
Packagings can be consumed without content loss from sealed source capsule.
Radioactive source capsules and Type B packages are designed to withstand temperatures of 1475°F (800°C).

EMERGENCY ACTION

Priority response actions may be performed before taking radiation measurements.
Priorities are life saving, control of fire and other hazards, and first aid.
Isolate hazard area and deny entry. Notify Radiation Authority of accident conditions.
Delay final cleanup until instruction or advice of Radiation Authority.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide adequate protection against internal radiation exposure, but not external exposure.

Fire
Do not move damaged packages; move undamaged packages out of fire zone.
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog (flooding amounts).

Spill or leak
Do not touch damaged packages or spilled material.
Slightly damaged or damp outer surfaces seldom indicate failure of inner container.
If source is identified as being out of package, stay away and await advice from radiation authority.

First aid
Use first aid treatment according to the nature of the injury.
Persons exposed to special form sources are not likely to be contaminated with radioactive material.

GUIDE 65

POTENTIAL HAZARDS

Health Hazards
Radiation presents minimal risk to lives of persons during transportation accidents.
Undamaged packages are safe; damaged packages or released material can cause external radiation exposure; released material entering or contaminating the body can cause internal radiation exposure.
Packages (drums, metal boxes, etc.) identified as "Type A" or "AF" by marking on packages or by shipping papers contain materials that are not life endangering if released. External radiation levels are low and packages are designed, evaluated, and tested to control releases and to prevent fission accidents under severe transport accident conditions.
Packages (metal and usually very heavy) identified as "Type B", "B(U)F", or "B(M)P" by marking on packages or by shipping papers contain potentially life endangering amounts. Because of design, evaluation, and testing of packages, fission accidents are prevented and releases are not expected to be life endangering for all accidents except those of utmost severity.
Some radioactive materials cannot be detected by commonly available instruments.
Water from cargo fire control is not expected to cause pollution.

Fire or Explosion
These materials are not flammable and packagings are designed to withstand fires without damage to contents.
Radioactivity does not change flammability or other properties of the materials.
Packages are designed to withstand temperatures of 1475°F (800°C).

EMERGENCY ACTION

Priority response actions may be performed before taking radiation measurements.
Priorities are life saving, control of fire and other hazards, and first aid.
Isolate hazard area and deny entry. Notify Radiation Authority of accident conditions.
Uninjured persons or equipment with suspected contamination should be detained or isolated; delay cleanup until instructions are received from Radiation Authority.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide adequate protection against internal radiation exposure, but not external exposure.

Fire
Do not move damaged packages; move undamaged packages out of fire zone.
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog (flooding amounts).

Spill or leak
Do not touch damaged packages or spilled material.
Slightly damaged or damp outer surfaces seldom indicate failure of inner container.
Liquid spills: package contents are seldom liquid. If released liquids have radioactive contamination it will be low-level, if any.

First aid
Use first aid treatment according to the nature of the injury.
Persons exposed to fissile radioactive material packages are not expected to be contaminated, unless the packages are badly damaged in utmost severity accidents.

GUIDE 66

POTENTIAL HAZARDS

Health Hazards
Chemical hazard greatly exceeds radiation hazard.
Material reacts with water and water vapor in air to form a poisonous, corrosive vapor and an extremely irritating, white-colored, water-soluble residue.
If inhaled may be fatal.
Contact causes chemical burns to skin, eyes, and respiratory tract.
Radiation presents minimal risk to lives of persons during transportation accidents.
Low-level radioactive materials; very little radiation hazard to people.
Runoff from control of cargo fire may cause low-level pollution.

Fire or Explosion
Containers in protective overpacks (identified as "AF" or "B(U)F" by marking on packages or by shipping papers) are designed to withstand severe accidents and temperatures of 1475°F (800°C).
Bare containers may explode if engulfed in fire; the material may react violently with fuels.
Radioactivity does not change flammability or other properties of the materials.

EMERGENCY ACTION

Priority response actions may be performed before taking radiation measurements.
Priorities are life saving, control of fire and other hazards, and first aid.
Isolate hazard area and deny entry. Notify Radiation Authority of accident conditions.
Uninjured persons or equipment with suspected contamination should be detained or isolated; delay cleanup until instructions are received from Radiation Authority.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. Structural firefighters' protective clothing will not provide protection from vapors.
Avoid vapors, stay upwind and out of low areas.

Fire

Move container from fire area if you can do it without risk.
Small fires: dry chemical or CO_2.
Large fires: water spray, fog or regular foam.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks. If this is impossible, withdraw from area and let fire burn.

Spill or leak

Without fire or smoke, leak will be evident by visible and irritating vapors and residue forming at point of the release.
Use water fine spray to reduce vapors; **do not** put water directly on point of material release from container.
Dike far ahead of spill to collect runoff water.

First aid

Use first aid treatment according to the nature of the injury.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes. Burns may be similar to those from hydrogen fluoride.
If persons have contacted released material, use standard hazmat procedures for care of contaminated persons, for transport of the injured, and for notifications to authorities.

GUIDE 67

POTENTIAL HAZARDS

Health Hazards
Poison; **extremely hazardous.**
Inhalation **extremely dangerous**; may be fatal.
Contact with liquid may cause frostbite.
Initial odor may be irritating, foul or absent and may deaden your sense of smell.

Fire or Explosion
Extremely flammable; may be ignited by heat, sparks or flames.
Flame may be invisible.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat of fire.
Vapor explosion and poison hazard indoors, outdoors or in sewers.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

Fire
Let burn unless leak can be stopped immediately.
Small fires: dry chemical, CO_2 or water spray.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Stop leak if you can do it without risk.
Isolate area until gas has dispersed.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of frostbite, thaw frosted parts with water.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 68

POTENTIAL HAZARDS

Fire or Explosion
Flammable/combustible material; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat of fire.
Vapor explosion hazard indoors, outdoors or in sewers.
Runoff to sewer may create fire or explosion hazard.

Health Hazards
Poisonous if swallowed.
May be poisonous if inhaled.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: **dry chemical, CO_2, water spray or regular foam.**

Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Water spray may reduce vapor; but it may not prevent ignition in closed spaces.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike far ahead of liquid spill for later disposal.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 69

POTENTIAL HAZARDS

Fire or Explosion
Extremely flammable; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat of fire.

Health Hazards
Poisonous; may be fatal if inhaled.
Vapor **extremely irritating;** contact causes burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and chemical

protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection. Structural firefighters' protective clothing is **not** effective for these materials. Isolate the leak or spill area immediately for at least 150 feet in all directions.
See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action. **Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.**

Fire
Small fires: dry chemical, CO_2, water spray or alcohol-resistant foam.
Large fires: water spray, fog or alcohol-resistant foam.
Let burn unless leak can be stopped immediately.
Move container from fire area if you can do it without risk.
Fight fire from maximum distance. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Stop leak if you can do it without risk.
Water spray may reduce vapor; but it may not prevent ignition in closed spaces.
Small spills: flush area with flooding amounts of water.
Do not get water inside container.
Large spills: dike liquid spill for later disposal.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 70

POTENTIAL HAZARDS

Fire or Explosion
Extremely flammable.
May ignite itself if control temperature is exceeded.
May explode from heat or loss of temperature control.

Health Hazards
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Loss of cooling
Specified control temperature of material must be maintained. Obtain liquid nitrogen, dry ice or ice for cooling. If none can be obtained, evacuate area.

Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: flood fire area with water.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
If fire can be controlled, cool container with water from unmanned hose or monitor nozzles until well after fire is out.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
Spills: moisten material with water and place it into loosely-covered plastic or fiberboard containers for later disposal.

First aid
Move victim to fresh air.
In case of contact with material, immediately flush eyes with running water at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.

Keep victim quiet and maintain normal body temperature.

GUIDE 71

POTENTIAL HAZARDS

Fire or Explosion
May be ignited by heat, sparks or flames.
May burn rapidly.
Container may explode violently in heat of fire.
May explode from friction, heat or contamination.

Health Hazards
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: flood fire area with water.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.
If fire can be controlled, cool container with water from unmanned hose holder or monitor nozzles until well after fire is out.
If this is impossible, withdraw from area and let fire burn.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
Spills: moisten material with water and place it into loosely-covered plastic or fiberboard containers for later disposal.

First aid
Move victim to fresh air.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.

Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 72

POTENTIAL HAZARDS

Fire or Explosion
May be ignited by heat, sparks or flames.
Container may explode in heat of fire.

Health Hazards
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: flood fire area with water.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
Spills: moisten material with water and place it into loosely-covered plastic or fiberboard containers for later disposal.

First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 73

POTENTIAL HAZARDS

Fire or Explosion
May ignite other combustible materials (wood, paper, oil, etc.).
These materials will accelerate burning when they are involved in a fire; some may react violently with fuels.
Flammable/poisonous gases may accumulate in tanks and hopper cars.
Runoff to sewer may create fire or explosion hazard.

Health Hazards
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
If water pollution occurs, notify the appropriate authorities.

Fire
Some of these materials may react violently with water.
Do not get water inside container.
Small fires: water only; no dry chemical, CO_2 or halon.
Large fires: flood fire area with water.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak
Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
If you have not donned special protective clothing approved for this material, do not expose yourself to any risk of this material touching you.
Use water spray to reduce vapor; do not get water inside container.
Small spills: flush area with flooding amounts of water.

Large spills: dike far ahead of liquid spill for later disposal.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 74

POTENTIAL HAZARDS

Health Hazards
Vapors may cause dizziness or suffocation.
Exposure in an enclosed area may be very harmful.
Contact may irritate or burn skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
Most vapors heavier than air.
Air/vapor mixtures **may explode** when ignited.
Container may explode in heat of fire.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
Remove and isolate contaminated clothing at the site.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: dry chemical or CO_2.
Large fires: water spray, fog or regular foam.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Stop leak if you can do it without risk.
Small liquid spills: take up with sand, earth or other noncombustible absorbent material.
Large spills: dike far ahead of liquid spill for later disposal.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.
Use first aid treatment according to the nature of the injury.

GUIDE 75

POTENTIAL HAZARDS

Fire or Explosion
Extremely flammable; will ignite itself if exposed to air.
May burn rapidly with flare-burning effect.
Runoff to sewer may create fire or explosion hazard.

Health Hazards
Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Isolate for ½ mile in all directions if tank, rail car or tank truck is

involved in fire.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: let burn unless leak can be stopped immediately.
Large fires: withdraw from area and let fire burn.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Spills: dike for later disposal; do not apply water unless directed to do so.
Cleanup only under supervision of an expert.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 76

POTENTIAL HAZARDS

Fire or Explosion
Flammable/combustible material; may be ignited by heat, sparks or flames.
May burn rapidly with flare-burning effect.
May ignite in presence of moisture.
Violent reaction with water.

Health Hazards
Fire may produce irritating or poisonous gases.
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.

Fire
Use water spray to reduce vapor; do not get water inside container.
Do not use water or foam.
Do not get water inside container.
Small fires: dry chemical, soda ash, lime or sand.
Magnesium fires: use dry sand, sodium chloride powder or graphite powder.
Move container from fire area if you can do it without risk.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak
Do not touch or walk through spilled material.
Shut off ignition sources; no flares, smoking or flames in hazard area.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
No water on spilled material; do not get water inside container.
Spills: dike for later disposal; do not apply water unless directed to do so.
Magnesium spills: cover powder spill with plastic sheet or tarp to minimize spreading and keep powder dry.
Cleanup only under supervision of an expert.
Move undamaged packages from spill area.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
Wipe material from skin immediately; flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 77

POTENTIAL HAZARDS

Fire or Explosion
Material is transported in molten form at a temperature above 1300°F (705°C).
Violent reaction with water; contact may cause an explosion or may produce

a flammable gas.
Will ignite combustible materials (wood, paper, oil, debris, etc.).
Contact with nitrates or other oxidizers may cause an explosion.
Contact with containers or other materials, including cold, wet or dirty tool may cause an explosion.
Contact with concrete will cause spalling and small pops.

Health Hazards
Contact causes severe burns to skin and eyes.
Fire may produce irritating or poisonous gases from the materials ignited.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area for at least 150 feet in all directions, and deny entry.
Where possible allow molten material to solidify naturally.
Avoid contact even after material solidifies. Molten, heated and cold aluminum look alike; do not touch unless you know it is cold.
Positive pressure self-contained breathing apparatus (SCBA) and flame-retardant structural firefighters' protective clothing, including face shield, helmet and gloves, will provide limited thermal protection.

Fire
Do not use water, except in life threatening situations and then only in a fine spray.
Do not use halogenated extinguishing agents or foam.
Move combustibles out of path of advancing pool if you can do so without risk.
Extinguish fires started by molten material by using appropriate method for burning material; keep water, halogenated extinguishing agents and foam away from the molten material.

Spill or leak
Do not touch or walk through spilled material.
Do not attempt to stop leak, due to danger of explosion.
Keep combustibles (wood, paper, oil, debris, etc.) away from spilled material.
Material is very fluid, spreads quickly, and may splash. Do not try to stop it with shovels or other objects.
Dike far ahead of spill; use dry sand to contain the flow of material.
Cleanup under the supervision of an expert after material has solidified.

First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.

For severe burns, immediate medical attention is required.
Removal of solidified molten material from skin requires medical assistance.

6

Chemical Compatibility Information

This chapter provides technical data on the fire potential for commonly used chemicals. The information provided includes the chemical name, the chemical's formula, common synonyms for the chemical, a list of the materials that the chemical is incompatible with in terms of fire and explosion hazard or polymerization, the chemical's flash point temperature, and the chemical's explosion limits in terms of the lower explosion limit (LEL) and upper explosion limit (UEL). The data summarized in this chapter were derived from literature sources including published OSHA and NIOSH publications, and RETCS. Chemicals listed are in alphabetical order. Not all of these chemicals represent fire hazards, and indeed many represent toxic materials in terms of inhalation or ingestion exposure hazards. Those chemicals which are either strong oxidizers or represent potential fire hazards are highlighted for ready identification by the reader. The criteria used for highlighting high fire hazard materials is its incompatibility with strong oxidizers, and/or low LELs. As a general rule, any chemical with a LEL below about 3% is highlighted. This does not mean that any non-highlighted chemical is not a fire or explosion hazard. The reader should carefully read the list of incompatible ingredients for the product he/she is handling and consult other references.

Note also that synonyms for each chemical are common shipping or industry names. Brand or company product names are not given. The reader should carefully examine product material safety data sheets to identify ingredients or specific components that are potentially active or toxic, and then identify the chemical ingredients in the accompanying table.

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Acetaldehyde	CH_3CHO	Ethanal, Acetic aldehyde	Strong oxidizers, acids, bases, alcohol, ammonia, amines, phenols, ketones, HCN, hydrogen sulfide	-36	4	60
Acetic acid	CH_3COOH	Glacial acetic acid, Methane carboxylic acid, Ethanoic acid, Vinegar acid	Strong oxidizers, chromic acid, sodium peroxide, nitric acid, strong caustics	104	5.4	16
Acetic anhydride	$(CH_3CO)_2O$	Ethanoic anhydride, Acetic acid anhydride, Acetyl oxide	Water, alcohols, strong oxidizers, chromic acid, amines, strong caustics	120	2.9	10.3
Acetone	CH_3COCH_3	2- Propanone, Dimethyl ketone, Ketone propane	Oxidizing materials, acids	1.4	2.6	12.8
Acetonitrile	CH_3CN	Methylcyanide	Strong oxidizers	42	4.4	16
2-Acetylamino-fluorene	$C_{15}H_{13}NO$	2-Acetamidofluorene, 2-AAF, AAF, 2-Acet-aminofluorene, N-Acetyl-2-amino-fluorene, FAA, 2-FAA, 2-Fluoroenyl-acetamide, N-2-Fluor-enylacetamide, N-Fluoren-2-acetyl-acetamide, N-Fluorenyl-2-acetamide	Not available	?	?	?
Acetylene tetrabromide	$CHBr_2CHBr_2$	Tetrabromoethane; symmetrical tetra-bromoethane; 1,1,2,2-Tetra-bromoethane	Chemically active metals, caustics, hot iron, aluminum, zinc in presence of steam	Not combustible		
Acrolein	CH_2CHCHO	Acrylic aldehyde, Acryl-aldehyde, Propenal, Allyl-aldehyde	Oxidizers, acids, alkalies, ammonia	-15	2.8	31
Acrylamide	$CH_2CHCONH_2$	Propenamide, Acrylamide monomer, Acylic amide	Strong oxidizers	?	?	?
Acrylonitrile	CH_2CHCN	Propenenitrile, An, Vinyl cyanide	Strong oxidizers (especially bromine), strong bases, copper, copper alloys, ammonia, amines	30	3	17
Aldrin	$C_{12}H_8Cl_6$	1,2,3,4,10,10-Hexa-chloro-1,4,4a,5,8,8a-hexahydro-endo,exo-1,4,5,8-dimenthano-naphthalene; Octalene	None hazardous	Not combustible		
Allyl alcohol	CH_2CHCH_2OH	2-Propenol, 2-Propen-1-ol, Vinyl carbinol	Strong oxidizers		2.5	18

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Allyl chloride	CH_2CHCH_2Cl	3-Chloropropene, 1-Chloro-2-propene	Strong oxidizers, acids, aluminum, zink, amines, peroxides, chlorides of iron and aluminum	-25	3.3	11
Allyl glycidyl ether	$C_6H_{10}O_2$	AGE; 1-Allyloxy-2,3-epoxy-propane	Strong oxidizers	135	?	?
4-Amino-diphenyl	$C_{12}H_{11}N$	p-Aminobiphenyl; Biphenylamine; (1,1-Biphenyl)-4-amine; p-Phenyl-aniline; Xenylamine; 4-Amino-biphenyl; p-Aminobiphenyl; p-Biphenylamine; Paraminodiphenyl; 4-Biphenylamine	None	307	?	?
2-Amino-pyridine	$C_5H_6N_2$	alpha-Aminopyridine	Strong oxidizers	154	?	?
Ammonia	NH_3	Anhydrous ammonia	Strong oxidizers, calcium, hypo-chlorite bleaches, gold, mercury, silver, halogens	NA	16	25
Ammonium sulfamate	$NH_2SO_3NH_4$	Ammate herbicide	Strong oxidizers, hot water	Not combustible		
n-Amyl acetate	$CH_3COOC_5H_{11}$	1-Pentanol acetate, n-Amyl acetate (mixed isomers)	Nitrates; strong oxidizers, alkalies, and acids	77	1.1	7.5
sec-Amyl acetate	$C_7H_{14}O_2$	2-Pentanol acetate	Nitrates; strong oxidizers, alkalies, and acids	89	1	?
Aniline	$C_6H_5NH_2$	Aminobenzene, Phenyl-amine, Aniline oil	Stong acids and oxidizers	158	1.3	?
Anisidine (o-, p-isomers)	$NH_2C_6H_4OCH_3$	o-Methoxyaniline, p-Methoxyaniline	Strong oxidizers	86 para	?	?
Antimony and compounds (as Sb)	Sb	Synonyms vary depending upon specific compound	Oxidizers, acids, halogenated acids	?	?	?
ANTU	$C_{11}H_{10}N_2S$	alpha-Naphthyl thio-urea, alpha-Napthyl thiocarbamide, n-l-Napthyl-thiourea, 1-(1-Naphthly)-2-thiourea	Strong oxidizers	?	?	?
Arsenic and compounds (as As)	As	Synonyms vary depending upon specific compound	Not applicable	Properties vary depending upon specific compound		
Arsine	AsH_3	Hydrogen arsenide, Arsenic trihydride	Strong oxidizers, chlorine, nitric acid	Not combustible		
Asbestos		Chrysotile, Amosite, Crocidolite, Tremolite, Anthophyllite, Actinolite	None	Properties vary depending upon specific compound		

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Azinphos-methyl	$C_{10}H_{12}N_3O_3PS_2$	Guthion; o,o-Dimethyl S-4-oxo-1,2,3-benzo-triazin-3(4H)-yl-methyl phosphoro-dithioate	Strong oxidizers	?	?	?
Barium (soluble compounds as Ba)	Ba	Synonyms vary depending upon specific compound	Incompatibilities vary depending upon specific compound	Properties vary depending upon specific compound		
Benzene	C_6H_6	Benzol, Cyclohexa-triene, Coal tar naphtha, Phenyl hydride	Strong oxidizers; chlorine, bromine with iron	12	1.3	7.1
Benzidine	$C_{12}H_{12}N_2$	1,1-Biphenyl-4,4-diamine; 4,4-Diamino biphenyl; 4,4-Biphenyldiamine; 4,4-Bianiline; 4,4-Diphenyl-enediamine; 4,4-Diamino-diphenyl; Azoic Diazo Component 112; Fast Corinth Base B; Biphenyl, 4,4'-diamino-p-Diamino-diphenyl	Not available	Com-bustible solid	?	?
Benzoyl peroxide	$(C_6H_5CO)_2O_2$	Dibenzoyl peroxide	Combustible substances, wood, paper, lithium aluminum hydride; explosive at high temperatures	?	?	?
Benzyl chloride	$C_6H_5CH_2Cl$	alpha-Chlorotoluene, Benzylchloride anhydrous, Benzyl-chloride (stabilized)	Active metals: copper, aluminum, magnesium, iron, zinc, tin; strong oxidizers	140	1.1	?
Beryllium and compounds (as Be)	Be	Synonyms vary depending upon specific compound	None	Properties vary depending upon specific compound		
Boron oxide	B_2O_3	Anhydrous boric acid, Boric anhydride, Boric oxide	None hazardous	Not combustible		
Boron trifluoride	BF_3	None	Reacts with alkalies, fumes in moist air, particulates reduce visibility	Not combustible		
Bromine	Br_2	None	Combustible organics, oxidizable material, aqueous ammonia; anhydrous Br_2 reacts with aluminum, titanium, mercury, potassium; wet Br_2 reacts with other metals	Not combustible, but strong oxidizer		

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Bromoform	$CHBr_3$	Tribromomethane	Chemically active metals: sodium, potassium, calcium, powdered aluminum, zinc, magnesium, strong caustics	Not combustible		
Butadiene	$CH_2CHCHCH_2$	1,3-Butadiene; Divinyl; Biethylene; Erythrene	Strong oxidizers, copper, copper alloys	NA	2	11.5
2-Butanone	$CH_3COCH_2CH_3$	Methyl ethyl ketone, MEK, Ethyl methyl ketone	Very strong oxidizers	21	2	10
2-Butoxy ethanol	$C_4H_9OCH_2CH_2OH$	Butyl cellosolve, ethylene-glycol monobutylether, Dowanol EB, Butyl oxitol, Jeffersol EB, Ektasolve EB	Strong oxidizers and caustics	141	1.1	10.6
Butyl acetate	$CH_3COO(CH_2)_3CH_3$	n-Butyl acetate, Butyl ethanoate, Acetic acid butyl ester	Nitrates; strong oxidizers, alkalies, and acids	72	1.7	7.6
sec-Butyl acetate	$CH_3COOCH(CH_3)C_2H_5$	1-Methylpropylacetate	Nitrates; strong oxidizers, alkalies, and acids	62	1.7	9.8
tert-Butyl acetate	$CH_3COOC(CH_3)_3$	Acetic acid tert-butyl ester	Nitrates; strong oxidizers, alkalies, and acids	62 to 72(est)	1.5	?
Butyl alcohol	$CH_3CH_2CH_2CH_2OH$	1-Butanol, Propyl-carbinol, n-Butanol, n-Butyl alcohol, NBA	Strong oxidizers	84	1.4	11.2
sec-Butyl alcohol	$CH_3CHOHCH_2CH_3$	2-Butanol, Methyl ethyl carbinol, Butylene hydrate, 2-Hydroxybutane	Strong oxidizers	75	1.7	9.8
tert-Butyl alcohol	$(CH_3)_3COH$	2-Methyl-2-propanol, TBA, Trimethyl-carbinol	Strong mineral acids, strong hydrochloric acid	52	2.4	8
Butylamine	$C_4H_9NH_2$	n-Butylamine, 1-Amino-butane	Strong oxidizers and acids	10	1.7	9.8
tert-Butyl chromate (as CrO_3)	$((CH_3)_3CO)_2\ CrO_2$	Chromic acid, di-tert-Butyl ester; bis (tert-Butyl) chromate	Reducing agents, moisture	?	?	?
n-Butyl glycidyl ether	$C_4H_9OCH_2CHOCH_2$	BGE;1,2-Epoxy-3-butoxy-propane	Strong oxidizers and caustics	130	?	?
Butyl mercaptan	$CH_3CH_2CH_2CH_2SH$	n-Butanethiol, 1-Mercapto-butane, 1-Butanethiol	Strong oxidizers, such as dry bleaches	35	?	?
p-tert-Butyltoluene	$CH_3C_6H_4C_4H_9$	1-Methyl-4-tert-butyl-benzene	Oxidizers	155(oc)	?	?
Cadmium dust (as Cd)	Cd	Synonyms vary depending upon specific compounds	Strong oxidizers, elemental sulfur, selenium, tellurium	Properties vary depending upon specific compound		
Cadmium fume (as Cd)	Cd/CdO	Cadmium oxide fume	Not applicable	NA	NA	NA

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Calcium arsenate (as As)	$Ca_3(AsO_4)_2$	Tricalcium arsenate; Tricalcium ortho-arsenate; Cucumber dust; arsenic acid, calcium salt (2:3)	None hazardous	Not combustible		
Calcium oxide	CaO	Quicklime, Pebble lime	Water	Not combustible		
Camphor	$C_{10}H_{16}O$	2-Camphonone, Synthetic camphor, Gum camphor, Laurel camphor	Oxidizers, chromic anhydride	150	0.6	3.5
Carbaryl (Sevin®)	$C_{12}H_{11}NO_2$	1-Naphthyl n-methyl-carbamate, alpha-Naphthyl n-methyl-carbamate	Strong oxidizers	?	?	?
Carbon black		Channel black, Lamp black, Furnace black, Thermal black, Acetyl-ene black	Strong oxidizers, such as chlorates, bromates, nitrates	NA	?	?
Carbon dioxide	CO_2	Carbonic acid gas, Dry ice	Chemically active metals, such as sodium, potassium, hot titanium	Not combustible		
Carbon disulfide	CS_2	Carbon bisulfide	Strong oxidizers; chemically active metals, such as sodium, potassium, zinc; azides, organic amines	-22	1.3	50
Carbon monoxide	CO	Monoxide	Strong oxidizers	NA	12.5	74
Carbon tetrachloride	CCl_4	Tetrachloromethane	Chemically active metals, such as sodium, potassium, magnesium	Not combustible		
Chlordane	$C_{10}H_4Cl_8$ (approx)	1,2,4,5,6,7,8,8-Octa-chloro-3a,4,7,7a-tetra-hydro-4,7-methano-indane	Strong oxidizers	Not combustible		
Chlorinated camphene	$C_{10}H_{10}Cl_8$	Toxaphene	Strong oxidizers	275	?	?
Chlorinated diphenyl oxide	$C_{12}H_4Cl_6O$	Hexachlorodiphenyl oxide	Strong oxidizers	NA	?	?
Chlorine	Cl_2	None	Combustible substances, finely divided metals	Not combustible, but strong oxidizer		
Chlorine dioxide	ClO_2	None	Combustible substances, dust, organic matter, sulfur	NA	10	?
Chlorine trifluoride	ClF_3	None	Combustible substances, water, sand, glass, asbestos, silicon-containing compounds	Not combustible but highly reactive		

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Chloroacetaldehyde	$ClCH_2CHO$	2-Chloroethanal, Chloro-acetaldehyde (40% aqueous)	Oxidizers, acids, water	190 (40%)	?	?
alpha-Chloroacetophenone	$C_6H_5COCH_2Cl$	Phenacyl chloride, omega-Chloroacetophenone, Chloromethyl phenyl ketone, Phenyl chloro-methyl ketone, "tear gas", CN	Water, steam	244	NA	NA
Chlorobenzene	C_6H_5Cl	Monochlorobenzene, Chlorobenzol, Phenyl chloride, MCB	Strong oxidizers	84	1.3	7.1
o-Chlorobenzylidene malonitrile	$C_{10}H_5ClN_2$	OCBM, CS	Strong oxidizers			
Chlorobromomethane	CH_2BrCl	Bromochloromethane, Methylene chlorobromide, CB, CBM, Halon 1011	Chemically active metals: calcium, powdered aluminum, zinc, magnesium	Not combustible		
Chlorodiphenyl (42% chlorine)	$C_{12}H_7Cl_3$ (approx)	Polychlorinated biphenyl, PCB	Strong oxidizers	349	?	?
Chlorodiphenyl (54% chlorine)	$C_{12}H_5Cl_5$ (approx)	Polychlorinated biphenyl, PCB	Strong oxidizers	432	?	?
Chloroform	$CHCl_3$	Trichloromethane	Strong caustics, chemically active metals, such as aluminum, magnesium powder, sodium, potassium	Not combustible		
bis-Chloromethyl ether	$O(CH_2Cl)_2$	Dichloromethylether; BCME; sym-Dichloro-dimethylether; Chloro-(chloromethoxy)methane; sym-Dichloromethyl ether; Oxybis (chloro-methane); Dimethyl-1,1-dichloroether; Chloromethyl ether; Methane, oxybis (chloro-bis-CHE)	Water, unstable	?	?	?
Chloromethyl methyl ether	$ClCH_2OCH_3$	Methyl chloromethyl ether; Chloromethoxy-methane; CMME; Ether, dimethyl chloro; Monochlorodimethyl-ether; Dimethyl-chloroether; Chlorodi-methylether; Methyl chloromethyl ether, anhydrous (DOT)	Water, unstable	?	?	?
1-Chloro-1-nitropropane	$C_2H_5CHClNO_2$	None	Strong oxidizers	144		?

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Chloropicrin	CCl_3NO_2	Nitrotrichloromethane, Trichloronitromethane, Nitrochloroform	Strong oxidizers	Not combustible, but heated material will detonate		
Chloroprene	$CH_2CClCHCH_2$	2-Chloro-1,3-Butadiene; Chlorobutadiene; beta-Chloroprene	Peroxides, other oxidizers	-4	4	20
Chromic acid and chromates (as CrO_3)	H_2CrO_4	Synonyms vary depending upon specific compound	Combustible, organic, or other readily oxidizable materials: paper, wood, sulfur, aluminum, plastics, etc.	Properties vary depending upon specific compound		
Chromium metal and insoluble salts (as Cr)	Cr	Synonyms vary depending upon specific compound	Strong oxidizers	Properties vary depending upon specific compound		
Chromium: soluble chromic and chromous salts (as Cr)	Cr	Synonyms vary depending upon specific compound	Water	Properties vary depending upon specific compound		
Coal tar pitch volatiles		Synonyms vary depending upon specific compound	Strong oxidizers	Properties vary depending upon specific compound		
Cobalt metal, fume, and dust (as Co)	Co	Synonyms vary depending upon specific compound	Strong oxidizers	NA	NA	NA
Copper dust and mist (as Cu)	Cu	Synonyms vary depending upon specific compound	Acetylene gas, magnesium metal	?	?	?
Copper fume (as Cu)	Cu	Synonyms vary depending upon specific compound	Acetylene gas	NA	NA	NA
Cotton dust (raw)		None	Strong oxidizers	NA	NA	NA
Crag® herbicide	$C_8H_7Cl_2OOSO_3Na$	Sesone; Crag® herbicide No. 1; Sodium-2-(2,4-dichloro-phenoxy) ethyl sulfate	Strong oxidizers	Not combustible		
Cresol	$CH_3C_6H_4OH$	Cresylic acid; ortho-, meta-, or para-Cresol; 2-,3-, or 4-Methyl phenol	Strong oxidizers	o-178/ m-187/ p-187	?	?
Crotonaldehyde	$CH_3CHCHCHO$	beta-Methylacrolein, Propylene aldehyde, Crontonic aldehyde, 2-Butenal	Caustics, ammonia, organic amines, mineral acids, strong oxidizers	55	2.1	15.5
Cumene	$C_6H_5C_3H_7$	Isopropyl benzene, 2-Phenyl propane, Cumol	Oxidizers	111	0.9	6.5
Cyanides (as CN)	KCN/NaCN	1) Potassium cyanide 2) Sodium cyanide	Strong oxidizers, such as nitrates, chlorates, acids, acid salts	Not combustible		

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Cyclohexane	C_6H_{12}	Hexahydrobenzene, Hexamethylene, Benzene hexahydride	Oxidizers	-4	1.3	8.4
Cyclohexanol	$C_6H_{11}OH$	Hexalin, Hydralin, Hydroxycyclohexane, Anol, Hexahydrophenol, Cyclohexyl alcohol	Strong oxidizers	154	2.4	?
Cyclohexanone	$C_6H_{10}O$	Pimelic ketone, Cyclohexyl ketone	Oxidizing agents, nitric acid	111	1.1 (212°F)	?
Cyclohexene	C_6H_{10}	Benzene tetrahydride	Strong oxidizers	10	1	5 (212°F)
Cyclopentadiene	C_5H_6	1,3-Cyclopentadiene	Strong oxidizers	<90 (oc)	?	?
2,4-D	$C_8H_6Cl_2O_3$	2,4-Dichlorophenoxyacetic acid	Strong oxidizers	?	?	?
DDT	$C_{14}H_9Cl_5$	p,p'-DDT; 2,2-bis(p-Chlorophenyl)-1,1,1-trichloroethane; Dichloro-diphenyl-trichloroethane	Strong oxidizers	Not combustible		
Decaborane	$B_{10}H_{14}$	None	Oxidizers, water, halogenated compounds	176	?	?
Demeton®	$C_8H_{19}O_3PS_2OC_2H_4SC_2H_5)_2$	Systox®; o,o-Diethyl o-(2-ethylthio)ethyl phosphorothioate mixture; demeton-o	Strong oxidizers	?	?	?
Diacetone alcohol	$(CH_3)_2C(OH)CH_2COCH_3$	Diacetone, 4-Hydroxy-4-methyl-2-pentanone, 2-Methyl-2-pentanol-4-one	Strong oxidizers and alkalies	136	1.8	6.9
Diazomethane	CH_2N_2	Azimethylene, Diazirine	Alkali metals, drying agents such as calcium sulfate	NA	?	?
Diborane	B_2H_6	Boroethane	Air, halogenated compounds, aluminum, lithium, active metals, oxidized surfaces	?	0.8	98
Dibutyl phosphate	$(C_4H_9O)_2(OH)PO$	Dibutyl acid o-phosphate, Di-n-butyl hydrogen phosphate, Dibutyl phosphoric acid	Strong oxidizers	?	?	?
Dibutylphthalate	$C_6H_4(CO_2C_4H_9)_2$	DBP; Dibutyl; 1,2,-Benzene-dicarboxylate	Nitrates; strong oxidizers, alkalies, and acids	315	0.5 (at Fl.P)	?
o-Dichlorobenzene	$C_6H_4Cl_2$	1,2-Dichlorobenzene; o-Dichlorobenzol	Strong oxidizers, hot aluminum or aluminum alloys	151	2.2	9.2
p-Dichlorobenzene	$C_6H_4Cl_2$	1,4-Dichlorobenzene; Dichloricide; PDCB	None hazardous	150	2.5	?

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
3,3'-Dichloro-benzidine (and its salts)	$C_{12}H_{10}Cl_2N_2$	Dichlorobenzidine base; o,o'-Dichloro-benzidine; 3,3'-Dichlorobiphenyl - 4,4'-diamine; 3,3'-Dichloro-4,4'-biphenyl-diamine; DCB; 4,4'-Diamino-3,3'-Dichlorobiphenyl; 3,3'-Dichloro-4 4'-diaminobiphenyl	Not available	NA	NA	NA
Dichlorodi-fluoro-methane	CCl_2F_2	Refrigerant 12, Freon 12, Propellant 12, Halon 122	Chemically active metals: sodium, potassium, calcium, powdered aluminum, zinc, magnesium	Not combustible		
1,3-Dichloro-5,5-dimethyl-hydantoin	$C_5H_6Cl_2N_2O_2$	Halane, Dactin	Water, strong acids, easily oxidized materials, such as ammonia salts, sulfides, etc.	346	?	?
1,1-Dichloro-ethane	CH_3CHCl_2	Asymmetrical Dichloro-ethane, Ethylidene chloride; 1,1-Ethylidene dichloride	Strong oxidizers and caustics	17	6	16
1,2-Dichloro-ethylene	ClCHCHCl	Acetylene dichloride, cis-Acetylene dichloride, Dioform, trans-Acetylene dichloride, sym-Dichloro-ethylene	Strong oxidizers	36 to 39	9.7	12.8
Dichloroethyl ether	$(ClCH_2CH_2)_2O$	bis(2-Chloroethyl) ether; 2,2-Dichloro-diethytether	Strong oxidizers	131	?	?
Dichloromono-fluoromethane	$CHCl_2F$	Refrigerant 21, Freon 21, Halon 112, Dichlorofluoro-methane	Chemically active metals: sodium, potassium, calcium, powdered aluminum, zinc, magnesium	Not combustible		
1,1-Dichloro-1-nitroethane	$CH_3CCl_2NO_2$	None	Strong oxidizers	136	?	?
Dichlorotetra-fluoroethane	$F_2ClCCClF_2$	1,2-Dichlorotetra-fluoroethane; Freon 114; Refrigerant 114; Halon 242	Chemically active metals: sodium, potassium, calcium, powdered aluminum, zinc, magnesium	Not combustible		
Dichlorvos	$(CH_3O)_2POOCH$ CCl_2	DDVP; 2,2-Dichloro-vinyl dimethyl phosphate	None hazardous	Not combustible		

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Dieldrin	$C_{12}H_8Cl_6O$	1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-exo-5,8-di-methano-naphthalene	Strong oxidizers, active metals like sodium, strong acids, phenols	Not combustible		
Diethylamine	$(C_2H_5)_2NH$	None	Strong oxidizers and acids	<0	1.8	10.1
Diethylamino-ethanol	$(C_2H_5)_2NC_2H_4OH$	2-Diethylaminoethyl alcohol; N,N-Diethyl-ethanolamine; Diethyl-(2-hydroxy-ethyl)amine; 2-Diethylamino ethanol	Strong oxidizers and acids	126	6.7	11.7
Difluoro-dibromo-methane	Cbr_2F_2	Dibromodifluoro-methane, Freon 12B2	Chemically active metals: sodium, potassium, calcium, powdered aluminum, zinc, magnesium	Not combustible		
Diglycidyl ether	$C_6H_{10}O_3$	di(Epoxyproply)ether ; bis(2,3-Epoxypropyl)-ether; 2-Epoxypropyl ether; Diallyl ether dioxide; DGE	Strong oxidizers	?	?	?
Diisobutyl ketone	$((CH_3)_2CHCH_2)_2CO$	2,6-Dimethyl-4-heptan-one; sym-Diisopropyl-acetone; Isovalerone; Valerone	Strong oxidizers	140	0.8	6.2
Diisopropyl-amine	$(CH_3)_2CHNHCH(CH_3)_2$	None	Strong oxidizers, strong acids	20	0.8	7.1
Dimethyl acetamide	$CH_3CON(CH_3)_2$	N,N-Dimethyl acet-amide; DMAC	Carbon tetra-chloride; other halogenated com-pounds, when in contact with iron	150(oc)	1.8	11.5
Dimethylamine	$(CH_3)_2NH$	Dimethylamine, anhydrous	Strong oxidizers, chlorine, mercury	NA	2.8	14.4
4-Dimethyl-aminoazo-benzene	$C_{14}H_{15}N_3$	N,N-dimethyl-4-aminoazo-benzene; N,N-Dimethyl-4-(phenylazo)-benzen-amine; p-Dimethyl-aminoazo-benzene; Methyl yellow; Butter yellow; DAB; N,N-Dimethyl-p-phenylazo-aniline	Not available	NA	NA	NA
Dimethylaniline	$C_6H_5N(CH_3)_2$	N,N-Dimethylaniline	Strong oxidizers, strong acids	145	1	?
Dimethyl-1,2-dibromo-2,2-dichloroethyl phosphate	$C_4H_7O_4PBr_2Cl_2$	Naled; 1,2-Dibromo-2,2, dichloro-ethyl dimethyl phosphate; Dibrom	Strong oxidizers	Not combustible		

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Dimethyl formamide	$HCON(CH_3)_2$	N,N-Dimethyl formamide; DMF	Carbon tetrachloride; other halogenated compounds, when in contact with iron; strong oxidizers; alkyl aluminums	136	2.2	15.2
1,1-Dimethyl-hydrazine	$(CH_3)_2NNH_2$	Unsymmetrical Dimethyl-hydrazine, UDMH	Oxidizers, halogens, metallic mercury, fuming nitric acid, hydrogen peroxide	5	2	95
Dimethyl-phthalate	$C_{10}H_{10}O_4$	DMP	Nitrates, strong oxidizers, alkalies, and acids	295	1.2 (at Fl.P)	?
Dimethylsulfate	$(CH_3)_2SO_4$	Methyl sulfate	Strong oxidizers and ammonia solutions	182	?	?
Dinitrobenzene (all isomers)	$C_6H_4(NO_2)_2$	o-Dinitrobenzene, 1,2-Dinitrobenzene; m-Dinitrobenzene, 1,3-Dinitrobenzene; p-Dinitrobenzene, 1,4-Dinitrobenzene	Strong oxidizers, caustics, metals, such as tin, zinc	Explodes	?	?
Dinitro-o-cresol	$CH_3C_6H_2OH(NO_2)_2$	3,5-Dinitro-2-hydroxy-toluene; 4,6-Dinitro-o-cresol; 4,6-Dinitro-2-methyl-phenol; DNOC; DN	Strong oxidizers	None		
Dinitrotoluene	$C_6H_3CH_3(NO_2)_2$	DNT	Strong oxidizers, caustics, metals, such as tin, zinc	404	?	?
Di-sec-octyl phthalate	$C_{24}H_{38}O_4$	DOP, bis-(2-Ethyl-hexyl) phthalate, Di-2-Ethyl-hexyl phthalate, DEHP	Nitrates; strong oxidizers, acids, and alkalides	425(oc)	?	?
Dioxane	$OCH_2CH_2OCH_2CH_2$	Diethylene dioxide; Diethylene ether; Dioxan; p-Dioxane; 1,4-Dioxane	Strong oxidizers	54	2	22
Diphenyl	$C_6H_5C_6H_5$	Biphenyl, Phenyl benzene	Oxidizers	235	0.6 (212°F)	5.8 (311°F)
Dipropylene glycol methyl ether	$C_7H_{16}O_3$	Dipropylene glycol monomethyl ether, Dowanol 50B	Strong oxidizers	185	?	?
Endrin	$C_{12}H_8Cl_6O$	1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4.4a,5,6,7,8,8a-octahydro-1,4-endo-endo-5,8-dimethano-naphthalene	Strong oxidizers and acids	Not combustible, but may be dissolved in flammable solvent		
Epichlorohydrin	C_3H_5OCl	1-Chloro-2,3-epoxy-propane; 2-Chloro-propylene oxide; gamma-Chloropropyl-ene oxide	Strong oxidizers and acids, caustics, zinc, aluminum, chlorides of iron and aluminum	100	3.8	21

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
EPN	$C_{14}H_{14}NO_4PS$	o-Ethyl o-p-nitrophenyl thionobenzene phosphonate, o-Ethyl o-p-nitrophenyl benzene-phonothioate	Strong oxidizers	Not combustible		
Ethanolamine	$HOCH_2CH_2NH_2$	Ethylolamine, Monoethanolamine, beta-Aminoethyl alcohol, 2-Amino-ethanol, 2-Hydrox-ethylamine	Strong oxidizers and acids	185	5.5	≈17
2-Ethoxyethyl-acetate	$C_2H_5OCH_2CH_2OOCCH_3$	Ethylene glycol monoethyl ether, Cellosolve® solvent	Strong oxidizers	120(oc)	1.8	14
2-Ethoxyethyl-acetate	$C_2H_5OCH_2CH_2OOCCH_3$	Cellosolve® acetate, Glycol monoethyl ether acetate, Ethylene glycol monoethyl ether acetate	Nitrates; strong oxidizers, alkalies, and acids	117	1.7	?
Ethyl acetate	$CH_3COOC_2H_5$	Acetic ester, Acetic ether, Ethyl enthanoate	Nitrates; strong oxidizers, alkalies, and acids	24	2.2	11
Ethylamine	$C_2H_5NH_2$	Ethylamine, anhydrous; Aminoethane; Mono-ethylamine	Strong acids and oxidizers	<0	3.5	14
Ethyl acrylate	$CH_2CHCOOC_2H_5$	Ethyl propenoate	Oxidizers, per-oxides, polymer-izers, strong alkalies, moisture	48	1.8	?
Ethyl benzene	$C_2H_5C_6H_5$	Phenylethane, Ethyl-benzol	Strong oxidizers	59	1.0	6.7
Ethyl bromide	C_2H_5Br	Bromoethane	Chemically active metals: sodium, potassium, calcium, powdered aluminum, zinc, magnesium	<-4	6.7	11.3
Ethyl butyl ketone	$C_2H_5COC_4H_9$	Butyl ethyl ketone, 3-Heptanone	Oxidizers	115(oc)	1.4	8.8
Ethyl chloride	C_2H_5Cl	Chloroethane, Monochloroethane, Hydrochloric ether, Muriatic ether	Chemically active metals; sodium, potassium, calcium, powdered aluminum	-58	3.8	15.4
Ethylene chlorohydrin	CH_2ClCH_2OH	2-Chloroethanol, 2-Chloroethyl alcohol	Strong oxidizers and caustics	140	4.9	15.9
Ethylene-diamine	$NH_2CH_2CH_2NH_2$	1,2-Diaminoethane; Ethylenediamine, anhydrous; 1,2-Ethanediamine	Strong acids and oxidizers, chlorinated organic compounds	93	5.8	11.1

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Ethylene dibromide	CH_2BrCH_2Br	1,2-Dibromoethane; Ethylene bromide	Chemically active metals: sodium, potassium, calcium, powdered aluminum, zinc, magnesium; liquid ammonia; strong oxidizers	Not combustible		
Ethylene dichloride	$ClCH_2CH_2Cl$	Ethylene chloride; 1,2-Dichloroethane; Glycol dichloride	Strong oxidizers and caustics, chemically active metals, such as aluminum or magnesium powder, sodium, potassium	55	6.2	16
Ethylene glycol dinitrate and/or Nitroglycerin	$C_2H_4(NO_3)_2$ $C_3H_5(NO_3)_3$	Glycol dinitrate, Nitroglycol Blasting gelatin, Glycerin trinitrate, EGDN	Acids	Explodes		
Ethyleneimine	C_2H_5N	Ethyleimine; Dimethyl-enimine; Dihydro-azirine; Azirane; Aziridine; Aminoethyl-ene; Azacyclo-propane; 1H-Azirine, dihydro-; Dihydro-1H-azirine; Dimethyl-eneimine; Ethylimine	Polymerizes explosively in presence of oxidizing materials	12	3.3	46
Ethylene oxide	C_2H_4O	Dimethylene oxide; 1,2-Epoxy ethane; Oxirane	Even small amounts of strong acids, alkalies, oxidizers; catalytic anhydrous chlorides of iron, aluminum, tin; oxides of iron; aluminum	<0	3	100
Ethyl ether	$C_2H_5OC_2H_5$	Diethyl ether, Ethyl oxide, Ether, Diethyl oxide, Solvent ether	Strong oxidizers	-49	1.9	36
Ethyl formate	$HCOOC_2H_5$	Ethyl methanoate, Formic acid ethyl ester	Nitrates; strong oxidizers, alkalies, and acids	-4	2.8	16
Ethyl mercaptan	C_2H_5SH	Ethanethiol, Ethyl sulfhydrate	Strong oxidizers	-55	2.8	18
n-Ethylmorpho-line	$C_6H_{13}ON$	4-Ethylmorpholine	Strong acids and oxidizers	90	1.0	9.8
Ethyl silicate	$(C_2H_5)_4SiO_4$	Ethyl silicate, condensed; Tetraethyl silicate; Ethyl ortho-silicate; Tetraethoxy-silane	Strong oxidizers, water	99	1.3	23
Ferbam	$((CH_3)_2NCS_2)_3Fe$	Ferric dimethyl dithio-carbamate, tris (Dimethyl-dithio-carbamate) iron	Strong oxidizers			
Ferrovanadium dust		None	Strong oxidizers	NA		

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Fluorides (as F)	F	Synonyms vary depending upon specific compound	Strong acids	Properties vary depending upon specific compound		
Fluorine	F_2	None	Water, nitric acid, most oxidizable materials	Not combustible but strong oxidizer	?	?
Fluorotrichloromethane	CCl_3F	Refrigerant 11, Monofluorotrichloromethane, Trichlorofluoromethane, Trichloromonofluoromethane, Freon 11	Chemically active metals: sodium, potassium, calcium, powdered aluminum, zinc, magnesium	Not combustible		
Formaldehyde	HCHO	1) Methylene oxide; 2)Formalin, methanol free (30 to 50% formaldehyde); 3) Formalin, stabilized, N.F. (6 to 15% methanol)	Strong oxidizers, alkalies, and acids; phenols; urea	NA/185/122	7	73
Formic acid	HCOOH	1) Formic acid 85%; 2)Formic acid 90%; 3)Formic acid 95%; Hydrogencarboxylic acid; Methanoic acid	Strong oxidizers, strong caustics, concentrated sulfuric acid	NA/185/122	18	57
Furfural	C_4H_3OCHO	2-Furaldehyde, Furfur-aldehyde, Fural, 2-Furan-carboxaldehyde	Strong acids, oxidizers	140	2.1	19.3
Furfuryl alcohol	$C_4H_3OCH_2OH$	2-Hydroxy-methylfuran, 2-Furylmethanol	Strong oxidizers, strong acids, organic acids may lead to polymerization	149	1.8	16.3
Glycidol	$C_3H_4O_2$	2-Hydroxymethyl-oxiran; Hydroxymethyl ethylene oxide; Epoxy-propyl alcohol; 3-Hydroxy-propylene oxide; 2,3-Epoxy-1-propanol	Strong oxidizers, nitrates	162	?	?
Graphite (natural)	C	Plumbago, Potelot, Corbo minerals, Black lead, Carburet of iron, Silver lead, Crayon noir	Very strong oxidizers, such as fluorine, chlorine trifluoride, potassium peroxide			
Hafnium and compounds (as Hf)	Hf	Synonyms vary depending upon specific compounds	Strong oxidizers and chlorine	Properties vary depending upon specific compound		
Heptachlor	$C_{10}H_5Cl_7$	1,4,5,6,7,8,8-Heptachloro-3a,4,7,7a-tetra-hydro-4,7-methano-idene	Melted heptachlor with iron and rust	Not combustible		

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Heptane	$CH_3(CH_2)_5CH_3$	Normal heptane, n-heptane	Strong oxidizers	25	1.1	6.7
Hexachloro-ethane	CCl_3 Ccl_3	Perchloroethane	Hot iron, zinc, aluminum, alkalies	Not combustible		
Hexachloro-naphthalene	$C_{10}H_2Cl_4$	Halowax 1014	Strong oxidizers	Not combustible		
Hexane	$CH_3(CH_2)_4CH_3$	Hexyl hydride, Normal hexane, n-hexane	Strong oxidizers	-7	1.1	7.5
2-Hexanone	$CH_3CO(CH_2)_3CH_3$	Methyl butyl ketone, MBK, Butyl methyl ketone, Methyl n-butyl ketone	Strong oxidizers	77	1.2	8
Hexone	$CH_3COCH_2C_3H_7$	4-Methyl-2-pentanone, Methyl isobutyl ketone, Isobutyl methyl ketone, MIBK	Strong oxidizers	73	1.4	7.5
sec-Hexyl acetate	$C_8H_{16}O_2$	1,3-Dimethylbutyl acetate; Methylamyl acetate; Methylisoamyl acetate; Methylisobutyl carbinol	Nitrates, strong oxidizers, alkalies, and acids	113	0.9 (at Fl.P)	?
Hydrazine	N_2H_4	Hydrazine, anhydrous	Oxidizers, hydrogen peroxide, nitric acid; metal oxides, strong acids; porous materials	100	4.7	100
Hydrogen bromide	Hbr	Anhydrous hydrobromic acid	Strong oxidizers, strong caustics, metals, moisture	Not combustible		
Hydrogen chloride	HCl	Anhydrous hydrogen chloride; Hydrochloric acid, anhydrous	Most metals, alkali or active metals	Not combustible		
Hydrogen cyanide (as CN)	HCN	Hydrocyanic acid, Prussic acid, Formonitrile	Bases, such as caustics, amines	0	5.6	40
Hydrogen fluoride	HF	Anhydrofluoric acid, HF-A	Metals, concrete, glass, ceramics	Not combustible		
Hydrogen peroxide	H_2O_2	High-strength hydroperoxide, Peroxide, Hydrogen dioxide	Oxidizable materials; iron, copper, brass, bronze, chromium, zinc, lead, manganese, silver, catalytic metals	Not combustible, but powerful oxidizer		
Hydrogen selenide	H_2Se	Selenium hydride	Oxidizers, acids, water, halogenated hydrocarbons	NA	?	?
Hydrogen sulfide	H_2S	Sulfuretted hydrogen, Hydrosulfuric acid, Hepatic gas	Strong oxidizers, metals	NA	4.3	46

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Hydroquinone	$C_6H_4O_2$	Quinol; 1,4-Dihydroxybenzene; 1,4-Benzenediol	Strong oxidizers	329	?	?
Iodine	I_2	None	Gaseous or aqueous ammonia, acetylene, acet-aldehyde, powdered aluminum, active metals	Not combustible		
Iron oxide fume	Fe_2O_3	Ferric oxide fume	Calcium hypochloride	Not combustible		
Isoamyl acetate	$C_7H_{14}O_2$	3-Methyl-1-butanol acetate, Banana oil, 2-Methylbutyl ethanoate	Nitrates; strong oxidizers, alkalies, and acids	77	1 (212°F)	7.5
Isoamyl alcohol	$(CH_3)_2CHCH_2CH_2OH$	3-Methyl-1-butanol, Isobutylcarbinol, Isopentyl alcohol, Fermentation amyl alcohol, Fusel oil	Strong oxidizers	109	1.2 (212°F)	9 (212°F)
Isobutyl acetate	$CH_3COOCH_2CH(CH_3)_2$	2-Methylpropyl acetate, beta-Methylpropyl ethanoate, Acetic acid isobutyl ester	Nitrates; strong oxidizers, alkalies, and acids	64	2.4	10.5
Isobutyl alcohol	$(CH_3)_2CHCH_2OH$	Isobutanol, IBA, 2-Methyl-1-propanol, Isopropylcarbinol	Strong oxidizers	82	1.2 (212°F)	10.9 (212°F)
Isophorone	$C_9H_{14}O$	3,5,5-Trimethyl-2-cyclohexene-1-one	Strong oxidizers	184	0.8	3.8
Isopropyl acetate	$CH_3COOCH(CH_3)_2$	Isopropyl ester of acetic acid, sec-Propyl acetate	Nitrates; strong oxidizers, alkalies, and acids	40	1.8	8
Isopropyl alcohol	$CH_3CHOHCH_3$	Isopropanol, IPA, 2-Propanol, sec-Propyl alcohol	Strong oxidizers	53	2	12
Isopropylamine	$(CH_3)_2CHNH_2$	Monoisopropylamine, 2-Aminopropane	Strong acids and oxidizers	-35	2.0	10.4
Isopropyl ether	$((CH_3)_2CH)_2O$	Diisopropyl ether, 2-Isopropoxy propane	Strong oxidizers	-18	1.4	7.9
Isopropyl glycidyl ether	$C_6H_{12}O_2$	Isopropoxymethyl-oxiran; 1,2-Epoxy-3-isopropoxypropane; isopropyl epoxypropyl ether; IGE	Strong oxidizers and caustics	92	?	?
Ketene	CH_2CO	Carbomethene, Ethenone	Water, variety organic compounds	NA	?	?
Lead, inorganic fumes and dusts (as Pb)	Pb	Synonyms vary depending upon specific compound	Strong oxidizers, hydrogen peroxide, active metals: sodium, potassium	Properties vary depending upon specific compound		
Lead arsenate	$Pb_3(AsO_4)_2$	Synonyms vary depending upon specific compound	None hazardous	Properties vary depending upon specific compound		

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Lindane	$C_6H_6Cl_6$	1,2,3,4,5,6-Hexachlorocyclohexane; gamma-Hexachlorocyclohexane; Benzene hexachloride	None hazardous	Not combustible		
Lithium hydride	LiH	None	Oxidizers, halogenated hydrocarbons, acids, water	NA	NA	NA
LPG		Liquefied petroleum gas, Bottled gas	Strong oxidizers	NA	1.9	9.5
Magnesium oxide fume	MgO	Magnesia fume	Chlorine trifluoride	Not combustible		
Malathion	$C_{10}H_{19}O_6PS_2$	o,o-Dimethyl dithiophosphate of diethyl mercaptosuccinate; o,o-Dimethyl S-(1,2-dicarbethoxyethyl)phosphoro-dithiocite	Strong oxidizers	Not combustible		
Maleic anhydride	$(CHCO)_2O$	2,5-Furanedione; cis-Butenedioic anhydride; Toxilic anhydride	Strong oxidizers; alkali metals, caustics, amines at > 150°F	215	3.4	7.1
Manganese and compounds (as Mn)	Mn	Synonyms vary depending upon specific compound	Variable	?	?	?
Mercury and inorganic compounds (as Hg)	Hg	Quicksilver	Acetylenes, ammonia gases	Not combustible		
Mercury, (organo) alkyl compounds (as Hg)		Synonyms vary depending upon specific compound	Strong oxidizers, such as chlorine	Properties vary depending upon specific compound		
Mesityl oxide	$CH_3COCH=C(CH_3)_2$	4-Methyl-3-penten-2-one, Isobutenyl methyl ketone, Methyl iso-butenyl ketone, Isopropylidene acetone	Oxidizers	87	1.4	?
Methoxychlor	$C_{16}H_{15}Cl_3O_2$	2,2-bis(p-Methoxyphenyl)-1,1,1-Trichloroethane	Strong oxidizers	NA	NA	NA
Methyl acetate	CH_3COOCH_3	Acetic acid, methyl ester; Methyl acetic ester; Methyl ethanoate	Nitrates; strong oxidizers, alkalies, and acids	14	3.1	16
Methyl acetylene	C_3H_4	Propyne, Allylene	Strong oxidizers, chlorine, copper, copper alloys	NA	1.7	11.7
Methyl acetylene-propadiene mixture		MAPP gas, Methyl acetylene-allene mixture, Propyne-allene mixture	Strong oxidizers, copper alloys (>67% Cu)	NA	3.4	11
Methyl acrylate	$CH_2CHCOOCH_3$	Methyl propenoate	Nitrates, oxidizers, peroxides, polymerizers, strong alkalies, moisture	13	2.8	25

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Methylal	$CH_3OCH_2OCH_3$	Dimethyoxymethane, Methyl formal, Formal, Dimethylacetal formaldehyde	Strong oxidizers, acids	0 (oc)	1.6	17.6
Methyl alcohol	CH_3OH	Methanol, Wood alcohol, Columbian spirits, Carbinol	Strong oxidizers	52	6.7	36
Methylamine	CH_3NH_2	Monomethylamine, Anhydrous methylamin	Mercury, strong oxidizers	NA	5	21
Methyl (n-amyl) ketone	$CH_3COC_5H_{11}$	n-Amyl methyl ketone, 2-Heptanone	Strong acids, alkalies, oxidizers	120	1.1	7.9
Methyl bromide	CH_3Br	Bromomethane	Aluminum, strong oxidizers	?	13.5	14.5
Methyl cellosolve	$CH_3OCH_2CH_2OH$	2-Methoxyethanol, Glycol monomethyl ether, Ethylene glycol monomethyl ether, Methyl oxitol, Ekta-solve, Jeffersol EM	Strong oxidizers and caustics	107	2.5	19.8
Methyl cellosolve acetate	$C_5H_{10}O_3$	2-Methoxyethyl acetate, Glycol mono-methyl ether acetate, Ethylene glycol mono-methyl ether acetate	Nitrates; strong oxidizers, alkalies, and acids	111	1.1	8.2
Methyl chloride	CH_3Cl	Chloromethane	Chemically active metals: potassium, powdered aluminum, zinc, magnesium	NA	7.6	19
Methyl chloroform	CH_3CCl_3	1,1,1-Trichloro-ethane; 1,1,1-Trichloro-ethane, stabilized	Strong caustics, strong oxidizers, chemically active metals, such as aluminum, magnesium powders, sodium, potassium	None	7	16
Methyl chloromethyl ether-See Chloromethyl methyl ether						
Methylcyclo-hexane	$CH_3C_6H_{11}$	Cyclohexylmethane, Hexahydrotoluene	Strong oxidizers	25	1.2	6.7
Methylcyclo-hexanol	$CH_3C_6H_{10}OH$	Hexahydrocresols; mixture of 2-,3-, and 4-Methylcylohexanols	Strong oxidizers	149	?	?
o-Methylcyclo-hexanone	$C_7H_{12}O$	2-Methylcyclo-hexanone	Strong oxidizers	118	?	?
Methylene bisphenyl isocyanate	$C_{15}H_{10}O_2N_2$	MDI; 4,4-Diphenyl-methane diisocyanate; Methylene bis(4-phenyl isocyanate); 4,4-Diiso-cyano-diphenylmethane	Strong alkalies, acids, alcohol	396(oc)	NA	NA

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Methylene chloride	CH_2Cl_2	Dichloromethane, Methylene dichloride	Strong oxidizers and caustics; chemically active metals, such as aluminum or magnesium powders; sodium, potassium	?	12	19
Methyl formate	$HCOOCH_3$	Methyl methanoate, Formic acid, Methyl ester	Strong oxidizers	-2	5	23
5-Methyl-3-heptanone	$C_8H_{16}O$	Ethyl sec-amyl ketone, Ethyl amyl ketone, Amyl ethyl ketone	Oxidizers	110	?	?
Methyl iodide	CH_3I	Iodomethane	Strong oxidizers	Not combustible		
Methyl isobutyl carbinol	$C_6H_{14}O$	Methyl amyl alcohol, 4-Methyl-2-pentanol, MIBC	Strong oxidizers	106	1	5.5
Methyl isocyanate	CH_3NCO	None	Water, rapid reaction in presence of acid, alkali, amine; iron, tin, copper, their salts, other catalysts	<0(oc)	5.3	26
Methyl mercaptan	CH_3SH	Methanethiol	Strong oxidizers, bleaches	0 (oc)	3.9	21.8
Methyl methacrylate	$CH_2C(CH_3)COOCH_3$	Methacrylic acid, methyl ester	Nitrates, oxidizers, peroxides, polymerizers, strong alkalies, moisture	50 (oc)	1.7	8.2
alpha-Methyl styrene	$C_6H_5C(CH_2)CH_2$	1-Methyl-1-phenyl-ethylene, AMS	Oxidizers, peroxides, halogens, catalysts for vinyl or ionic polymers; aluminum, iron chloride	129	1.9	6.1
Mica (less than 1% quartz)		Varies depending upon specific hydrous silicate	None	Not combustible		
Molybdenum, soluble compounds (as Mo)	Mo	Synonyms vary depending upon specific compound	Alkali metals; sodium, potassium, molten magnesium	Properties vary depending upon specific compound		
Molybdenum, insoluble compounds (as Mo)	Mo	Synonyms vary depending upon specific compound	Strong oxidizers	Properties vary depending upon specific compound		
Monomethyl aniline	$C_6H_5NHCH_3$	N-Methyl aniline, MA, Methyl aniline	Strong acids, strong oxidizers	175	?	?

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Monomethyl hydrazine	CH_3NHNH_2	Methyl hydrazine	Oxides of iron, copper; manganese, lead, copper alloys; porous metals, earth, asbestos, wood, cloth; oxidants, hydrogen peroxide, nitric acid	17	2.5	98
Morpholine	C_4H_9ON	Tetrahydro-1,4-oxazine; Diethylenimide oxide	Strong acids, strong oxidizers	95	1.8	11
Naphtha (coal tar)		Naphta, Crude Solvent coal tar naphtha, High solvent naphtha	Strong oxidizers	100 to 109	?	?
Naphthalene	$C_{10}H_8$	White tar, Naphthalin	Strong oxidizers	174	0.9	5.9
alpha-Naphthylamine	$C_{10}H_9N$	1-Naphthylamine, 1-Amino-naphthalene	Not available	315	?	?
beta-Naphthylamine	$C_{10}H_9N$	2-Naphthylamine; 2-Amino-naphthalene	Not available	Combustible solid	?	?
Nickel, metal and soluble compounds (as Ni)	Ni	Synonyms vary depending upon specific compound	Strong acids, sulfur, $Ni(NO_3)_2$; wood, other combustibles	Properties vary depending upon specific compound		
Nickel carbonyl	$Ni(CO)_4$	None	Nitric acid, chlorine, other oxidizers, combustible vapors	<-4	2	?
Nicotine	$C_{10}H_{14}N_2$	3-(1-Methyl-2-pyrrolidyl) pyridine	Strong oxidizers, strong acids	203	0.7	4
Nitric acid	HNO_3	Aqua fortis, White fuming nitric acid (WFNA), Red fuming nitric acid (RFNA), Hydrogen nitrate	Combustible organics, oxidizable matter; wood, turpentine, metal powder, hydrogen sulfide, etc.; strong bases	Not combustible		
Nitric oxide	NO	Nitrogen monoxide	Combustible matter, chlorinated hydrocarbons, ammonia, carbon disulfide, metals, fluorine, ozone	Not combustible		
p-Nitroaniline	$C_6H_6N_2O_2$	Azoic diazo component 37, para-Aminonitrobenzene, Fast red GG base, 4-Nitroaniline, PNA	Strong oxidizers and reducers	390	?	?
Nitrobenzene	$C_6H_5NO_2$	Nitrobenzol, Oil of mirbane	Concentrated nitric acid, nitrogen tetroxide, caustic, chemically active metals like tin or zinc	190	1.8	?

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
4-Nitrobiphenyl	$C_{12}H_9NO_2$	p-Nitrobiphenyl, p-Nitrodiphenyl, 4-Nitrodiphenyl, 4-Phenyl-nitro-benzene, p-Phenyl-nitro-benzene, PNB	Strong reducers	NA	NA	NA
p-Nitrochloro-benzene	$ClC_6H_4NO_2$	PNCB, PCNB, 4-Chloronitro-benzene, p-Chloronitro-benzene, 1-Chloro-4-nitro-benzene	Strong oxidizers	261	?	?
Nitroethane	$C_2H_5NO_2$	None	Amines, strong acids, alkalies, and oxidizers; hydro-carbons, other combustibles; metal oxides	82	3.4	?
Nitrogen dioxide	NO_2 and N_2O_4	Nitrogen tetroxide, NTO, Dinitrogen tetroxide, Nitrogen peroxide	Combustible matter, chlorinated hydrocarbons, ammonia, carbon disulfide	Not combustible		
Nitrogen trifluoride	NF_3	None	Water, oil, grease; oxidizable materials; ammonia, carbon monoxide, methane, hydro-gen, hydrogen sulfide, active metals; oxides	Not combustible		
Nitromethane	CH_3NO_2	None	Amines, strong acids, alkalies, and oxidizers; hydro-carbons, other combustibles; metallic oxides	95	7.3	?
1-Nitropropane	$CH_3CH_2CH_2NO_2$	None	Amines, strong acids, alkalies; strong oxidizers; hydrocarbons, other combust-ibles, metal oxides	96	2.2	?
2-Nitropropane	$CH_3CH(NO_2)CH_3$	sec-Nitropropane	Amines, strong acids, alkalies, and oxidizers, metal oxides, combustible materials	82	2.6	?
N-Nitrosodi-methylamine	$C_2H_6N_2O$	N-Nitrosodimethyl-amine; NDMA; Dimethylnitrosamine; DMNA; N,N-Dimethylnitros-amine; DMN; N-Methyl-N-Nitroso-methanamine	Strong oxidizing agents	?	?	?

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Nitrotoluene	$NO_2C_6H_4CH_3$	Orthonitrotoluene, o-Nitrotoluol, Metanitrotoluene, m-Nitrotoluol, Paranitrotoluene, p-Nitrotoluol	Strong oxidizers, sulfuric acid	223/ 214/ 223	2.2/ 1.6/ 1.6	?
Octachloro-naphthalene	$C_{10}Cl_8$	Halowax 1051	Strong oxidizers	Not combustible		
Octane	C_8H_{18}	Normal octane	Strong oxidizers	56	1	6.5
Oil mist (mineral)		Mist of white mineral oil, cutting oil, heat-treating oil, hydraulic oil, cable oil, lubricating oil	None hazardous	275	NA	NA
Osmium tetroxide	OsO_4	Osmic acid	Hydrochloric acid, easily oxidized organic materials	Not combustible		
Oxalic acid	$HOOCCOOH\text{-}2H_2O$	Oxalic acid dihydrate, Ethane dioic acid	Strong oxidizers, silver	None	?	?
Oxygen difluoride	OF_2	Difluorine monoxide, Fluorine monoxide	All combustible materials, chlorine, bromine, iodine, platinum, metal oxides, moist air	Not combustible, but strong oxidizer		
Ozone	O_3	None	All oxidizable materials, both organic and inorganic	NA	NA	NA
Paraquat compounds		Synonyms vary depending upon specific compound	Strong oxidizers	Not combustible		
Parathion	$(C_2H_5O)_2PSOC_6H_4NO_2$	o,o-Diethyl-o,p-nitro-phenyl phosphoro-thioate; Ethyl parathion	Strong oxidizers	Not combustible		
Pentaborane	B_5H_9	Stable pentaborane, Pentaboron nonahydride	Oxidizers, halo-gens, halogenated compounds; impure material ignites spontane-ously	86	0.42	?
Pentachloro-naphthalene	$C_{10}H_3Cl_5$	Halowax 1013	Strong oxidizers	Not combustible		
Pentachloro-phenol	C_6Cl_5OH	PCP, Penta	Strong oxidizers	Not combustible		
Pentane	C_5H_{12}	Normal pentane	Strong oxidizers	-57	1.5	7.8
2-Pentanone	$CH_3COC_3H_7$	Methyl propyl ketone, Ethyl acetone, MPK	Oxidizing agents	45	1.5	8.2
Perchloromethyl mercaptan	CH_3SCl	PMM, Trichloromethyl sulfur chloride	Alkalies, amines, hot iron, hot water	Not combustible		

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Perchloryl fluoride	ClO_3F	Chlorine oxyfluoride	Combustibles, strong bases, amines, finely divided metals; oxidizable materials	Not combustible		
Petroleum distillates (naphtha)		Petroleum naphtha; Aliphatic petroleum naphtha; Petroleum ether (95 to 115°C); Naphtha, petroleum	Strong oxidizers	-40 to -86	1	6
Phenol	C_6H_5OH	Carbolic acid, Monohydroxy benzene	Strong oxidizers, calcium hypochlorite	174	1.7	8.6
p-Phenylene diamine	$C_6H_8N_2$	p-Diamino benzene; 1,4-Diaminobenzene	Strong oxidizers	312		
Phenyl ether	$(C_6H_5)_2O$	Diphenyl ether, Diphenyl oxide	Strong oxidizers	239	0.8	1.5
Phenyl ether-biphenyl mixture	$(C_6H_5)_2O$ and $C_6H_5C_6H_5$	Dowtherm A, Diphenyl oxide-diphenyl mixture	Strong oxidizers	255 (oc)	0.5	6.2 (500°F)
Phenyl glycidyl ether	$C_6H_5OCH_2CHOCH_2$	Glycidyl phenyl ether; Phenyl epoxypropyl ether; 1,2-Epoxy-3-phenoxypropane; PGE	Strong oxidizers, amines, strong acids, strong bases	248	?	?
Phenylhydrazine	$C_6H_5NHNH_2$	Hydrazinobenzene	Strong oxidizers, lead dioxide	192	?	?
Phosdrin	$C_7H_{13}O_4PO_2$	Mevinphos ®, 2-Carbomethoxy-l-methylvinyl dimethyl phosphate	Strong oxidizers	175 (oc)	?	?
Phosgene	$COCl_2$	Carbonyl chloride, Carbon oxychloride, Chloroformyl chloride	Moisture	Not combustible		
Phosphine	PH_3	Hydrogen phosphide, Phosphorus hydride, Phosphorated hydrogen	Air, oxidizers, chlorine, acids, moisture, halogenated hydrocarbons	NA	?	?
Phosphoric acid	H_3PO_4	White phosphoric acid, Orthophosphoric acid, 85% Phosphoric acid, Metaphosphoric acid	Strong caustics, most metals	Not combustible		
Phosphorus (yellow)	P_4	White phosphorus; WP; Phosphorus, elemental, white	Air, all oxidizing agents, including elemental sulfur, strong caustics	Spontaneous in air >86°F	NA	NA
Phosphorus pentachloride	PCl_5	None	Water; magnesium oxide; chemically active metals: sodium, potassium; alkalies	Not combustible		

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Phosphorus pentasulfide	P_2S_5 or P_4S_{10}	Phosphorus persulfide, Regular phosphorus pentasulfide, Reactive phosphorus penta-sulfide, Distilled phosphorus penta-sulfide, Undistilled phosphorus penta-sulfide	Water, alcohols, strong oxidizers	?		
Phosphorus trichloride	PCl_3	Phosphorus chloride	Water, alcohol, when in contact with combustible organics; chemically active metals: sodium, potassium, aluminum, strong nitric acid	Not combustible		
Phthalic anhydride	$C_6H_4(CO)_2O$	PAN	Strong oxidizers	304	1.7	10.4
Picric acid	$HOC_6H_2(NO_2)_3$	2,4,6-Trinitrophenol; Lyddite; Pertite; Shimose; Melinite	Copper, lead, zinc, other metals, salts, plaster, concrete	302	?	?
Pival ®	$C_{14}H_{14}O_3$	2-Pivalyl-1,3-indandione; Pivalyl; Pindone; tert-Butyl-valone; 1,3-Dioxo-2-pivaloylindane	None hazardous	?	?	?
Platinum (soluble salts as Pt)	Pt	Synonyms vary depending upon specific compound	None hazardous	Properties vary depending upon specific compound		
Portland cement (less than 1% quartz)		Hydraulic cement, Cement, Portland cement silicate	None hazardous	Not combustible		
Propane	$CH_3CH_2CH_3$	Dimethyl methane	Strong oxidizers	NA	2.2	9.5
beta-Propiolactone	$C_3H_4O_2$	Hydroacrylic acid, beta-lactone; 3-Hydroxy-propionic acid; beta-Lactone; 2-Oxetanone; Betaprone; Propanolide; Propiolactone; Propionic acid; 3-Hydroxy-beta-lactone; beta-Propiolactone; beta-Proprolactone; BPL	Acetates, halogens, thiocyanates, and thiosulphates	158	2.9	?
n-Propyl acetate	$CH_3COOCH_2CH_2CH_3$	Propylacetate; Acetic acid, n-propyl ester	Nitrates; strong oxidizers, alkalies, and acids	58	2	8
Propyl alcohol	$CH_3CH_2CH_2OH$	n-Propyl alcohol, 1-Propanol, Ethyl carbinol	Strong oxidizers	59	2	14
Propylene dichloride	$CH_3CHClCH_2Cl$	1,2-Dichloropropane	Strong oxidizers and acids	60	3.4	14.5
Propyleneimine	C_3H_7N	2-Methylaziridine	Acids, strong oxidizers	25	?	?

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Propylene oxide	CH_3CHOCH_2	1,2-Epoxy propane, Propene oxide, Methyloxirane	Anhydrous metal chlorides, iron; strong acids, caustics, peroxides	-35	2.1	37
n-Propyl nitrate	$C_3H_7NO_3$	None	Strong oxidizers, combustibles	68	2	100
Pyrethrum		Synonyms vary depending upon specific compound	Strong oxidizers	180 to 190(oc)	?	?
Pyridine	C_5H_5N	Azabenzene, Azine	Strong oxidizers, strong acids	68	1.8	12.4
Quinone	OC_6H_4O	p-Benzoquinone	Strong oxidizers	?	?	?
Rhodium, metal fume and dust (as Rh)	Rh	Synonyms vary depending upon specific compound	None hazardous	Not combustible		
Rhodium, soluble salts (as Rh)	Rh	Synonyms vary depending upon specific compound	None hazardous	Properties vary depending upon specific compound		
Ronnel	$(CH_3O)_2PSOC_6H_2Cl_3$	Fenchlorophos; o,o-Dimethyl o-(2,4,5-trichlorophenyl) phosphoro-thioate	Strong oxidizers	Not combustible		
Rotenone (commercial)	$C_{23}H_{22}O_6$	Tubatoxin, "Cube", Derrin	Strong oxidizers	?	?	?
Selenium compounds (as Se)	Se	Synonyms vary depending upon specific compound	Acids, strong oxidizing agents	Properties vary depending upon specific compound		
Selenium hexafluoride (as Se)	SeF_6	None	None reported	Not combustible		
Silica (amorphous)	SiO_2	Diatomite, Silicon dioxide (amorphous), Diatomaceous earth, Diatomaceous silica	Fluorine, oxygen difluoride, chlorine trifluoride	Not combustible		
Silica (crystalline)	SiO_2	Quartz, Cristobalite, Tridymite	Powerful oxidizers: fluorine, chlorine trifluoride, manganese trioxide, oxygen difluoride, etc.	Not combustible		
Silver, metal, and soluble compounds (as Ag)	Ag	Synonyms vary depending upon specific compounds	Acetylene, ammonia, hydrogen per-oxide	Properties vary depending upon specific compound		
Soapstone	$3MgO\text{-}4SiO_2\text{-}H_2O$	Massive talc, Steatite, Soapstone silicate	None hazardous	Not combustible		
Sodium fluoroacetate	$CH_2FCOONa$	1080, Sodium monofluoroacetate, SFA	None hazardous	Not combustible		
Sodium hydroxide	NaOH	Caustic soda, Soda lye, Lye	Water, acids, flammable liquids, organic halogens, metals: aluminum, tin, zinc; nitromethane and nitro compounds	Not combustible		

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Stibine	SbH_3	Hydrogen antimonide, Antimony trihydride	Acids, halogenated hydrocarbons, oxidizers, moisture	NA	?	?
Stoddard solvent	C_9H_{20}	Dry cleaning safety solvent, Mineral spirits	Strong oxidizers	102 to 140	0.8	?
Strychnine	$C_{21}H_{22}N_2O_2$	None	Strong oxidizers	Not combustible		
Styrene	$C_6H_5CHCH_2$	Phenylethylene, Vinylbenzene, Cinnamene, Styrene monomer	Oxidizers, catalysts for vinyl polymers; peroxides, strong acids, aluminum chloride	90	1.1	6.1
Sulfur dioxide	SO_2	None	Powdered and alkali metals such as sodium, potassium	Not combustible		
Sulfuric acid	H_2SO_4	Oil of vitriol	Organics:chlorates, carbides, fulminates, picrates, metals	Not combustible, but highly reactive		
Sulfur monochloride	S_2Cl_2	Sulfur chloride, Sulfur subchloride	Peroxides, oxides of phosphorous, organics; water	245	?	?
Sulfur pentafluoride	S_2F_{10}	Disulfur decafluoride	None reported	Not combustible		
Sulfuryl fluoride	SO_2F_2	None	None hazardous	Not combustible		
2,4,5-T	$Cl_3C_6H_2OCH_2COOH$	2,4,5-Trichlorophenoxyacetic acid	None hazardous	Not combustible		
Talc (non-asbestiform)		Hydrous magnesium silicate, Steatite talc, Non-fibrous talc, Non-asbestiform talc	None hazardous	Not combustible		
Tantalum metal, oxide dusts (as Ta)	Ta	Synonyms vary depending upon specific compound	Strong oxidizers	Properties vary depending upon specific compound		
TEDP	$(C_2H_5)_4P_2S_2O_5$	Tetraethyl pyrophosphorodithionate, Sulfotepp, Tetraethyl dithiono-pyrophosphate, Tetraethyl dithio-pyro-phosphate	Strong oxidizers	Not combustible		
Tellurium compounds (as Te)	Te	Synonyms vary depending upon specific compound	Hazards vary depending upon specific compound	Properties vary depending upon specific compound		
Tellurium hexafluoride (as Te)	TeF_6	None	None hazardous	Not combustible		
TEPP	$(C_2H_5)_4P_2O_7$	Tetraethyl pyrophosphate, Commercial 40%, Ethyl pyrophosphate, Bladan, Nifost, Vapotone, Tetron, Killax, Moropal	Strong oxidizers	Not combustible		

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Terphenyls	$C_{18}H_{14}$	Triphenyls, ortho-Terphenyl, meta-Terphenyl, para-Ter-phenyl, Mixed ter-phenyls, Diphenyl benzenes	None hazardous	325 to 405(oc)	?	?
1,1,2,2-Tetra-chloro-1,2-difluoroethane	$CCl_2F\text{-}CCl_2F$	Refrigerant 112, Halocarbon 112, Freon 112	Chemically active metals: sodium, potassium, beryllium, powdered aluminum, zinc, magnesium	Not combustible		
1,1,1,2-Tetra-chloro-2,2-difluoroethane	$CC_3F\text{-}CClF_2$	Refrigerant 112a; Halocarbon 112a; 2,2-Difluoro-1,1,1,2-Tetrachloroethane; Freon 112a	Chemically active metals: sodium, potassium, beryllium, powdered aluminum, zinc, magnesium	Not combustible		
1,1,2,2-Tetra-chloroethane	$CHCl_2CHCl_2$	Symmetrical tetrachloroethane, Acetylene tetra-chloride, sym-tetra-chloroethane	Chemically active metals: strong caustics; hot iron, aluminum, zinc in presence of steam	Not combustible		
Tetrachloro-ethylene	CCl_2CCl_2	Perchloroethylene, Perchlorethylene, Tetrachlorethylene, Perk	Strong oxidizers, chemically active metals, such as barium, lithium, beryllium	Not combustible		
Tetrachloro-naphthalene	$C_{10}H_4Cl_4$	Halowax, Seekay wax, Nibren wax	Strong oxidizers	410(oc)	?	?
Tetraethyl lead (as Pb)	$Pb(C_2H_5)_4$	TEL, Lead tetraethyl, Motor fuel anti-knock compound	Strong oxidizers, sulfuryl chloride, potassium per-manganate	200	?	?
Tetrahydro-furan	C_4H_8O	Diethylene oxide, Tetramethylene oxide, THF	Strong oxidizers	6	2	11.8
Tetramethyl lead (as Pb)	$Pb(CH_3)_4$	TML, Lead tetra-methyl, Motor fuel anti-knock compound	Strong oxidizers, such as sulfuryl chloride or potassium per-manganate	100	?	?
Tetramethyl succinonitrile	$(CH_3)_2C(CN)C(CN)(CH_3)_2$	TMSN	Strong oxidizers	?	?	?
Tetranitro-methane	$C(NO_2)_4$	Tetan	Hydrocarbons, alkalies, metals	Not combustible		
Tetryl	$(NO_2)_3C_6H_2N(NO_2)CH_3$	2,4,6-Trinitrophenyl-methylnitramine; N-Methyl-N-2,4,6-tetra-nitro-aniline; Nitramine; Tetralite	Oxidizable materials	Explodes		
Thallium, soluble compounds (as Tl)	Tl	Synonyms vary depending upon specific compound	None hazardous	Properties vary depending upon specific compound		
Thiram	$C_6H_{12}N_2S_4$	Tetramethylthiuram disulfide	Strong oxidizers and acids, oxidiz-able materials	192		

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Tin, inorganic compounds except oxides (as Sn)	Sn	Synonyms vary depending upon specific compound	Chlorine, turpentine; for stannic chloride: water, alcohols, amines	Properties vary depending upon specific compound		
Tin, organic compounds (as Sn)	Sn	Synonyms vary depending upon specific compound	Strong oxidizers	Properties vary depending upon specific compound		
Titanium dioxide	TiO_2	Rutile, Anatase, Brookite	None hazardous	Not combustible		
Toluene	$C_6H_5CH_3$	Toluol, Phenyl methane, Methyl benzene	Strong oxidizers	40	1.3	7.1
Toluene-2,4-diisocyanate	$CH_3C_6H_3(NCO)_2$	TDI; 2,4-Toluene diisocyanate	Strong oxidizers, water, acids, bases, amines, etc., cause foam and spatter	270	0.9	9.5
o-Toluidine	$CH_3C_6H_4NH_2$	ortho-Aminotoluene; o-Methylaniline; 1-Methyl-1,2-amino-benzene; 2-Methyl-aniline	Strong oxidizers	185	1.5	?
Tributyl phosphate	$(C_4H_9O)_3PO$	Tri-n-butyl phosphate, TBP	None hazardous	330	?	?
1,1,2-Trichloro-ethane	$CHCl_2CH_2Cl$	Vinyl trichloride, beta-Trichloroethane	Strong oxidizers and caustics, chemically active metals, such as aluminum, magnesium powders, sodium, potassium	None	6	15.5
Trichloro-ethylene	$CHClCCl_2$	Ethylene trichloride, Triclene	Strong caustics; when acidic reacts with aluminum; chemically active metals; barium, lithium, sodium, magnesium, titanium	None	11	41
Trichloro-naphthalene	$C_{10}H_4Cl_3$	Halowax, Seekay wax, Nibren wax	Strong oxidizers	392(oc)	?	?
1,2,3-Trichloro-propane	$CH_2ClCHClCH_2Cl$	Allyl trichloride, Glyceroltrichloro-hydrin, Glycerin trichlorohydrin, Trichlorohydrin	Active metals, strong caustics and oxidizers	164	3.2	12.6
1,1,2-Trichloro-1,2,2-trifluoro-ethane	Ccl_2FCClF_2	Halocarbon 113, Refrigerant 113, TTE, Freon 113	Chemically active metals: calcium, powdered aluminum, zinc, magnesium, beryllium; contact alloys >2% Mg decomposes	Not combustible		
Triethylamine	$(C_2H_5)_3N$	None	Strong oxidizers and acids	20 (oc)	1.2	8

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Trifluoromonobromomethane	$CBrF_3$	Halon 1301, Halocarbon 13B1, Refrigerant 13B1, Bromotrifluoromethane, Freon 13B1	Chemically active metals, calcium, powdered aluminum, zinc, magnesium	Not combustible		
Trinitrotoluene	$CH_3C_6H_2(NO_2)_3$	TNT; Trinitrotoluol; 2,4,6-Trinitrotoluene ; sym-Trinitrotoluene	Strong oxidizers, ammonia, strong alkalies, oxidizable materials	Explodes		
Triorthocresyl phosphate	$(CH_3C_6H_4O)_3PO$	o-Tritolyl phosphate, TCP, TOCP	None hazardous	437	?	?
Triphenyl phosphate	$(C_6H_5O)_3PO$	Phenyl phosphate, TPP	None hazardous	428	?	?
Turpentine	$C_{10}H_{16}$	Gumspirits, Turps, Wood turpentine, Spirits of turpentine, Sulfate wood turpentine, Steam distilled turpentine, Gum turpentine	Strong oxidizers, chlorine	95	0.8	?
Uranium, insoluble compounds (as U)	U	Synonyms vary depending upon specific compound	Uranium: CO_2, CCl_4, HNO_3, Uranium hydride: strong oxidizers; H_2O, halogenated hydrocarbons	Properties vary depending upon specific compound		
Uranium, soluble compounds (as U)	U	Synonyms vary depending upon specific compound	Uranyl nitrates: combustibles, Uranium hexafluoride: water	Properties vary depending upon specific compound		
Vanadium pentoxide dust (as V)	V_2O_5	None	None hazardous	Not combustible		
Vanadium pentoxide fume (as V)	V_2O_5	None	None hazardous	Not combustible		
Vinyl chloride	C_2H_3Cl	Chloroethylene, Chloroethene, Monochloroethylene, Ethylene monochloride, Monochloroethene, Vinyl C monomer, Trovidur, VC, Vinyl chloride monomer, VCM	Copper oxidizing materials	-108	3.6	33
Vinyltoluene	$CH_3C_6H_4CHCH_2$	Methylstryrene, Tolyethylene; meta- and para-vinyltoluene (mixed isomers)	Oxidizing agents, catalysts for vinyl polymerization, such as peroxides, strong acids, aluminum chloride	127	0.1	11
Warfarin	$C_{19}H_{16}O_4$	3-(alpha-Acetonyl) benzyl-4-hydroxy-coumarin, WARF compound, compound 42, coumarin	Strong oxidizers	NA	?	?

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
Xylene (o-, m-, and p-isomers)	$C_6H_4(CH_3)_2$	p-ortho-Xylene, 1,2-Dimethyl-benzene ; meta-Xylene, 1,3-Dimethyl-benzene ; para-Xylene, 1,4-Dimethyl-benzene	Strong oxidizers	90/84/81	1/1.1/1.1	6/7/7
Xylidine	$(CH_3)_2C_6H_3NH_2$	2,4-Dimethylaniline, etc. (6 isomers); Xylidine isomers; Xylidine mixed o-m-p	Strong oxidizers, hypochlorite bleaches	206	1.5	?
Yttrium compounds (as Y)	Y	Synonyms vary depending upon specific compound	Yttrium nitrate; combustible materials	Properties vary depending upon specific compound		
Zinc Chloride fume	$ZnCl_2$	None	None hazardous	Not combustible		
Zinc oxide fume	ZnO	Calamine	Chlorinated rubber	Not combustible		
Zirconium compounds (as Zr)	Zr	Synonyms vary depending upon specific compound	ZrCl: water, moist air, alkali metals; ZrH_2: strong oxidizers	Properties vary depending upon specific compound		
*Dibromochloro-propane	$C_3H_5Br_2Cl$	1-Chloro-2,3-dibromo-propane, DBCP, 1,2-Dibromo-3-chloro-propane	Chemically active metals: aluminum, magnesium, tin and alloys; attacks some rubber and coatings	170(oc)	?	?

7

Responding to Spills and Leaks

INTRODUCTION

The spill or leak from a container, storage vessel or any type of transport vehicle of a potentially flammable or even combustible material can pose a serious fire hazard and health risk. In the United it is the U.S. Department of Transportation's (DOT) responsibility to enforce regulations that ensure that transporters not only follow all safety precautions and meet technical requirements for the safe transport of hazardous materials, but that in the event of an emergency such as a spill or leak, that proper emergency response action is implemented. Additionally, the DOT is in part responsible for enforcing environmental regulations in that it must work along with the environmental regulatory agencies to ensure that both the general public and the environment are not exposed to a hazardous chemical spill and that proper clean up action is implemented.

The U.S. DOT has prepared a guidebook, from which a great deal of the information in earlier chapters has been extracted, for use by firefighters, police, and other emergency services personnel who may be the first to arrive at the scene of a hazardous materials incident. That guidebook, or in fact this publication, can be used to assist first responders in :

- quickly identifying the specific or generic classification of the material(s) involved in the incident, and
- protecting themselves and the general public during the initial response phase of the incident.

The *initial response phase* is defined as that period following arrival at the scene of an incident during which the presence and/or identification of a hazardous material is confirmed; protective actions and area securement are initiated; and assistance of qualified personnel is requested.

One organization supported by industry in the United Sates is the Chemical Transportation Emergency Center or CHEMTREC, which is an emergency information center that can provide technical advise on how best to handle a specific hazard materials incident. In the U.S., the toll free number to contact CHEMTREC is 1-800-424-9300. CHEMTREC is a service of the chemical industry that operates in two stages. First, on receipt of a call providing the name of the chemical, it provides immediate advise on the nature of the material and the steps to be taken in handling the early stages of the incident. Second, CHEMTREC promptly contacts the shipper of the material involved for more detailed information and on the scene assistance when feasible. When contacting CHEMTREC or a similar agency in other parts of the world, the following information should be provided:

- Your name and a call back telephone number
- Location and nature of the incident
- Shipper and/or manufacturer
- Container type
- Rail car or truck number
- Carrier name
- Consignee
- Local conditions

In any spill or leak of a hazardous material, it is essential that first responders immediately identify the product. In the U.S., because there are strict transportation safety regulations, hazardous materials shipments are normally well documented and there is normally sufficient information to identify the product and its dangerous properties. One can identify the material readily by finding any one of the following:

- The 4-digit ID number on the vehicle's placard or orange colored panel
- The 4-digit ID number (after UN or NA) on a shipping paper or package. UN stands for United Nations, signifying that the shipment is allowed internationally. NA stands for North America, indicating that the shipment is only permitted within the continental United States or Canada (often applied to wastes)
- The name of the material on a shipping paper, placard, or package.

A second important way to identify the material in a hazard materials incident is to look up the material's 2-digit Guide Number. Appendix A of this book provides the DOT listing of hazardous chemicals according to their 4-digit UN/NA identification number, along with reference to the emergency response information for first responders that is summarized in Chapter 5. Either Chapter 5 or the Appendix can be used to identify the material involved in a spill, and to obtain general safety precautions and emergency action responses, use the fact sheets in Chapter 5. For explosives, one should refer to the following guide numbers in Chapter 5:

- Division 1.1 (Explosives A) - use guide number 46
- Division 1.2 (Explosives A and B) - use guide number 46
- Division 1.3 (Explosives B) - use guide number 46
- Division 1.4 (Explosives C) - use guide number 50
- Division 1.5 (Blasting Agents) - use guide number 46
- Division 1.6 -use guide number 46

The hazard class of a material is indicated either by its class (or division) number, or its class name. For a placard corresponding to the primary hazard class of a material, the hazard class or division number must be displayed in the lower corner of the placard. The UN hazard classes are as follows:

Class 1 *Explosives*
Division 1.1 Explosives with a mass explosion hazard
Division 1.2 Explosives with a projection hazard
Division 1.3 Explosives with predominantly a fire hazard
Division 1.4 Explosives with no significant blast hazard
Division 1.5 Very insensitive explosives; blasting agents
Division 1.6 Extremely insensitive detonating substances
Class 2 *Gases*
Division 2.1 Flammable gas
Division 2.2 Non-flammable, non-poisonous compressed gas
Division 2.3 Gas poisonous by inhalation
Division 2.4 Corrosive gas
Class 3 *Flammable liquid and Combustible liquid*
Class 4 *Flammable Solid; Spontaneously combustible material; and Dangerous when wet material*
Class 5 *Oxidizers and Organic Peroxides*
Division 5.1 Oxidizer
Division 5.2 Organic peroxide
Class 6 *Poisonous material and infectious substance*
Division 6.1 Poisonous materials
Division 6.2 Infectious substance
Class 7 *Radioactive material*
Class 8 *Corrosive material*
Class 9 *Miscellaneous hazardous material*

With this as an introduction, we turn our attention to the subject of spills and leaks, from an emergency standpoint and with emphasis given to a first responder having the concern over potential fire and explosion. The general approaches and concepts presented in this chapter apply to all hazardous materials for indeed there are potential risks and dangers other than fire such as exposure to toxic or lethal chemicals. The general guidelines to follow in approaching any hazard materials incident can be summarized by the following:

- Approach the scene with caution - Resist the urge to rush in; you

cannot help others until you know what you are facing.

- Identify the hazards -Placards, container labels, shipping papers and/or knowledgeable persons on the scene are valuable information sources. Evaluate all of them, and then consult recommended safe response procedures before placing yourself and others at risk.
- Secure the scene - Without entering the immediate hazard area, do what you can to isolate the area and assure the safety of people and the environment. Move and keep people away from the scene and the perimeter of the incident. Allow room enough to move and remove any necessary equipment.
- Call for assistance - Advise your headquarters to notify responsible agencies and call for assistance from qualified personnel.
- Decide on site entry - Any efforts that are made to rescue persons, protect property or the environment must be weighed against the possibility that responders could become part of the problem. Enter the area only when wearing appropriate protective equipment and if you are fully trained and qualified to do so.

PREPLANS AND APPROACHING THE SCENE

Preplans for spills or leaks that are not on fire upon the arrival of emergency response forces require that several factors receive attention. The major items to be consider and evaluate include:

- *The type and nature of the product* - Is the material a flammable or a combustible product? An emergency involving a flammable liquid requires that immediate controlling actions be initiated to alleviate the vapor problem. Steps for blanketing, disposal, or otherwise securing the spill area must be taken immediately upon arrival at the scene. Combustible liquids usually can be gathered in a temporary compound and retained until picked up and removed since the higher flash point of these liquids allows this without presenting a significant fire hazard. Regardless of the category of product, all sources of ignition must he prohibited from the vicinity of the spill.

- *The condition and arrangement of any sewer systems within the vicinity of the incident* -If the spill occurs within the grounds of a plant operation, many refineries, bulk storage terminals, and similar chemical and petroleum- handling facilities have sewer systems that are designed and constructed to accommodate the flushing of spilled liquids into them for disposal. Unless similarly constructed, however, a public sewer system could present a serious problem if hazardous chemicals in any quantity enter it. An absolute necessity is that the appropriate local authorities be consulted to ascertain if spills can be safely flushed into sewer inlets.

- *The proximity of waterways* - Every effort should be made to prevent

spills from entering local waterways which can result in serious environmental damage and /or endangerment to the public. Recall the properties of water solubility and specific gravity, because these will determine the extent of problem should a hazardous liquid spill discharge to a waterway. The lighter-than-water chemical product will float on the water's surface, thus spreading the spill over a larger area, and if highly miscible in water like alcohol, the chemical will disperse creating a costly and difficult clean up problem, not to mention a potentially greater nightmare from an environmental liability standpoint.

- *Atmospheric conditions* - Preplans that take into consideration atmospheric temperatures, wind direction, and velocity can only be general in nature, for example, the direction of the prevailing winds would influence the choice of a preplanned response route. However, at the time of the hazard materials incident, priority would be given to the necessity of approaching the scene from an upwind direction. In summer months, parts of the country may experience daytime temperatures higher than the flash point of certain combustible liquids. Whether a specific liquid is to be treated as a flammable or a combustible might depend upon the hour of the day. This eventually must he taken into account, depending upon the location and magnitude of the spill. Additionally, there are a number of hazardous chemicals that pose serious enough inhalation hazards that initial isolation distances should be defined in approaching the problem. This consideration is covered in greater detail later in this chapter.

- *The availability of clean-up equipment* - All spills should be reported to the proper regulatory agency and in the United States, CHEMTREC should be consulted. In the U.S. a spill on land would require notifying the office of the Environmental Protection Agency (EPA). The U.S. Coast Guard should be notified of any spill on water. The various regulations require the owner or operator of the equipment causing the spill to make the notification. Both the EPA and the Coast Guard have the authority under U.S. law to initiate clean-up activities. If the party responsible for causing the spill is unable to do so, or if there is a question concerning responsibility, both these federal agencies are empowered to implement clean-up contingency plans.

If the spill involves a flammable liquid and the possibility of a fire exists, it is the emergency response coordinator's duty and concern to protect the public. Protective hose lines, stand-by equipment, or foam coverage may be needed until the spill-containment team is functioning. For the protection of the community and public, the emergency response force's activities are normally directed toward the following:

- Protection of life and property. This may mean flushing the spill to a

safe location or blanketing it with foam or both. On occasion, conditions might dictate evacuation of the civilian population from the area.

- Containment of the spill by the erection of dikes or dams.
- Policing the area to remove all sources of ignition.
- Halting the flow of liquid at its source.

There are a number of chemical dispersants available that, when properly used, will render a liquid incapable of being ignited. These products are a worthwhile method for handling a relatively small spill. The major difficulty when confronted with a spill of a large size is that the various dispersants require a mix ratio of about one part dispersant to one part flammable liquid. It is easy to visualize the logistics involved if the decision was made to use a material of this type to attempt to save a spill from a severely ruptured 7000-gallon tank truck. If dispersants are considered, the mix ratio and then the method of application should be investigated.

In contrast to a non-fire spill, spill fires can be more serious and require coordination not only of fire fighting forces, but evacuation of local communities. The identical quantities of liquid can be involved in either event. The spill, however, has the potential for covering much more area. When encountering flowing or pooled petroleum and other chemical liquids in a fire situation, the factors previously identified for spills not on fire must be evaluated. A basic consideration, after safety, is the protection of exposures. The immediate application of water for cooling purposes will be the initial activity. A second method by which the needed protection might be accomplished is the use of hose streams to drive the burning liquid into a field or other open area. Presumably, the area selected is one where the liquid can burn harmlessly until consumed or extinguished. Flushing the burning liquid away from exposures usually means that the total water requirements for control will be less.

The decision to allow the fire to consume all fuel present will be influenced by three factors. First is: "What category of liquid is involved?" A flammable liquid, if extinguished, will present the likelihood of a hazardous vapor condition developing. Vapor clouds can be more difficult to control than a fire. The second factor to consider is the surrounding area. Will the plume of thick, black smoke interfere with the safety of the community? Are schools or a hospital downwind that might need evacuation? The third point to consider would be the volume of product present versus the resources available. Can control be retained while the product continues to burn for many hours? Conversely, if extinguished, is the capability of control obtainable until the liquid is eliminated?

Spills or leaks within fixed facilities can be preplanned more readily than for an incident occurring while products are in transit. The terrain, the product, the volume, and the type of extinguishing agent can all be

determined with reasonable accuracy. When preplanning for a rail car or tank car emergencies, those considerations cannot be predetermined as easily. The main reason for this is because the exact location is not known until the event happens. Without this information, the preplan can only be prepared in anticipation of the worst-case situation. In any event however, plans should be flexible enough to accommodate both a 100-gallon spill fire and a 10,000-gallon one. The type of chemical handling facilities within a fire district will determine the maximum spill potential. Some basic considerations include:

- If the potential is from a bulk storage plant, what is the capacity of the tanks? Are the critical block valves known to all employees? If the potential is an underground pipeline, what size is it? Are the telephone numbers of the pumping stations readily available?
- If the potential is a truck loading rack, is it manned around-the-clock? If not, who must be notified? How many trucks can load simultaneously?
- If the potential hazard is from tank trucks or rail cars, are fire department personnel trained in the operation of shut-off devices?

Special items included in the plan would be provisions for quantities or foam and proportioning and dispensing equipment. Spills do not cover a nice well-defined area. Instead, the liquid follows the contours of the ground. To provide maximum maneuverability to counter this tendency, foam nozzles of 100 to 200 gal/min with in-line proportioners would be advantageous. A selection of hard rubber or wooden plugs suitable for the plugging of small leaks should also be on hand. A source which can be depended upon any hour of the day or night, for shovels, sand, and bags for building dams or dikes will prove worthwhile.

INITIAL ISOLATION AND PROTECTIVE ACTION DISTANCES

This section provides a table (Table 1) on initial isolation and protective action distances recommended by the United States Department of Transportation for high hazard chemicals that could be spilled or leak. The table provides the information for small and large spills in a non-fire situation. What distinguishes between large and small spills is a matter of judgement and experience on the part of the first responder, and is closely related to how dangerous the chemical is. As a rough rule of thumb, a small spill is one which involves a single, small package (i.e., up to a 55 gallon drum), small cylinder, or a small leak from a large package. A large spill is one which involves a spill from a large package, or multiple spills from many small packages. For each size category of spill, guidelines are given for an initial isolation distance in all directions from the spill, and a protection distance downwind from the spill for both day and night conditions. The time of day for the incident is important because

meteorological conditions will change thus effecting wind patterns and strength.

To use the information in Table 1, we must first identify the material that has spilled. This can be readily done from the 4-digit UN shipping number designation. If the chemical name is only known, refer to the table of hazardous chemicals in Chapter 5 which is an alphabetical listing of high hazard chemicals. If the chemical you look up in the Chapter 5 table is highlighted (boldface lettering), then it has a recommended isolation distance. Obtain the 4-digit ID number, and then locate the chemical in Table 1 in this chapter. After identifying the product, look up the initial isolation distance. Use this guideline to direct all persons to move, in an upwind or crosswind direction, away from the spill to the specified distance - in feet.

Next, look up the initial **Protective Action Distance** given in Table 1. For a given hazardous material, spill size, and whether day or night, the table provides the distance - in miles - downwind for which protective actions should be considered. The *Protective Action Zone* is defined as the area in which people are at risk of harmful exposure. From a practical standpoint, we define this by the configuration of a square, whose length and width are the same as the downwind distance shown in the table. This definition is illustrated in Figure 1.

Protective actions should be initiated to the extent possible, beginning with those closest to the spill site and working away from the site in the downwind direction. Again, the shape of the area in which protective actions should be taken (the Protective Action Zone) is illustrated in Figure 1. In this figure, the spill is located at the center of the small circle. The larger circle represents the initial isolation zone around the spill.

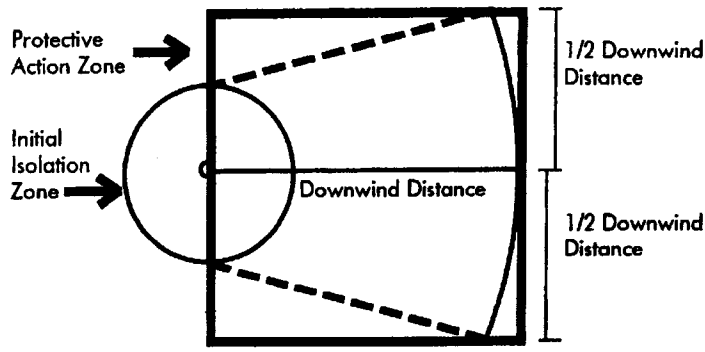


Figure 1. Illustrates protective action and initial isolation zones.

The basis for the protective action distances given in Table 1 is based on analysis using state-of-the-art source term and vapor cloud dispersion modeling, probabilistic application of actual atmospheric data, and information on toxicological exposure guidelines for each chemical.

Source term modeling considered three factors - (1) DOT package sizes authorized to transport each hazardous material, (2) spill rates from damage to each package, and (3) release of vapors by evaporation from a liquid pool, direct release or gaseous vapors from a package into the atmosphere, or a combination of both. Liquid pool evaporation rates were calculated assuming a sunny, 35°C (95°F) day. Analysis of small and large spills is as follows: A leaking package of 55 gallons or less (such as a drum, jerrican, or box with inner containers) is considered a "small spill." Larger packages leaking less than 55 gallons and compressed gas leaking from a small cylinder are also considered small spills. A large spill involves many smaller leaking packages or a leaking package greater than 55 gallons (such as a cargo tank, portable tank, or "one-ton" compressed gas cylinder).

Dispersion models calculated downwind vapor concentrations based on actual, 24-hour, groundlevel and upper-air meteorological data from 61 cities (including one each in Alaska and Hawaii) over a 5-year period. The models approximated atmospheric conditions at over 40,000 U.S. hypothetical incident sites derived from truck-fatal accident locations in the same 5-year period. A sensitivity study indicated heavy gas effects on vapor plume dispersion were minimal for the incident release sizes considered when compared to uncertainty in other input parameters. Data also showed nighttime atmospheric conditions generally transported vapor plumes much greater distances than daytime conditions, therefore, daytime and nighttime protective action guidance is provided to more accurately describe risk. Specific local daytime hours are a function of the season, geographic latitude, and use of daylight savings time, however, for Table 1 a "Day" incident should be considered as occurring anytime after sunrise and before sunset, while "Night" includes all hours between sunset and sunrise.

Toxicological short-term exposure guidelines for the materials were applied to vapor concentrations to determine how far downwind the public is in danger. An independent panel of toxicological experts from industry and academia recommended that toxicological exposure guidelines be chosen from emergency response guidelines, occupational health guidelines (TLV, PEL, REL, WEEL, etc.), and lethal concentrations determined from animal studies (LC_{50}). Specific means of application of these health criteria and adjustments based on time-of-exposure were made when recommended by the panel of experts.

Following this analysis, the resulting protective action distances were ordered from the 100th to the 0th percentile (largest protective action distance to the smallest) for both daytime and nighttime scenarios. The

distances appearing in Table 1 provide guidance describing the 90th percentile incident. This means that for a specific material analyzed at the incident locations mentioned above, 90 percent required protective actions less than the table indicates, while 10 percent required larger distances.

The Protective Action Zone assumes random changes in wind direction confines the vapor plume to an area within 30 degrees on either side of the predominant wind direction, resulting in a crosswind protective action distance equal to the downwind protective action distance. Within the protective action zone a level of vapor concentration may exist resulting in nearly all unprotected persons becoming incapacitated and unable to take protective action and/or incurring serious or irreversible health effects . The Initial Isolation Zone is determined as an area, including upwind from the incident, within which a high probability of localized wind reversal may expose nearly all persons without appropriate protection to life threatening concentrations of the material.

Table 1. Initial isolation and protection action distances.

		SMALL SPILLS (From a small package or small leak from a large package)			LARGE SPILLS (From a large package or from many small packages)		
		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND	
ID#	NAME OF MATERIAL		DAY (Miles)	NIGHT (Miles)		DAY (Miles)	NIGHT (Miles)
1005	AMMONIA	500	0.1	0.6	500	0.3	2.2
1005	AMMONIA, ANHYDROUS, liquefied	500	0.1	0.6	500	0.3	2.2
1005	AMMONIA SOLUTIONS with more than 50% ammonia	500	0.1	0.6	500	0.3	2.2
1005	ANHYDROUS AMMONIA	500	0.1	0.6	500	0.3	2.2
1008	BORON TRIFLUORIDE	500	0.3	2.0	500	0.8	2.9
1016	CARBON MONOXIDE	500	0.3	2.0	500	0.7	2.8
1017	CHLORINE	500	0.7	2.8	1500	2.4	4.6
1023	COAL GAS	500	0.1	1.2	500	0.7	2.8
1026	CYANOGEN	500	0.1	1.1	500	0.7	2.8
1026	CYANOGEN, liquefied	500	0.1	1.1	500	0.7	2.8
1026	CYANOGEN GAS	500	0.1	1.1	500	0.7	2.8
1040	ETHYLENE OXIDE	500	0.1	0.9	500	0.2	1.5
1040	ETHYLENE OXIDE with nitrogen	500	0.1	0.9	500	0.2	1.5
1045	FLUORINE, compressed	1000	1.7	3.8	1500	3.9	6.5
1048	HYDROGEN BROMIDE, anhydrous	500	0.1	0.7	500	0.3	2.2
1050	HYDROCHLORIC ACID, anhydrous	500	0.3	1.9	1000	1.1	3.2
1050	HYDROGEN CHLORIDE, anhydrous	500	0.3	1.9	1000	1.1	3.2
1051	HYDROCYANIC ACID	500	0.2	1.4	500	0.3	2.2

ID#	NAME OF MATERIAL	SMALL SPILLS (From a small package or small leak from a large package)			LARGE SPILLS (From a large package or from many small packages)		
		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND	
			DAY (Miles)	NIGHT (Miles)		DAY (Miles)	NIGHT (Miles)
1051	HYDROGEN CYANIDE, anhydrous, stabilized	500	0.2	1.4	500	0.3	2.2
1051	HYDROGEN CYANIDE, stabilized, containing less than 3% water	500	0.2	1.4	500	0.3	2.2
1052	HYDROFLUORIC ACID, anhydrous	500	0.1	0.5	500	0.3	2.2
1052	HYDROGEN FLUORIDE, anhydrous	500	0.1	0.5	500	0.3	2.2
1053	HYDROGEN SULFIDE	500	0.2	1.8	1000	1.3	3.4
1053	HYDROGEN SULFIDE, liquefied	500	0.2	1.8	1000	1.3	3.4
1062	METHYL BROMIDE	500	0.1	0.4	500	0.3	2.1
1064	METHYL MERCAPTAN	500	0.1	0.4	500	0.3	2.0
1067	DINITROGEN TETROXIDE, liquefied	500	0.1	0.4	500	0.7	2.8
1067	NITROGEN DIOXIDE, liquefied	500	0.1	0.4	500	0.7	2.8
1067	NITROGEN PEROXIDE	500	0.1	0.4	500	0.7	2.8
1067	NITROGEN TETROXIDE	500	0.1	0.4	500	0.7	2.8
1069	NITROSYL CHLORIDE	500	0.3	2.1	1000	1.8	3.9
1071	OIL GAS	500	0.3	2.1	1500	2.2	4.3
1076	PHOSGENE	500	0.6	2.6	1500	3.2	5.5
1079	SULFUR DIOXIDE	500	0.5	2.5	1500	2.0	4.1
1079	SULFUR DIOXIDE, liquefied	500	0.5	2.5	1500	2.0	4.1
1082	TRIFLUOROCHLOROETHYLENE	500	0.1	0.4	500	0.3	2.1
1082	TRIFLUOROCHLOROETHYLENE, inhibited	500	0.1	0.4	500	0.3	2.1
1092	ACROLEIN, inhibited	500	1.0	3.1	1000	1.8	3.9
1098	ALLYL ALCOHOL	500	0.1	0.8	500	0.3	2.2
1135	ETHYLENE CHLOROHYDRIN	500	0.1	0.5	500	0.1	1.0
1143	CROTONALDEHYDE, inhibited	500	0.1	0.1	500	0.1	0.6
1143	CROTONALDEHYDE, stabilized	500	0.1	0.1	500	0.1	0.6
1163	DIMETHYLHYDRAZINE, unsymmetrical	500	0.1	1.4	1500	2.1	4.2
1182	ETHYL CHLOROFORMATE	500	0.1	1.2	500	0.2	1.5
1185	ETHYLENEIMINE, inhibited	500	0.5	2.5	500	0.7	2.8
1238	METHYL CHLOROCARBONATE	500	0.2	1.4	500	0.2	1.8
1238	METHYL CHLOROFORMATE	500	0.2	1.4	500	0.2	1.8
1239	METHYL CHLOROMETHYLETHER	500	0.1	1.1	500	0.3	2.1
1244	METHYLHYDRAZINE	500	0.8	3.0	1500	3.1	5.3
1251	METHYL VINYL KETONE	1000	1.3	3.4	1500	2.0	4.1
1259	NICKEL CARBONYL	1500	2.1	4.2	1500	4.4	7.0+
1380	PENTABORANE	1000	1.2	3.3	1500	3.3	5.0
1510	TETRANITROMETHANE	500	0.1	0.1	500	0.1	0.9

ID#	NAME OF MATERIAL	SMALL SPILLS (From a small package or small leak from a large package)			LARGE SPILLS (From a large package or from many small packages)		
		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND	
			DAY (Miles)	NIGHT (Miles)		DAY (Miles)	NIGHT (Miles)
1541	ACETONE CYANOHYDRIN, stabilized	500	0.1	0.1	500	0.1	0.5
1545	ALLYL ISOTHIOCYANATE, inhibited	500	0.1	0.1	500	0.1	0.2
1545	ALLYL ISOTHIOCYANATE, stabilized	500	0.1	0.1	500	0.1	0.2
1556	METHYLDICHLOROARSINE	500	0.2	1.9	1000	1.0	3.2
1560	ARSENIC CHLORIDE	1500	2.9	5.1	1500	3.5	5.8
1560	ARSENIC TRICHLORIDE	1500	2.9	5.1	1500	3.5	5.8
1569	BROMOACETONE	500	0.1	1.4	1000	1.4	3.5
1580	CHLOROPICRIN	500	0.5	2.6	500	0.8	2.9
1581	CHLOROPICRIN and METHYL BROMIDE MIXTURES	500	0.5	2.6	500	0.8	2.9
1581	METHYL BROMIDE and CHLOROPICRIN MIXTURES	500	0.5	2.6	500	08	2.9
1582	CHLOROPICRIN and METHYL CHLORIDE MIXTURES	500	0.5	2.6	500	0.8	2.9
1582	METHYL CHLORIDE and CHLOROPICRIN MIXTURES	500	0.5	2.6	500	0.8	2.9
1583	CHLOROPICRIN MIXTURES, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	500	0.5	2.6	500	0.8	2.9
1589	CYANOGEN CHLORIDE, inhibited	500	0.5	2.4	500	0.9	3.1
1595	DIMETHYL SULFATE	500	0.1	0.2	500	0.1	0.4
1595	METHYL SULFATE	500	0.1	0.2	500	0.1	0.4
1605	1,2-DIBROMOETHANE	500	0.1	0.2	500	0.1	0.2
1605	ETHYLENE DIBROMIDE	500	0.1	0.2	500	0.1	0.2
1612	HEXAETHYL TETRAPHOSPHATE and COMPRESSED GAS MIXTURES	500	0.6	2.6	1500	3.2	5.5
1613	HYDROCYANIC ACID, aqueous solution, with not more than 20% hydrogen cyanide (When "Inhalation Hazard" is on a package or shipping paper.)	500	0.2	1.4	500	0.3	2.2
1613	HYDROGEN CYANIDE, aqueous solution, with not more 20% hydrogen cyanide (When "Inhalation Hazard" is on a package or shipping paper.)	500	0.2	1.4	500	0.3	2.2
1614	HYDROGEN CYANIDE anhydrous, stabilized (absorbed)	500	0.2	1.4	500	0.3	2.2
1614	HYDROGEN CYANIDE, stabilized, containing less than 3% water (absorbed in a porous inert material)	500	0.2	1.4	500	0.3	2.2
1647	METHYL BROMIDE and ETHYLENE DIBROMIDE MIXTURES, liquid)	500	0.1	0.4	500	0.3	2.1
1660	NITRIC OXIDE	500	0.1	0.1	500	0.3	1.9
1670	PERCHLOROMETHYL MERCAPTAN	500	0.1	1.0	500	0.1	1.4
1672	PHENYLCARBYLAMINE CHLORIDE	500	0.2	1.9	1500	3.2	5.4

ID#	NAME OF MATERIAL	SMALL SPILLS (From a small package or small leak from a large package)			LARGE SPILLS (From a large package or from many small packages)		
		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND	
			DAY (Miles)	NIGHT (Miles)		DAY (Miles)	NIGHT (Miles)
1695	CHLOROACETONE, stabilized	500	0.1	0.1	500	0.1	0.3
1695	MONOCHLOROACETONE, inhibited	500	0.1	0.1	500	0.1	0.3
1695	MONOCHLOROACETONE, stabilized	500	0.1	0.1	500	0.1	0.3
1703	TETRAETHYL DITHIOPYROPHOSPHATE and compressed gas mixture	500	0.6	2.6	1500	3.2	5.5
1703	TETRAETHYL DITHIOPYROPHOSPHATE and gases, mixtures, or in solution (LC50 more than 200 ppm but not more than 5000 ppm)	500	0.6	2.6	1500	3.2	5.5
1703	TETRAETHYL DITHIOPYROPHOSPHATE and gases, mixtures, or in solution (LC50 not more than 200 ppm)	500	0.6	2.6	1500	3.2	5.5
1705	TETRAETHYL PYROPHOSPHATE and compressed gas mixture	500	0.6	2.6	1500	3.2	5.5
1705	TETRAETHYL PYROPHOSPHATE and compressed gas mixtures (LC50 more than 200 ppm but not more than 5000 ppm)	500	0.6	2.6	1500	3.2	5.5
1705	TETRAETHYL PYROPHOSPHATE and compressed gas mixtures (LC50 not more than 200 ppm)	500	0.6	2.6	1500	3.2	5.5
1722	ALLYL CHLOROCARBONATE	500	0.1	1.3	500	0.2	1.6
1722	ALLYL CHLOROFORMATE	500	0.1	1.3	500	0.2	1.6
1741	BORON TRICHLORIDE	500	0.1	0.1	500	0.1	1.1
1744	BROMINE	500	0.7	2.8	1000	1.1	3.2
1744	BROMINE SOLUTIONS (When "Inhalation Hazard" is on a package or shipping paper.)	500	0.2	1.6	500	0.3	1.9
1745	BROMINE PENTAFLUORIDE	500	0.7	2.8	1500	2.3	4.4
1746	BROMINE TRIFLUORIDE	500	0.1	1.2	500	0.1	1.4
1749	CHLORINE TRIFLUORIDE	500	0.2	1.9	1000	1.7	3.8
1752	CHLOROACETYL CHLORIDE	500	0.2	1.9	500	0.3	2.1
1754	CHLOROSULFONIC ACID	500	0.1	0.2	500	0.1	1.2
1754	CHLOROSULFONIC ACID and SULFUR TRIOXIDE MIXTURE	500	0.1	0.2	500	0.1	1.2
1809	CHLORIDE OF PHOSPHORUS	500	0.5	2.5	500	0.8	2.9
1809	PHOSPHORUS TRICHLORIDE	500	0.5	2.5	500	0.8	2.9
1810	PHOSPHORUS OXYCHLORIDE	500	0.4	2.3	500	0.6	2.6
1810	PHOSPHORYL CHLORIDE	500	0.4	2.3	500	0.6	2.6
1828	CHLORIDE OF SULFUR	500	0.1	0.1	500	0.1	0.5
1828	SULFUR CHLORIDES	500	0.1	0.1	500	0.1	0.5
1829	SULFURIC ANHYDRIDE	500	0.1	0.5	500	0.3	1.9
1829	SULFUR TRIOXIDE	500	0.1	0.5	500	0.3	1.9

ID#	NAME OF MATERIAL	SMALL SPILLS (From a small package or small leak from a large package)			LARGE SPILLS (From a large package or from many small packages)		
		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND	
			DAY (Miles)	NIGHT (Miles)		DAY (Miles)	NIGHT (Miles)
1829	SULFUR TRIOXIDE, inhibited	500	0.1	0.5	500	0.3	1.9
1829	SULFUR TRIOXIDE, uninhibited	500	0.1	0.5	500	0.3	1.9
1831	OLEUM, with not less than 30% free sulfur trioxide	500	0.1	0.1	500	0.1	0.2
1831	SULFURIC ACID, fuming, with not less than 30% free sulfur trioxide	500	0.1	0.1	500	0.1	0.2
1834	SULFURYL CHLORIDE	500	0.2	1.8	500	0.3	2.1
1838	TITANIUM TETRACHLORIDE	500	0.1	0.9	500	0.1	1.3
1859	SILICON TETRAFLUORIDE	1500	2.0	4.1	1500	4.3	6.9
1892	ETHYLDICHLOROARSINE	500	0.1	0.2	500	0.1	1.4
1911	DIBORANE	1000	2.0	4.1	1500	4.3	6.9
1953	COMPRESSED GAS, toxic, flammable, n.o.s. (Inhalation Hazard Zone A)	1000	1.0	3.2	1500	5.9	6.9
1953	COMPRESSED GAS, toxic, flammable, n.o.s. (Inhalation Hazard Zone B)	500	0.8	2.9	1500	2.4	4.6
1953	COMPRESSED GAS, toxic, flammable, n.o.s. (Inhalation Hazard Zone C)	500	0.2	1.7	1000	1.7	3.8
1953	COMPRESSED GAS, toxic, flammable, n.o.s. (Inhalation Hazard Zone D)	500	0.2	1.7	1000	1.7	3.8
1953	COMPRESSED GASES, flammable, poisonous, n.o.s.	1000	1.0	3.2	1500	5.9	6.9
1953	COMPRESSED GASES, flammable, toxic, n.o.s. (Inhalation Hazard Zone A)	1000	1.0	3.2	1500	5.9	6.9
1953	COMPRESSED GASES, flammable, toxic, n.o.s. (Inhalation Hazard Zone B)	500	0.8	2.9	1500	2.4	4.6
1953	COMPRESSED GASES, flammable, toxic, n.o.s. (Inhalation Hazard Zone C)	500	0.3	2.1	1500	2.2	4.3
1953	COMPRESSED GASES, flammable, toxic, n.o.s. (Inhalation Hazard Zone D)	500	0.2	1.7	1000	1.7	3.8
1953	LIQUEFIED GASES, flammable, poisonous, n.o.s.	1000	1.0	3.2	1500	5.9	7.0+
1953	LIQUEFIED GASES, flammable, toxic, n.o.s. (Inhalation Hazard Zone A)	1000	1.0	3.2	1500	5.9	7.0+
1953	LIQUEFIED GASES, flammable, toxic, n.o.s. (Inhalation Hazard Zone B)	500	0.8	2.9	1500	2.4	4.6
1953	LIQUEFIED GASES, flammable, toxic, n.o.s. (Inhalation Hazard Zone C)	500	0.3	2.1	1500	2.2	4.3
1953	LIQUEFIED GASES, flammable, toxic, n.o.s. (Inhalation Hazard Zone D)	500	0.2	1.7	1000	1.7	3.8
1955	CHLOROPICRIN and NON-FLAMMABLE COMPRESSED GAS MIXTURE	500	0.5	2.6	500	0.8	2.9
1955	COMPRESSED GASES, poisonous, n.o.s.	1000	1.0	3.2	1500	5.9	6.9
1955	COMPRESSED GASES, toxic, n.o.s. (Inhalation Hazard Zone A)	1000	1.0	3.2	1500	5.9	6.9

ID#	NAME OF MATERIAL	SMALL SPILLS (From a small package or small leak from a large package)			LARGE SPILLS (From a large package or from many small packages)		
		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND	
			DAY (Miles)	NIGHT (Miles)		DAY (Miles)	NIGHT (Miles)
1955	COMPRESSED GASES, toxic, n.o.s. (Inhalation Hazard Zone B)	500	0.8	2.9	1500	2.4	4.6
1955	COMPRESSED GASES, toxic, n.o.s. (Inhalation Hazard Zone C)	500	0.3	2.1	1500	2.2	4.3
1955	COMPRESSED GASES, toxic, n.o.s. (Inhalation Hazard Zone D)	500	0.2	1.7	1000	1.7	3.8
1955	LIQUEFIED GASES, poisonous, n.o.s.	1000	1.0	3.2	1500	5.9	7.0+
1955	LIQUEFIED GASES, toxic, n.o.s. (Inhalation Hazard Zone A)	1000	1.0	3.2	1500	5.9	7.0+
1955	LIQUEFIED GASES, toxic, n.o.s. (Inhalation Hazard Zone B)	500	0.8	2.9	1500	2.4	4.6
1955	LIQUEFIED GASES, toxic, n.o.s. (Inhalation Hazard Zone C)	500	0.3	2.1	1500	2.2	4.3
1955	LIQUEFIED GASES, toxic, n.o.s. (Inhalation Hazard Zone D)	500	0.2	1.7	1000	1.7	3.8
1955	METHYL BROMIDE and NON-FLAMMABLE COMPRESSED GAS MIXTURE	500	0.1	0.4	500	0.3	2.1
1955	ORGANIC PHOSPHATE, mixed with COMPRESSED GAS	500	0.6	2.6	1500	3.2	5.5
1955	ORGANIC PHOSPHATE COMPOUND, mixed with COMPRESSED GAS	500	0.6	2.6	1500	3.2	5.5
1955	ORGANIC PHOSPHORUS COMPOUND, mixed with COMPRESSED GAS	500	0.6	2.6	1500	3.2	5.5
1967	INSECTICIDE GASES, toxic, n.o.s.	500	0.1	0.6	1000	1.0	3.2
1967	METHYL PARATHION and COMPRESSED GAS MIXTURE	500	0.1	0.6	1000	1.0	3.2
1967	PARATHION and COMPRESSED GAS MIXTURE	500	0.1	0.1	1000	1.0	3.2
1975	NITRIC OXIDE and DINITROGEN TETROXIDE MIXTURES	500	0.1	0.1	500	0.3	1.9
1975	NITRIC OXIDE and NITROGEN DIOXIDE MIXTURES	500	0.1	0.1	500	0.3	1.9
1975	NITRIC OXIDE and NITROGEN TETROXIDE MIXTURES	500	0.1	0.1	500	0.3	1.9
1994	IRON PENTACARBONYL	500	0.1	1.3	1000	1.4	3.5
2032	NITRIC ACID, fuming	500	0.1	1.2	500	0.2	1.6
2032	NITRIC ACID, red fuming	500	0.1	1.2	500	0.2	1.6
2186	HYDROGEN CHLORIDE, refrigerated liquid (cryogenic liquid)	500	0.3	1.9	1000	1.1	3.2
2188	ARSINE	1500	2.5	4.7	1500	7.0+	7.0+
2189	DICHLOROSILANE	500	0.1	0.3	500	0.3	2.2
2190	OXYGEN DIFLUORIDE	1500	4.2	7.0+	1500	7.0+	7.0+
2191	SULFURYL FLUORIDE	500	0.2	1.7	1000	1.7	3.8

ID#	NAME OF MATERIAL	SMALL SPILLS (From a small package or small leak from a large package)			LARGE SPILLS (From a large package or from many small packages)		
		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND	
			DAY (Miles)	NIGHT (Miles)		DAY (Miles)	NIGHT (Miles)
2192	GERMANE (germanium hydride)	1000	1.9	4.0	1500	5.3	7.0+
2194	SELENIUM HEXAFLUORIDE	1500	2.8	5.0	1500	5.4	7.0+
2195	TELLURIUM HEXAFLUORIDE	500	0.3	2.1	1500	3.6	6.1
2196	TUNGSTEN HEXAFLUORIDE	500	0.2	1.4	500	0.5	2.5
2197	HYDROGEN IODIDE, anhydrous	500	0.1	0.4	500	0.3	2.0
2198	PHOSPHORUS PENTAFLUORIDE	1000	1.6	3.7	1500	3.8	6.2
2199	PHOSPHINE	1500	2.0	4.1	1500	4.1	6.7
2202	HYDROGEN SELENIDE, anhydrous	1500	2.6	4.8	1500	6.7	7.0+
2204	CARBONYL SULFIDE	500	0.1	1.2	500	0.7	2.8
2232	CHLOROACETALDEHYDE	500	0.1	0.3	500	0.2	1.6
2232	2-CHLOROETHANAL	500	0.1	0.3	500	0.2	1.6
2334	ALLYLAMINE	500	0.1	1.1	500	0.2	1.6
2337	PHENYL MERCAPTAN	500	0.1	0.1	500	0.1	0.2
2382	DIMETHYLHYDRAZINE, symmetrical	500	0.1	0.2	500	0.2	1.4
2407	ISOPROPYL CHLOROFORMATE	500	0.1	0.1	500	0.1	0.5
2417	CARBONYL FLUORIDE	500	0.6	2.7	1500	2.4	4.6
2418	SULFUR TETRAFLUORIDE	1000	1.4	3.5	1500	4.9	7.0+
2420	HEXAFLUOROACETONE	500	0.8	2.9	1500	4.3	6.9
2421	NITROGEN TRIOXIDE	500	0.9	3.1	1500	4.4	6.9
2438	TRIMETHYLACETYL CHLORIDE	500	0.1	0.1	500	0.3	2.0
2442	TRICHLOROACETYL CHLORIDE	500	0.1	0.9	500	0.1	1.3
2474	THIOPHOSGENE	1000	1.6	3.6	1500	2.2	4.3
2477	METHYL ISOTHIOCYANATE	500	0.1	0.2	500	0.3	2.1
2480	METHYL ISOCYANATE	1000	1.2	3.3	1500	3.5	5.9
2481	ETHYL ISOCYANATE	500	0.2	1.9	1500	3.2	5.4
2482	n-PROPYL ISOCYANATE	500	0.1	0.2	500	0.1	1.3
2483	ISOPROPYL ISOCYANATE	500	0.2	1.9	1500	3.2	5.4
2484	tert-BUTYL ISOCYANATE	500	0.1	0.4	500	0.2	1.8
2485	n-BUTYL ISOCYANATE	1000	1.0	3.2	1000	1.8	3.9
2486	ISOBUTYL ISOCYANATE	1000	1.2	3.3	1500	3.5	5.9
2487	PHENYL ISOCYANATE	500	0.1	0.1	500	0.1	0.8
2488	CYCLOHEXYL ISOCYANATE	500	0.1	0.6	500	0.1	1.3
2521	DIKETENE	500	0.1	0.1	500	0.1	0.7
2534	METHYLCHLOROSILANE	500	0.2	1.6	500	0.3	2.1
2548	CHLORINE PENTAFLUORIDE	500	0.3	1.9	1500	2.6	4.8
2600	CARBON MONOXIDE and HYDROGEN MIXTURE	500	0.3	2.0	500	0.7	2.8

ID#	NAME OF MATERIAL	SMALL SPILLS (From a small package or small leak from a large package)			LARGE SPILLS (From a large package or from many small packages)		
		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND	
			DAY (Miles)	NIGHT (Miles)		DAY (Miles)	NIGHT (Miles)
2605	METHOXYMETHYL ISOCYANATE	500	0.2	1.9	1500	3.2	5.4
2606	METHYL ORTHOSILICATE	500	0.1	0.1	500	0.1	0.8
2644	METHYL IODIDE	500	0.1	0.1	500	0.1	1.1
2646	HEXACHLOROCYCLOPENTADIENE	500	0.1	0.5	500	0.1	0.8
2668	CHLOROACETONITRILE	500	0.1	0.1	500	0.1	0.4
2676	STIBINE	500	0.5	2.5	1500	2.1	4.2
2692	BORON TRIBROMIDE	500	0.1	0.5	500	0.1	0.7
2740	n-PROPYL CHLOROFORMATE	500	0.1	0.1	500	0,1	0.4
2742	sec-BUTYL CHLOROFORMATE	500	0.1	0.2	500	0.3	2.2
2742	ISOBUTYL CHLOROFORMATE	500	0.1	1.3	1000	2.0	4.1
2743	n-BUTYL CHLOROFORMATE	500	0.1	1.3	1000	2.0	4.1
2810	POISONOUS LIQUIDS, n.o.s. (Inhalation Hazard Zone A)	1500	2.1	4.2	1500	4.4	6.9
2810	POISONOUS LIQUIDS. n.o.s. (Inhalation Hazard Zone B)	500	0.1	1.3	1000	2.0	4.1
2810	TOXIC LIQUID, organic, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	500	0.5	2.5	1500	4.4	6.9
2826	ETHYL CHLOROTHIOFORMATE	500	0.1	0.1	500	0.1	0.2
2845	ETHYL PHOSPHOROUS DICHLORIDE, anhydrous	500	0.1	1.4	1500	2.1	4.2
2845	METHYL PHOSPHONOUS DICHLORIDE	500	0.1	1.4	1500	2.1	4.2
2901	BROMINE CHLORIDE	500	0.1	0.2	500	0.4	2.3
2927	ETHYL PHOSPHONOTHIOIC DICHLORIDE, anhydrous	500	0.1	1.4	1500	2.1	4.2
2927	ETHYL PHOSPHORODICHLORIDATE	500	0.3	2.2	500	0.6	2.7
2927	POISONOUS LIQUIDS, corrosive, n.o.s. (Inhalation Hazard Zone A)	1000	1.2	3.3	1500	3.5	5.9
2927	POISONOUS LIQUIDS, corrosive, n.o.s. (Inhalation Hazard Zone B)	500	0.1	1.3	1000	2.0	4.1
2927	TOXIC LIQUID, corrosive, organic, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	500	0.5	2.5	1500	4.4	6.9
2929	POISONOUS LIQUIDS, flammable, n.o.s. (Inhalation Hazard Zone A)	1000	1.2	3.3	1500	3.5	5.9
2929	POISONOUS LIQUIDS, flammable, n.o.s. (Inhalation Hazard Zone B)	500	0.1	1.3	1000	2.0	4.1
2929	TOXIC LIQUID, flammable, organic, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	1000	1.2	3.3	1500	3.5	5.9
3023	tert-OCTYL MERCAPTAN	500	0.1	0.3	500	0.1	0.6
3057	TRIFLUOROACETYL CHLORIDE	500	0.1	0.2	500	0.3	2.2
3079	METHACRYLONITRILE, inhibited	500	0.1	0.2	500	0.2	1.5

ID#	NAME OF MATERIAL	SMALL SPILLS (From a small package or small leak from a large package)			LARGE SPILLS (From a large package or from many small packages)		
		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND		First ISOLATE in all Directions (Feet)	Then, PROTECT persons DOWNWIND	
			DAY (Miles)	NIGHT (Miles)		DAY (Miles)	NIGHT (Miles)
3083	PERCHLORYL FLUORIDE	500	0.3	2.1	1500	2.2	4.3
3122	POISONOUS LIQUIDS, oxidizing, n.o.s. (Inhalation Hazard Zone A)	1000	1.2	3.3	1500	3.5	5.9
3122	POISONOUS LIQUIDS, oxidizing, n.o.s. (Inhalation Hazard Zone B)	500	0.1	1.3	1000	2.0	4.1
3122	TOXIC LIQUID, oxidizing, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	1000	1.2	3.3	1500	3.5	5.9
3123	POISONOUS LIQUIDS, which in contact with water emit FLAMMABLE GASES, n.o.s. (Inhalation Hazard Zone A)	1000	1.2	3.3	1500	3.5	5.9
3123	POISONOUS LIQUIDS, which in contact with water emit FLAMMABLE GASES, n.o.s. (Inhalation Hazard Zone B)	500	0.1	1.3	1000	2.0	4.1
3123	TOXIC LIQUID, water-reactive, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	1000	1.2	3.3	1500	3.5	5.9
3160	LIQUEFIED GAS, toxic, flammable, n.o.s.	1000	1.0	3.2	1500	5.9	7.0+
3162	LIQUEFIED GAS, toxic, n.o.s.	1000	1.0	3.2	1500	5.9	7.0+
3246	METHANESULFONYL CHLORIDE	500	0.1	0.2	500	0.1	1.3
3275	NITRILES, toxic, flammable, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	1000	1.2	3.3	1500	3.5	5.9
3279	ORGANOPHOSPHORUS COMPOUND, toxic, flammable, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	1000	1.2	3.3	1500	3.5	5.9
3289	TOXIC LIQUID, corrosive, inorganic, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	1000	1.2	3.3	1500	3.5	5.9
3294	HYDROGEN CYANIDE, solution in alcohol with not more than 45% hydrogen cyanide (When "Inhalation Hazard" is on a package or shipping paper.)	500	0.2	1.4	500	0.3	2.2
3300	ETHYLENE OXIDE and CARBON DIOXIDE MIXTURE, with more than 87% ethylene oxide	500	0.1	0.9	500	0.2	1.5
9192	FLUORINE, refrigerated liquid (cryogenic liquid)	1000	1.7	3.8	1500	3.9	6.5
9202	CARBON MONOXIDE, refrigerated liquid (cryogenic liquid)	500	0.3	2.0	500	0.7	2.8
9206	METHYL PHOSPHONIC DICHLORIDE	500	0.1	0.7	1000	1.2	3.3
9263	CHLOROPIVALOYL CHLORIDE	500	0.1	0.3	500	0.5	2.6
9264	3,5-DICHLORO-2,4,6-TRIFLUOROPYRIDINE	500	0.1	0.7	1000	1.3	3.4
9269	TRIMETHOXYSILANE	500	0.1	0.2	500	0.4	2.4

FINAL COMMENTS ON FIRE AND SPILL CONTROL

Fire Control

Water is the most common and generally most available fire extinguishing agent. Exercise caution in selecting a fire extinguishing method since there are many factors to be considered in any individual case. Water may be ineffective in fighting fires involving some materials; much depends on the method of application.

Spill fires involving flammable liquids are generally controlled by applying a firefighting foam to the surface of the burning material. Fighting flammable liquid fires requires foam concentrate which is chemically compatible with the burning material, correct mixing of the foam concentrate with water and air, and careful application and maintenance of the foam blanket. There are two general types of firefighting foam: "regular" and "alcohol-resistant." Examples of "regular" foam are "protein-base," "fluoroprotein", and aqueous film forming foam (AFFF). Some flammable liquids, including many petroleum products, can be controlled by applying "regular" foam. Other flammable liquids, including polar solvents such as alcohols and ketones, have different chemical properties. A fire involving these materials cannot be controlled with "regular" foam and requires application of alcohol-resistant type foam. Polar-solvent (flammable liquids which are water soluble) fires may be difficult to control and require a higher foam application rate than other flammable liquid fires (see NFPA/ANSI Standards 11 and 11A for further information). "Regular" foam is recommended for the materials covered by Guide 27, alcohol-resistant foam is recommended for the materials covered by Guide 26. Although it is impossible to make specific recommendations for flammable liquids which have subsidiary corrosive or poison hazards, alcohol-resistant foam may be effective for many of these materials. The emergency response telephone number on the shipping document, or CHEMTREC (1-800-424-9300), should be contacted as soon as possible for guidance on the proper extinguishing agent to use. The final selection of an agent and method depends on many factors such as incident location, exposure hazards, size of the fire, environmental concerns, as well as the availability of extinguishing agents and equipment at the scene.

Water Reactive Materials

Water is sometimes used to flush spills and to reduce or direct vapors in spill situations. Some of the materials covered in this publication can react violently or even explosively with water. In these cases, consider letting the fire burn or leaving the spill alone until technical advice can be obtained. The applicable guides clearly warn you of these potentially dangerous reactions. These materials require technical advice since

(1) water getting inside a ruptured or leaking container may cause an explosion.

(2) water may be needed to cool adjoining containers to prevent their rupturing (exploding) or further spread of the fires;
(3) water may be effective in mitigating an incident involving a water-reactive material only if it can be applied at a sufficient "flooding" rate for an extended period; and
(4) the products from the reaction with water may be more toxic, corrosive, or otherwise more undesirable than the product of the fire without water applied.

When responding to an incident involving water-reactive chemicals, take into account the existing conditions such as wind, precipitation, location and accessibility to the incident, as well as the availability of the agents to control the fire or spill. Because of the great number of variables, the decision to use water on fires or spills involving water-reactive materials should be made by an authoritative source.

Vapor Control

Limiting the amount of vapor released from a pool of flammable or corrosive liquids is an operational concern. This technique requires the use of proper protective clothing, specialized equipment, appropriate chemical agents, and skilled personnel. Before engaging in vapor control, get advice from an authoritative source as to the proper tactics.

There are several ways to minimize the amount of vapors escaping from pools of spilled liquids, such as special foams, adsorbing agents, absorbing agents, and neutralizing agents. To be effective, these vapor control methods must be selected for the specific material involved and performed in a manner that will mitigate, not worsen, the incident.

Where specific materials are known, such as at manufacturing or storage facilities, it is desirable for the hazardous materials response team to arrange with the facility operators to select and stockpile these control agents in advance of a spill. In the field, first responders may not have the most effective vapor control agent for the material. They are likely to have only water and only one type of firefighting foam. Therefore, it is likely that water spray will be used. Because the water is being used to form a vapor seal, care must be taken not to churn or further spread the spill during application. Vapors that do not react with water may be directed away from the site using the air currents surrounding the water spray.

Water spray has been used on large spills of some flammable materials in an attempt to reduce vapor concentration below the explosive limit. However, water sprayed into a confined area may actually increase the air concentration, possibly creating an explosive mixture of air and the flammable vapor. Before using water spray or other methods to safely control vapor emission or to suppress ignition, obtain trained technical advice, based on specific chemical name identification.

Appendix

Hazardous Chemicals Listing

The following tables were extracted from the DOT Emergency Response Guidebook. They provide a listing of chemicals according to the 4-digit UN shipping number designation. The reader can use this appendix to identify a hazardous chemical and determine the proper fire and emergency response by matching the Guide Number with the Fact Sheets in Chapter 5. Those chemicals that are boldfaced and highlighted represent chemicals that require an initial isolation distance when involved in a spill or leak from a container. Information and guidelines on isolation distances can be found in Chapter 7.

ID No	Guide No	Name of Material
--	46	AMMONIUM NITRATE - FUEL OIL MIXTURES
--	46	BLASTING AGENT, n.o.s.
--	46	EXPLOSIVE A
--	46	EXPLOSIVE B
--	50	EXPLOSIVE C
--	46	EXPLOSIVES, division 1.1,1.2, 1.3,1.5 or 1.6
--	50	EXPLOSIVES, division 1.4
0004	46	AMMONIUM PICRATE, dry or wetted with less than 10% water
0222	46	AMMONIUM NITRATE with more than 0.2% combustible material

ID No	Guide No	Name of Material
0223	46	AMMONIUM NITRATE FERTILIZER, which is more liable to explode than ammonium nitrate with 0.2% combustible material
0331	46	AMMONIUM NITRATE - FUEL OIL MIXTURE (containing only prilled ammonium nitrate and fuel oil)
0402	46	AMMONIUM PERCHLORATE
1001	17	ACETYLENE
1001	17	ACETYLENE, dissolved
1002	12	AIR, compressed
1003	23	AIR, refrigerated liquid (cryogenic liquid)
1005	**15**	**AMMONIA**
1005	**15**	**AMMONIA, ANHYDROUS, liquefied**
1005	**15**	**AMMONIA SOLUTIONS with more than 50% ammonia**
1005	**15**	**ANHYDROUS AMMONIA**
1006	12	ARGON, compressed
1008	**15**	**BORON TRIFLUORIDE**
1009	12	BROMOTRIFLUOROMETHANE
1010	17	BUTADIENES, inhibited
1011	22	BUTANE or BUTANE MIXTURES
1012	22	BUTYLENE
1013	21	CARBON DIOXIDE
1014	14	CARBON DIOXIDE and OXYGEN MIXTURES
1015	12	CARBON DIOXIDE and NITROUS OXIDE MIXTURES
1016	**18**	**CARBON MONOXIDE**
1017	**20**	**CHLORINE**
1018	12	CHLORODIFLUOROMETHANE
1020	12	CHLOROPENTAFLUOROETHANE
1021	12	CHLOROTETRAFLUORO ETHANE

ID No	Guide No	Name of Material
1022	12	CHLOROTRIFLUOROMETHANE
1022	12	TRIFLUOROCHLOROMETHANE
1023	**18**	**COAL GAS**
1026	**18**	**CYANOGEN**
1026	**18**	**CYANOGEN, liquefied**
1026	**18**	**CYANOGEN GAS**
1027	22	CYCLOPROPANE
1027	22	CYCLOPROPANE, liquefied
1028	12	DICHLORODIFLUOROMETHANE
1029	12	DICHLOROFLUOROMETHANE
1029	12	DICHLOROMONOFLUOROMETHANE
1030	22	1,1-DIFLUOROETHANE
1030	22	DIFLUOROETHANE
1032	19	DIMETHYLAMINE, anhydrous
1033	22	DIMETHYL ETHER
1035	22	ETHANE, compressed
1036	68	ETHYLAMINE
1036	68	MONOETHYLAMINE
1037	27	ETHYL CHLORIDE
1038	22	ETHYLENE, refrigerated liquid (cryogenic liquid)
1039	26	ETHYL METHYL ETHER
1039	26	METHYL ETHYL ETHER
1040	**69**	**ETHYLENE OXIDE**
1040	**69**	**ETHYLENE OXIDE with nitrogen**
1041	17	CARBON DIOXIDE and ETHYLENE OXIDE MIXTURE, with more than 6% ethylene oxide
1041	17	ETHYLENE OXIDE and CARBON DIOXIDE MIXTURE, with more than 6% ethylene oxide
1041	17	ETHYLENE OXIDE and CARBON DIOXIDE MIXTURE with more than 9% but not more than 87% ethylene oxide

ID No	Guide No	Name of Material
1043	16	FERTILIZER AMMONIATING SOLUTION, with more than 35% free ammonia
1044	.12	FIRE EXTINGUISHERS, with compressed or liquefied gas
1045	**20**	**FLUORINE, compressed**
1046	12	HELIUM, compressed
1048	**15**	**HYDROGEN BROMIDE, anhydrous**
1049	22	HYDROGEN, compressed
1050	**15**	**HYDROCHLORIC ACID, anhydrous**
1050	**15**	**HYDROGEN CHLORIDE, anhydrous**
1051	**13**	**HYDROCYANIC ACID**
1051	**13**	**HYDROGEN CYANIDE, anhydrous, stabilized**
1051	**13**	**HYDROGEN CYANIDE, stabilized, containing less than 3% water**
1052	**59**	**HYDROFLUORIC ACID, anhydrous**
1052	**59**	**HYDROGEN FLUORIDE, anhydrous**
1053	**13**	**HYDROGEN SULFIDE**
1053	**13**	**HYDROGEN SULFIDE, liquefied**
1055	22	ISOBUTYLENE
1056	12	KRYPTON, compressed
1057	17	CIGARETTE LIGHTER, with flammable gas
1057	17	FLAMMABLE GAS in LIGHTER for cigars, cigarettes, etc.
1057	17	LIGHTER REFILLS, cigarettes, containing flammable gas
1057	17	LIGHTERS, cigarettes, containing flammable gas
1058	12	LIQUEFIED GAS, nonflammable, charged with nitrogen, carbon dioxide or air
1058	12	LIQUEFIED NONFLAMMABLE GAS charged with nitrogen, carbon dioxide or air
1060	17	METHYL ACETYLENE and PROPADIENE MIXTURE, stabilized

ID No	Guide No	Name of Material
1061	19	METHYLAMINE, anhydrous
1061	19	MONOMETHYLAMINE, anhydrous
1062	**55**	**METHYL BROMIDE**
1063	18	METHYL CHLORIDE
1064	**13**	**METHYL MERCAPTAN**
1065	12	NEON, compressed
1066	12	NITROGEN, compressed
1067	**20**	**DINITROGEN TETROXIDE, liquefied**
1067	**20**	**NITROGEN DIOXIDE, liquefied**
1067	**20**	**NITROGEN PEROXIDE**
1067	**20**	**NITROGEN TETROXIDE**
1069	**16**	**NITROSYL CHLORIDE**
1070	14	NITROUS OXIDE, compressed
1071	**18**	**OIL GAS**
1072	14	OXYGEN, compressed
1073	23	OXYGEN, refrigerated liquid (cryogenic liquid)
1075	22	LIQUEFIED PETROLEUM GAS
1075	22	LPG, liquefied petroleum gas
1075	22	PETROLEUM GASES, liquefied
1076	**15**	**PHOSGENE**
1077	22	PROPYLENE
1078	12	CHLORODIFLUOROMETHANE and CHLOROPENTAFLUOROETHANE MIXTURE
1078	12	CHLOROTRIFLUOROMETHANE and TRIFLUOROMETHANE MIXTURE
1078	12	DICHLORODIFLUOROMETHANE and CHLORODIFLUOROMETHANE MIXTURE
1078	12	DICHLORODIFLUOROMETHANE and DICHLOROTETRAFLUOROETHANE MIXTURE

ID No	Guide No	Name of Material
1078	12	DICHLORODIFLUOROMETHANE and DIFLUOROETHANE MIXTURE
1078	12	DICHLORODIFLUOROMETHANE and TRICHLOROFLUOROMETHANE MIXTURE
1078	12	DICHLORODIFLUOROMETHANE, TRICHLOROFLUOROMETHANE and CHLORODIFLUOROMETHANE MIXTURE
1078	12	DICHLORODIFLUOROMETHANE and TRICHLOROTRIFLUOROETHANE MIXTURE
1078	12	DISPERSANT GAS, n.o.s.
1078	12	REFRIGERANT GASES, n.o.s.
1078	12	TRIFLUOROMETHANE and CHLOROTRIFLUOROMETHANE MIXTURE
1079	**16**	**SULFUR DIOXIDE**
1079	**16**	**SULFUR DIOXIDE, liquefied**
1080	12	SULFUR HEXAFLUORIDE
1081	17	TETRAFLUOROETHYLENE, inhibited
1082	**18**	**TRIFLUOROCHLOROETHYLENE**
1082	**18**	**TRIFLUOROCHLOROETHYLENE, inhibited**
1083	19	TRIMETHYLAMINE, anhydrous
1085	60	VINYL BROMIDE, inhibited
1086	17	MONOCHLOROETHYLENE
1086	17	VINYL CHLORIDE
1086	17	VINYL CHLORIDE, inhibited
1086	17	VINYL CHLORIDE, stabilized
1087	17	VINYL METHYL ETHER
1087	17	VINYL METHYL ETHER, inhibited
1088	26	ACETAL
1089	26	ACETALDEHYDE
1090	26	ACETONE, and solutions

ID No	Guide No	Name of Material
1091	26	ACETONE OILS
1092	**30**	**ACROLEIN, inhibited**
1093	30	ACRYLONITRILE, inhibited
1098	**57**	**ALLYL ALCOHOL**
1099	57	ALLYL BROMIDE
1100	57	ALLYL CHLORIDE
1104	26	AMYL ACETATES
1105	26	AMYL ALCOHOLS
1105	26	ISOAMYL ALCOHOL
1106	68	AMYLAMINES
1107	26	AMYL CHLORIDES
1108	26	n-AMYLENE
1108	26	1-PENTENE
1109	26	AMYL FORMATES
1110	26	AMYL METHYL KETONE
1110	26	METHYL AMYL KETONE
1111	27	AMYL MERCAPTANS
1112	26	AMYL NITRATE
1113	26	AMYL NITRITES
114	27	BENZENE
1115	26	BENZINE
1118	27	BRAKE FLUID, hydraulic
1120	26	BUTANOLS
1120	26	BUTYL ALCOHOL
1123	26	BUTYL ACETATES
1125	68	n-BUTYLAMINE
1126	29	1-BROMOBUTANE
1126	29	n-BUTYL BROMIDE
1127	27	BUTYL CHLORIDE
1127	27	CHLOROBUTANES
1128	26	n-BUTYL FORMATE

ID No	Guide No	Name of Material
1129	26	BUTYRALDEHYDE
1130	27	CAMPHOR OIL
1131	28	CARBON BISULFIDE
1131	28	CARBON DISULFIDE
1133	26	ADHESIVE
1133	26	ADHESIVES, containing flammable liquid
1133	26	CEMENT, containing flammable liquid
1133	26	CEMENT, liquid, n.o.s.
1134	27	CHLOROBENZENE
1135	55	ETHYLENE CHLOROHYDRIN
1136	27	COAL TAR DISTILLATES, flammable
1136	27	COAL TAR OIL
1137	27	COAL TAR DISTILLATE
1137	27	COAL TAR OIL
1139	26	COATING SOLUTION
1142	26	ANTI-FREEZE
1142	26	CLEANING COMPOUND
1142	26	COMPOUNDS, POLISHING liquid, etc. (flammable)
1142	26	FLAMMABLE LIQUID PREPARATIONS, n.o.s.
1142	26	REDUCING LIQUID
1142	26	REMOVING LIQUID
1143	**28**	**CROTONALDEHYDE, inhibited**
1143	**28**	**CROTONALDEHYDE, stabilized**
1144	27	CROTONYLENE
1145	26	CYCLOHEXANE
1146	27	CYCLOPENTANE
1147	27	DECAHYDRONAPHTHALENE
1148	26	DIACETONE ALCOHOL
1149	26	BUTYL ETHER

ID No	Guide No	Name of Material
1149	26	DIBUTYL ETHERS
1150	29	DICHLOROETHYLENE
1150	29	1,2-DICHLOROETHYLENE
1152	27	DICHLOROPENTANES
1153	26	DIETHOXYETHANE
1153	26	DIETHYL CELLOSOLVE
1153	26	ETHYLENE GLYCOL DIETHYL ETHER
1154	68	DIETHYLAMINE
1155	26	DIETHYL ETHER
1155	26	ETHER
1155	26	ETHYL ETHER
1156	26	DIETHYL KETONE
1157	26	DIISOBUTYL KETONE
1158	68	DIISOPROPYLAMINE
1159	26	DIISOPROPYL ETHER
1159	26	ISOPROPYL ETHER
1160	26	DIMETHYLAMINE SOLUTION
1161	26	DIMETHYL CARBONATE
1162	29	DIMETHYLDICHLOROSILANE
1163	**57**	**DIMETHYLHYDRAZINE, unsymmetrical**
1164	27	DIMETHYL SULFIDE
1164	27	METHYL SULFIDE
1165	26	DIOXANE
1166	26	DIOXOLANE
1167	30	DIVINYL ETHER, inhibited
1168	26	DRIER, paint or varnish, liquid, n.o.s.
1169	26	EXTRACTS, aromatic, liquid
1170	26	ALCOHOL (beverage)
1170	26	ALCOHOL (ethyl)
1170	26	ALCOHOLIC BEVERAGE
1170	26	ETHANOL, and solutions

ID No	Guide No	Name of Material
1170	26	ETHYL ALCOHOL, and solutions
1171	26	ETHOXYETHANOL
1171	26	ETHYLENE GLYCOL MONOETHYL ETHER
1172	26	ETHOXYETHYL ACETATE
1172	26	ETHYLENE GLYCOL MONOETHYL ETHER ACETATE
1173	26	ETHYL ACETATE
1175	26	ETHYL BENZENE
1176	26	ETHYL BORATE
1177	26	2-ETHYLBUTYL ACETATE
1178	26	2-ETHYLBUTYRALDEHYDE
1179	26	ETHYL BUTYL ETHER
1180	26	ETHYL BUTYRATE
1181	55	ETHYL CHLOROACETATE
1182	**28**	**ETHYL CHLOROFORMATE**
1183	29	ETHYLDICHLOROSILANE
1184	26	ETHYLENE DICHLORIDE
1185	**30**	**ETHYLENEIMINE, inhibited**
1188	26	ETHYLENE GLYCOL MONOMETHYL ETHER
1189	26	ETHYLENE GLYCOL MONOMETHYL ETHER ACETATE
1190	26	ETHYL FORMATE
1191	26	ETHYLHEXALDEHYDES
1191	26	OCTYL ALDEHYDES
1192	26	ETHYL LACTATE
1193	26	ETHYL METHYL KETONE
1193	26	METHYL ETHYL KETONE
1194	30	ETHYL NITRITE, and solutions
1195	26	ETHYL PROPIONATE
1196	29	ETHYLTRICHLOROSILANE

ID No	Guide No	Name of Material
1197	26	EXTRACTS, flavoring, liquid
1198	29	FORMALDEHYDE SOLUTIONS (Formalin)
1199	29	FURFURAL
1201	26	FUSEL OIL
1202	27	DIESEL FUEL
1202	27	GAS OIL
1202	27	HEATING OIL, light
1203	27	GASOHOL
1203	27	GASOLINE
1203	27	MOTOR SPIRIT
1203	27	PETROL
1204	26	GLYCERYL TRINITRATE SOLUTION
1204	26	NITROGLYCERIN SOLUTION in ALCOHOL, not more than 1 % nitroglycerin
1204	26	SPIRITS OF NITROGLYCERINE
1206	27	HEPTANES
1207	26	HEXALDEHYDE
1208	27	HEXANES
1208	27	NEOHEXANE
1210	26	INK, printer's, flammable
1210	26	PRINTING INK, flammable
1212	26	ISOBUTANOL
1212	26	ISOBUTYL ALCOHOL
1213	26	ISOBUTYL ACETATE
1214	68	ISOBUTYLAMINE
1216	27	ISOOCTENES
1218	27	ISOPRENE, inhibited
1219	26	ISOPROPANOL
1219	26	ISOPROPYL ALCOHOL
1220	26	ISOPROPYL ACETATE
1221	68	ISOPROPYLAMINE

ID No	Guide No	Name of Material
1222	27	ISOPROPYL NITRATE
1223	27	KEROSENE
1224	26	KETONES, liquid, n.o.s.
1226	26	CIGARETTE LIGHTER, with flammable liquid
1226	26	LIGHTER, for cigars, cigarettes, etc., with flammable liquid
1226	26	LIGHTER FLUID
1228	28	MERCAPTAN MIXTURE, aliphatic
1228	28	MERCAPTAN MIXTURE, liquid flammable, toxic, n.o.s.
1228	28	MERCAPTANS, liquid flammable, toxic, n.o.s.
1228	28	MERCAPTANS and MIXTURES liquid, n.o.s.
1229	26	MESITYL OXIDE
1230	28	METHANOL
1230	28	METHYL ALCOHOL
1231	26	METHYL ACETATE
1232	26	METHYL ACETONE
1233	26	METHYL AMYL ACETATE
1233	26	METHYL AMYL ACETATE
1234	26	METHYLAL
1235	68	METHYLAMINE, aqueous solution
1235	68	MONOMETHYLAMINE, aqueous solution
1237	26	METHYL BUTYRATE
1238	**28**	**METHYL CHLOROCARBONATE**
1238	**28**	**METHYL CHLOROFORMATE**
1239	**57**	**METHYL CHLOROMETHYL ETHER**
1242	29	METHYLDICHLOROSILANE
1243	26	METHYL FORMATE
1244	**57**	**METHYLHYDRAZINE**

ID No	Guide No	Name of Material
1245	26	METHYL ISOBUTYL KETONE
1246	26	METHYL ISOPROPENYL KETONE, inhibited
1247	26	METHYL METHACRYLATE monomer, inhibited
1248	26	METHYL PROPIONATE
1249	26	METHYL PROPYL KETONE
1250	29	METHYLTRICHLOROSILANE
1251	**28**	**METHYL VINYL KETONE**
1255	27	NAPHTHA, petroleum
1255	27	PETROLEUM NAPHTHA
1256	27	NAPHTHA, solvent
1257	27	NATURAL GASOLINE
1259	**57**	**NICKEL CARBONYL**
1261	26	NITROMETHANE
1262	27	ISOOCTANE
1262	27	OCTANES
1263	26	ENAMEL
1263	26	LACQUER
1263	26	LACQUER BASE, liquid
1263	26	PAINT, flammable liquid
1263	26	PAINT RELATED MATERIAL, flammable liquid
1263	26	POLISH, liquid
1264	26	PARALDEHYDE
1265	27	ISOPENTANE
1265	27	n-PENTANE
1265	27	PENTANES, liquid
1266	26	PERFUMERY PRODUCTS, with flammable solvent
1267	27	PETROLEUM CRUDE OIL
1268	27	PETROLEUM DISTILLATES n.o.s.

ID No	Guide No	Name of Material
1268	27	PETROLEUM PRODUCTS, n.o.s.
1270	27	OIL, petroleum, n.o.s.
1270	27	PETROLEUM OIL
1271	26	PETROLEUM ETHER
1271	26	PETROLEUM SPIRIT
1272	26	PINE OIL
1274	26	n-PROPANOL
1274	26	PROPYL ALCOHOL
1275	26	PROPIONALDEHYDE
1276	26	n-PROPYL ACETATE
1277	68	MONOPROPYLAMINE
1277	68	PROPYLAMINE
1278	26	1-CHLOROPROPANE
1278	26	PROPYL CHLORIDE
1279	27	DICHLOROPROPANES
1279	27	PROPYLENE DICHLORIDE
1280	26	PROPYLENE OXIDE
1281	26	PROPYL FORMATES
1282	26	PYRIDINE
1286	26	ROSIN OIL
1287	26	RUBBER SOLUTION
1288	27	SHALE OIL
1289	29	SODIUM METHYLATE, solutions in alcohol
1289	29	SODIUM METHYLATE SOLUTIONS in alcohol
1292	29	ETHYL SILICATE
1292	29	TETRAETHYL SILICATE
1293	26	TINCTURES, medicinal
1294	27	TOLUENE
1295	38	TRICHLOROSILANE
1296	68	TRIETHYLAMINE

ID No	Guide No	Name of Material
1297	29	TRIMETHYLAMINE, aqueous solution
1298	29	TRIMETHYLCHLOROSILANE
1299	27	TURPENTINE
1300	27	TURPENTINE SUBSTITUTE
1301	26	VINYL ACETATE
1301	26	VINYL ACETATE, inhibited
1302	26	VINYL ETHYL ETHER
1302	26	VINYL ETHYL ETHER, inhibited
1303	26	VINYLIDENE CHLORIDE, inhibited
1304	26	VINYL BUTYL ETHER
1304	26	VINYL ISOBUTYL ETHER
1304	26	VINYL ISOBUTYL ETHER, inhibited
1305	29	VINYLTRICHLOROSILANE
1306	26	WOOD PRESERVATIVES, liquid
1307	27	XYLENES, (Xylol)
1308	26	ZIRCONIUM METAL, liquid suspension
1308	26	ZIRCONIUM SUSPENDED IN A LIQUID
1309	32	ALUMINUM POWDER, coated
1310	33	AMMONIUM PICRATE, wetted with not less than 1 0% water
1312	32	BORNEOL
1313	32	CALCIUM RESINATE
1314	32	CALCIUM RESINATE, fused
1318	32	COBALT RESINATE, precipitated
1320	36	DINITROPHENOL, wetted with not less than 1 5% water
1321	36	DINITROPHENOLATE, wetted with not less than I 5% water
1322	36	DINITRORESORCINOL, wetted with not less than 1 5% water
1323	32	FERROCERIUM

ID No	Guide No	Name of Material
1324	32	FILM, MOTION PICTURE, nitrocellulose base
1324	32	FILM, NITROCELLULOSE BASE
1325	32	AIR BAG INFLATORS
1325	32	AIR BAG MODULES
1325	32	COSMETICS, flammable solid n.o.s.
1325	32	FLAMMABLE SOLID, n.o.s.
1325	32	FUSEE (rail or highway)
1325	32	MEDICINES, flammable, solid, n.o.s.
1325	32	PYROXYLIN PLASTIC, rod, sheet, roll, tube, or scrap
1325	32	SMOKELESS POWDER, small arms
1325	32	TETRAETHYLAMMONIUM PERCHLORATE, dry
1326	32	HAFNIUM powder, wetted with not less than 25% water
1327	32	HAY, STRAW or BHUSA, wet damp or contaminated with oil
1328	32	HEXAMETHYLENETETRAMINE
1328	32	HEXAMINE
1330	32	MANGANESE RESINATE
1331	32	MATCHES, strike anywhere
1332	32	METALDEHYDE
1333	32	CERIUM, slabs, ingots or rods
1334	32	CREOSOTE SALTS
1334	32	NAPHTHALENE, crude or refined
1336	33	NITROGUANIDINE, wetted with not less than 20% water
1336	33	PICRITE, wetted with not less than 20% water
1337	33	NITROSTARCH, wet with not less than 20% water
1337	33	NITROSTARCH, wet with not less than 30% solvent

ID No	Guide No	Name of Material
1338	32	PHOSPHORUS, amorphous, red
1338	32	RED PHOSPHORUS
1339	32	PHOSPHORUS HEPTASULFIDE, free from yellow or white phosphorus
1340	41	PHOSPHORUS PENTASULFIDE, free from yellow or white phosphorus
1341	41	PHOSPHORUS SESQUISULFIDE, free from yellow or white phosphorus
1343	41	PHOSPHORUS TRISULFIDE, free from yellow or white phosphorus
1344	33	PICRIC ACID, wet with not less than 10% water
1344	33	TRINITROPHENOL, wet
1344	33	TRINITROPHENOL, wetted with not less than 30% water
1345	32	RUBBER SCRAP, powdered or granulated
1345	32	RUBBER SHODDY, powdered or granulated
1346	32	SILICON POWDER, amorphous
1347	33	SILVER PICRATE, wetted with not less than 30% water
1348	36	SODIUM DINITRO-ortho-CRESOLATE, wetted with not less than 15% water
1349	33	SODIUM PICRAMATE, wetted with not less than 20% water
1350	32	SULFUR
1352	32	TITANIUM, metal, powder, wet with not less than 20% water
1352	32	TITANIUM POWDER, wetted with not less than 25% water
1353	32	FABRICS, impregnated with weakly nitrated nitrocellulose n.o.s.
1353	32	FIBERS, impregnated with weakly nitrated nitrocellulose, n.o.s.
1353	32	TOE PUFFS, nitrocellulose base
1354	33	TRINITROBENZENE, wet

ID No	Guide No	Name of Material
1354	33	TRINITROBENZENE, wetted with not less than 30% water
1355	33	TRINITROBENZOIC ACID, wet
1355	33	TRINITROBENZOIC ACID, wetted with not less than 30% water
1356	33	TRINITROTOLUENE, wet
1356	33	TRINITROTOLUENE, wetted with not less than 30% water
1357	33	UREA NITRATE, wet
1357	33	UREA NITRATE, wetted with not less than 20% water
1358	32	ZINC POWDER, wetted with not less than 25% water
1358	32	ZIRCONIUM METAL, powder, wet
1358	32	ZIRCONIUM POWDER, wet
1360	41	CALCIUM PHOSPHIDE
1361	32	CARBON, animal or vegetable origin
1361	32	CHARCOAL
1361	32	COAL, ground bituminous, sea coal, etc.
1361	32	COAL FACINGS
1361	32	SEA COAL
1362	32	ACTIVATED CARBON
1362	32	CARBON, activated
1363	37	COPRA
1364	32	COTTON WASTE, oily
1365	32	COTTON, wet
1366	40	DIETHYLZINC
1369	32	p-NITROSODIMETHYLANILINE
1370	40	DIMETHYLZINC
1372	32	FIBER, animal or vegetable burnt, wet or damp, n.o.s.
1373	32	FABRIC, animal or vegetable or synthetic, with oil, n.o.s.

ID No	Guide No	Name of Material
1373	32	FIBER, animal or vegetable or synthetic, with oil, n.o.s.
1374	32	FISH MEAL or SCRAP, unstabilized
1376	37	IRON OXIDE, spent
1376	37	IRON SPONGE, spent
1378	32	METAL CATALYST, finely divided, activated or spent, wet with not less than 40% water or other suitable liquid
1379	32	PAPER, treated with unsaturated oil
1380	**75**	**PENTABORANE**
1381	38	PHOSPHORUS, white or yellow , dry or under water or in solution
1381	38	WHITE PHOSPHORUS, dry
1381	38	WHITE PHOSPHORUS, wet
1381	38	YELLOW PHOSPHORUS, dry
1381	38	YELLOW PHOSPHORUS, wet
1382	32	POTASSIUM SULFIDE, anhydrous or with less than 30% water of hydration
1383	37	PYROPHORIC METALS or ALLOYS, n.o.s.
1384	37	SODIUM DITHIONITE
1384	37	SODIUM HYDROSULFITE
1385	34	SODIUM SULFIDE, anhydrous or with less than 30% water of crystallization
1386	32	SEED CAKE, with more than 1.5% oil and not more than 11% moisture
1389	40	ALKALI METAL AMALGAMS
1390	40	ALKALI METAL AMIDES
1391	40	ALKALI METAL DISPERSIONS
1391	40	ALKALINE EARTH METAL DISPERSIONS
1392	40	ALKALINE EARTH METAL AMALGAMS
1393	40	ALKALINE EARTH METAL ALLOYS, n.o.s.
1394	40	ALUMINUM CARBIDE

ID No	Guide No	Name of Material
1395	41	ALUMINUM FERROSILICON, powder
1396	40	ALUMINUM POWDER, uncoated
1397	41	ALUMINUM PHOSPHIDE
1398	40	ALUMINUM SILICON POWDER, uncoated
1400	40	BARIUM
1401	40	CALCIUM
1402	40	CALCIUM CARBIDE
1403	40	CALCIUM CYANAMIDE, with more than 0.1% calcium carbide
1404	40	CALCIUM HYDRIDE
1405	40	CALCIUM SILICIDE
1406	40	CALCIUM SILICON
1407	40	CAESIUM
1407	40	CESIUM
1408	41	FERROSILICON
1409	40	HYDRIDES, metal, n.o.s.
1409	40	METAL HYDRIDES, water-reactive, n.o.s.
1410	40	LITHIUM ALUMINUM HYDRIDE
1411	40	LITHIUM ALUMINUM HYDRIDE, ethereal
1412	40	LITHIUM AMIDE
1413	40	LITHIUM BOROHYDRIDE
1414	40	LITHIUM HYDRIDE
1415	40	LITHIUM
1415	40	LITHIUM METAL
1417	40	LITHIUM SILICON
1418	76	MAGNESIUM, powder
1418	76	MAGNESIUM ALLOYS, with more than 50% magnesium, powder
1419	41	MAGNESIUM ALUMINUM PHOSPHIDE
1420	40	POTASSIUM, METAL, alloy
1420	40	POTASSIUM, metal, liquid, alloy
1421	40	ALKALI METAL ALLOYS, liquid. n.o.s.

ID No	Guide No	Name of Material
1422	40	POTASSIUM SODIUM ALLOYS
1422	40	SODIUM POTASSIUM ALLOYS
1423	40	RUBIDIUM
1423	40	RUBIDIUM METAL
1426	32	SODIUM BOROHYDRIDE
1427	40	SODIUM HYDRIDE
1428	40	SODIUM
1428	40	SODIUM METAL
1431	40	SODIUM METHYLATE, dry
1432	41	SODIUM PHOSPHIDE
1433	41	STANNIC PHOSPHIDE
1435	40	ZINC ASHES
1436	76	ZINC METAL, powder or dust
1436	76	ZINC POWDER or DUST
1437	40	ZIRCONIUM HYDRIDE
1438	35	ALUMINUM NITRATE
1439	35	AMMONIUM DICHROMATE
1442	43	AMMONIUM PERCHLORATE
1444	35	AMMONIUM PERSULFATE
1445	42	BARIUM CHLORATE
1446	42	BARIUM NITRATE
1447	42	BARIUM PERCHLORATE
1448	42	BARIUM PERMANGANATE
1449	42	BARIUM PEROXIDE
1450	42	BROMATES, inorganic, n.o.s.
1451	35	CAESIUM NITRATE
1451	35	CESIUM NITRATE
1452	35	CALCIUM CHLORATE
1453	35	CALCIUM CHLORITE
1454	35	CALCIUM NITRATE
1455	35	CALCIUM PERCHLORATE

ID No	Guide No	Name of Material
1456	35	CALCIUM PERMANGANATE
1457	35	CALCIUM PEROXIDE
1458	35	BORATE and CHLORATE MIXTURE
1458	35	CHLORATE and BORATE MIXTURES
1459	35	CHLORATE and MAGNESIUM CHLORIDE MIXTURES
1461	35	CHLORATES, inorganic, n.o.s.
1462	43	CHLORITES, inorganic, n.o.s.
1463	42	CHROMIC ACID, solid
1463	42	CHROMIC ANHYDRIDE
1463	42	CHROMIUM TRIOXIDE, anhydrous
1465	35	DIDYMIUM NITRATE
1466	35	FERRIC NITRATE
1467	43	GUANIDINE NITRATE
1469	42	LEAD NITRATE
1470	42	LEAD PERCHLORATE, solid or solution
1471	45	LITHIUM HYPOCHLORITE, dry, including mixtures with more than 39% available chlorine
1472	47	LITHIUM PEROXIDE
1473	35	MAGNESIUM BROMATE
1474	35	MAGNESIUM NITRATE
1475	35	MAGNESIUM PERCHLORATE
1476	35	MAGNESIUM PEROXIDE
1477	35	NITRATES, inorganic, n.o.s.
1479	35	COSMETICS, oxidizer, n.o.s.
1479	35	CUPRIC NITRATE
1479	35	MEDICINES, oxidizing substance, solid, n.o.s.
1479	35	OXIDIZER, n.o.s.
1479	35	OXIDIZING MATERIAL, n.o.s.
1479	35	OXIDIZING SOLID, n.o.s.

ID No	Guide No	Name of Material
1479	35	OXIDIZING SUBSTANCES, solid n.o.s.
1479	35	POTASSIUM DICHROMATE
1479	35	SODIUM DICHROMATE
1481	35	PERCHLORATES, inorganic n.o.s.
1482	35	PERMANGANATES, inorganic n.o.s.
1483	35	PEROXIDE, inorganic, n.o.s.
1484	35	POTASSIUM BROMATE
1485	35	CHLORATE OF POTASH
1485	35	POTASSIUM CHLORATE
1486	35	POTASSIUM NITRATE
1487	35	POTASSIUM NITRATE and SODIUM NITRITE MIXTURE
1487	35	SODIUM NITRITE and POTASSIUM NITRATE MIXTURE
1488	35	POTASSIUM NITRITE
1489	35	POTASSIUM PERCHLORATE
1490	35	POTASSIUM PERMANGANATE
1491	47	POTASSIUM PEROXIDE
1492	35	POTASSIUM PERSULFATE
1493	45	SILVER NITRATE
1494	42	SODIUM BROMATE
1495	35	CHLORATE OF SODA
1495	35	SODIUM CHLORATE
1496	43	SODIUM CHLORITE
1498	35	SODIUM NITRATE
1499	35	SODIUM NITRATE and POTASSIUM NITRATE MIXTURES
1500	35	SODIUM NITRITE
1502	35	SODIUM PERCHLORATE
1503	35	SODIUM PERMANGANATE
1504	47	SODIUM PEROXIDE
1505	35	SODIUM PERSULFATE

ID No	Guide No	Name of Material
1506	35	STRONTIUM CHLORATE, solid or solution
1507	35	STRONTIUM NITRATE
1508	35	STRONTIUM PERCHLORATE
1509	47	STRONTIUM PEROXIDE
1510	**47**	**TETRANITROMETHANE**
1511	35	UREA HYDROGEN PEROXIDE
1511	35	UREA PEROXIDE
1512	35	ZINC AMMONIUM NITRITE
1513	35	ZINC CHLORATE
1514	35	ZINC NITRATE
1515	35	ZINC PERMANGANATE
1516	47	ZINC PEROXIDE
1517	33	ZINC PICRAMATE, wetted with not less than 20% water
1517	33	ZIRCONIUM PICRAMATE, wet
1541	**55**	**ACETONE CYANOHYDRIN, stabilized**
1544	55	ALKALOID SALTS, solid, n.o.s, poisonous
1544	55	ALKALOIDS, solid, n.o.s poisonous
1545	**57**	**ALLYL ISOTHIOCYANATE, inhibited**
1545	**57**	**ALLYL ISOTHIOCYANATE, stabilized**
1546	53	AMMONIUM ARSENATE
1547	57	ANILINE
1548	53	ANILINE HYDROCHLORIDE
1549	60	ANTIMONY COMPOUND, inorganic, n.o.s.
1549	60	ANTIMONY COMPOUNDS, inorganic, n.o.s.
1549	60	ANTIMONY TRIBROMIDE
1549	60	ANTIMONY TRIBROMIDE SOLUTION
1549	60	ANTIMONY TRIFLUORIDE
1549	60	ANTIMONY TRIFLUORIDE SOLUTION
1550	53	ANTIMONY LACTATE

ID No	Guide No	Name of Material
1551	53	ANTIMONY POTASSIUM TARTRATE
1553	55	ARSENIC ACID, liquid
1554	53	ARSENIC ACID, solid
1555	53	ARSENIC BROMIDE
1556	55	ARSENIC COMPOUNDS, liquid n.o.s.
1556	**55**	**METHYLDICHLOROARSINE**
1556	55	PHENYLDICHLOROARSINE
1557	53	ARSENIC COMPOUNDS, solid n.o.s.
1557	53	ARSENIC DISULFIDE
1557	53	ARSENIC IODIDE, solid
1557	53	ARSENIC SULFIDE
1557	53	ARSENIC TRISULFIDE
1558	53	ARSENIC
1559	53	ARSENIC PENTOXIDE
1560	**55**	**ARSENIC CHLORIDE**
1560	**55**	**ARSENIC TRICHLORIDE**
1561	53	ARSENIC, white, solid
1561	53	ARSENIC TRIOXIDE
1562	53	ARSENICAL DUST
1564	55	BARIUM COMPOUNDS, n.o.s.
1565	53	BARIUM CYANIDE
1566	53	BERYLLIUM CHLORIDE
1566	53	BERYLLIUM COMPOUNDS, n.o.s.
1566	53	BERYLLIUM FLUORIDE
1567	32	BERYLLIUM, powder
1569	**55**	**BROMOACETONE**
1570	53	BRUCINE
1571	36	BARIUM AZIDE, wetted with not less than 50% water
1572	53	CACODYLIC ACID
1573	53	CALCIUM ARSENATE

ID No	Guide No	Name of Material
1574	53	CALCIUM ARSENATE and CALCIUM ARSENITE MIXTURES, solid
1574	53	CALCIUM ARSENITE
1575	55	CALCIUM CYANIDE
1577	56	CHLORODINITROBENZENES
1577	56	DINITROCHLOROBENZENE
1578	55	CHLORONITROBENZENES
1578	55	NITROCHLOROBENZENE, liquid
1578	55	NITROCHLOROBENZENE, solid
1579	53	4-CHLORO-o-TOLUIDINE HYDROCHLORIDE
1580	**56**	**CHLOROPICRIN**
1581	**55**	**CHLOROPICRIN and METHYL BROMIDE MIXTURES**
1581	**55**	**METHYL BROMIDE and CHLOROPICRIN MIXTURES**
1582	**18**	**CHLOROPICRIN and METHYL CHLORIDE MIXTURES**
1582	**18**	**METHYL CHLORIDE and CHLOROPICRIN MIXTURES**
1583	**56**	**CHLOROPICRIN MIXTURES n.o.s.**
1584	53	COCCULUS
1585	53	COPPER ACETOARSENITE
1586	53	COPPER ARSENITE
1587	53	COPPER CYANIDE
1588	55	CYANIDE or CYANIDE MIXTURE, dry
1588	55	CYANIDES, inorganic, n.o.s.
1588	55	CYANIDES, inorganic, solid n.o.s.
1589	**15**	**CYANOGEN CHLORIDE inhibited**
1590	55	DICHLOROANILINES, solid or liquid
1591	58	o-DICHLOROBENZENE
1592	58	p-DICHLOROBENZENE
1593	74	DICHLOROMETHANE

ID No	Guide No	Name of Material
1593	74	METHYLENE CHLORIDE
1594	55	DIETHYLSULFATE
1594	**55**	**ETHYL SULFATE**
1595	**57**	**DIMETHYL SULFATE**
1595	57	METHYL SULFATE
1596	56	DINITROANILINES
1597	56	DINITROBENZENE SOLUTION
1597	56	DINITROBENZENES
1598	53	DINITRO-o-CRESOL
1599	57	DINITROPHENOL SOLUTIONS
1600	56	DINITROTOLUENES, molten
1601	55	DISINFECTANT, solid, toxic n.o.s.
1601	55	DISINFECTANTS, solid, n.o.s poisonous
1602	55	DYE, liquid, toxic, n.o.s.
1602	55	DYE INTERMEDIATE, liquid toxic, n.o.s.
1602	55	DYE INTERMEDIATES, liquid n.o.s. (poisonous)
1602	55	DYES, liquid n.o.s (poisonous)
1603	55	ETHYL BROMOACETATE
1604	29	ETHYLENEDIAMINE
1605	**55**	**1,2-DIBROMOETHANE**
1605	**55**	**ETHYLENE DIBROMIDE**
1606	53	FERRIC ARSENATE
1607	53	FERRIC ARSENITE
1608	53	FERROUS ARSENATE
1610	58	HALOGENATED IRRITATING LIQUIDS, n.o.s.
1611	55	HEXAETHYL TETRAPHOSPHATE
1612	**15**	**HEXAETHYL TETRAPHOSPHATE and COMPRESSED GAS MIXTURES**
1613	55	HYDROCYANIC ACID, aqueous solution, with less than 5% hydrocyanic acid

ID No	Guide No	Name of Material
1613	55	HYDROCYANIC ACID, aqueous solution, with not less than 5% hydrocyanic acid
1613	**55**	**HYDROCYANIC ACID, aqueous solution, with not more than 20% hydrogen cyanide**
1613	**55**	**HYDROGEN CYANIDE, aqueous solution, with not more than 20% hydrogen cyanide**
1614	**57**	**HYDROGEN CYANIDE, anhydrous, stabilized (absorbed)**
1614	**57**	**HYDROGEN CYANIDE stabilized containing less than 3% water (absorbed in a porous inert material)**
1616	53	LEAD ACETATE
1617	53	LEAD ARSENATES
1618	53	LEAD ARSENITES
1620	53	LEAD CYANIDE
1621	53	LONDON PURPLE
1622	53	MAGNESIUM ARSENATE
1623	53	MERCURIC ARSENATE
1624	53	MERCURIC CHLORIDE
1625	42	MERCURIC NITRATE
1626	53	MERCURIC POTASSIUM CYANIDE
1627	42	MERCUROUS NITRATE
1628	53	MERCUROUS SULFATE
1629	53	MERCURIC ACETATE
1629	53	MERCUROUS ACETATE
1629	53	MERCURY ACETATE
1630	53	MERCURY AMMONIUM CHLORIDE
1631	53	MERCURY BENZOATE
1633	53	MERCURY BISULFATE
1634	53	MERCURIC BROMIDE
1634	53	MERCUROUS BROMIDE
1634	53	MERCURY BROMIDES
1636	53	MERCURIC CYANIDE

ID No	Guide No	Name of Material
1636	53	MERCURY CYANIDE
1637	53	MERCURY GLUCONATE
1638	53	MERCURY IODIDE
1639	53	MERCUROL
1639	53	MERCURY NUCLEATE
1640	53	MERCURY OLEATE
1641	53	MERCURY OXIDE
1642	53	MERCURIC OXYCYANIDE
1642	53	MERCURY OXYCYANIDE, desensitized
1643	53	MERCURY POTASSIUM IODIDE
1644	53	MERCURY SALICYLATE
1645	53	MERCURIC SULFATE
1645	53	MERCURY SULFATE
1646	53	MERCURY THIOCYANATE
1647	**55**	**METHYL BROMIDE and ETHYLENE DIBROMIDE MIXTURES, liquid**
1648	28	ACETONITRILE
1648	28	METHYL CYANIDE
1649	56	ANTI-KNOCK COMPOUND
1649	56	ETHYL FLUID
1649	56	MOTOR FUEL ANTI-KNOCK COMPOUND
1649	56	MOTOR FUEL ANTI-KNOCK MIXTURES
1649	56	TETRAETHYL LEAD, liquid
1650	55	NAPHTHYLAMINE (beta)
1651	53	NAPHTHYLTHIOUREA
1652	53	NAPHTHYLUREA
1653	53	NICKEL CYANIDE
1654	55	NICOTINE
1655	55	NICOTINE COMPOUNDS, solid, n.o.s.
1655	55	NICOTINE PREPARATIONS, solid, n.o.s.
1656	55	NICOTINE HYDROCHLORIDE and solutions

ID No	Guide No	Name of Material
1657	53	NICOTINE SALICYLATE
1658	55	NICOTINE SULFATE, liquid
1658	55	NICOTINE SULFATE, solid
1659	53	NICOTINE TARTRATE
1660	**20**	**NITRIC OXIDE**
1661	55	NITROANILINES
1662	55	NITROBENZENE
1663	55	NITROPHENOLS
1664	55	NITROTOLUENES
1665	55	NITROXYLENES
1665	55	NITROXYLOL
1669	55	PENTACHLOROETHANE
1670	**55**	**PERCHLOROMETHYL MERCAPTAN**
1671	55	CARBOLIC ACID
1671	55	PHENOL, solid
1672	**55**	**PHENYLCARBYLAMINE CHLORIDE**
1673	53	PHENYLENEDIAMINES
1674	55	PHENYLMERCURIC ACETATE
1677	53	POTASSIUM ARSENATE
1678	54	POTASSIUM ARSENITE
1679	53	POTASSIUM CUPROCYANIDE
1680	55	POTASSIUM CYANIDE, solid
1680	55	POTASSIUM CYANIDE SOLUTION
1683	53	SILVER ARSENITE
1684	53	SILVER CYANIDE
1685	53	SODIUM ARSENATE
1686	54	SODIUM ARSENITE, aqueous solutions
1687	56	SODIUM AZIDE
1688	53	SODIUM CACODYLATE
1689	55	SODIUM CYANIDE
1690	54	SODIUM FLUORIDE, solid

ID No	Guide No	Name of Material
1690	54	SODIUM FLUORIDE SOLUTION
1691	53	STRONTIUM ARSENITE
1692	53	STRYCHNINE, and salts
1693	58	IRRITATING AGENT, n.o.s.
1693	58	ORM-A, n.o.s.
1693	58	TEAR GAS DEVICES
1693	58	TEAR GAS SUBSTANCES, liquid or solid, n.o.s.
1694	58	BROMOBENZYL CYANIDES
1695	**59**	**CHLOROACETONE, stabilized**
1695	**59**	**MONOCHLOROACETONE inhibited**
1695	**59**	**MONOCHLOROACETONE stabilized**
1697	55	CHLOROACETOPHENONE
1698	55	DIPHENYLAMINE CHLOROARSINE
1699	55	DIPHENYL CHLOROARSINE, solid or liquid
1700	58	TEAR GAS CANDLES
1701	55	XYLYL BROMIDE
1702	55	TETRACHLOROETHANE
1702	55	1,1,2,2-TETRACHLOROETHANE
1703	**15**	**TETRAETHYL DITHIOPYROPHOSPHATE and compressed gas mixture**
1703	**15**	**TETRAETHYL DITHIOPYROPHOSPHATE and gases, mixtures, or in solution (LC50 more than 200 ppm but not more than 5000 ppm)**
1703	**15**	**TETRAETHYL DITHIOPYROPHOSPHATE and gases, mixtures, or in solution (LC50 not more than 200 ppm)**
1704	55	TETRAETHYL DITHIOPYROPHOSPHATE dry, liquid or mixture
1705	**15**	**TETRAETHYL PYROPHOSPHATE and compressed gas mixture**

ID No	Guide No	Name of Material
1705	**15**	**TETRAETHYL PYROPHOSPHATE and compressed gas mixtures (LC50 more than 200 ppm but not more than 5000 ppm)**
1705	**15**	**TETRAETHYL PYROPHOSPHATE and compressed gas mixtures (LC50 not more than 200 ppm)**
1707	53	THALLIUM COMPOUND, n.o.s.
1707	53	THALLIUM SALT, n.o.s.
1707	53	THALLIUM SULFATE, solid
1708	55	TOLUIDINES
1709	53	2,4-TOLUENEDIAMINE
1709	53	2,4-TOLUYLENEDIAMINE
1710	74	TRICHLOROETHYLENE
1711	55	XYLIDINES
1712	53	ZINC ARSENATE
1712	53	ZINC ARSENATE and ZINC ARSENITE MIXTURES
1712	53	ZINC ARSENITE
1713	53	ZINC CYANIDE
1714	41	ZINC PHOSPHIDE
1715	39	ACETIC ANHYDRIDE
1716	60	ACETYL BROMIDE
1717	29	ACETYL CHLORIDE
1718	60	ACID BUTYL PHOSPHATE
1718	60	BUTYL ACID PHOSPHATE
1718	60	BUTYL PHOSPHORIC ACID
1719	60	ALKALINE CORROSIVE LIQUID, n.o.s.
1719	60	CAUSTIC ALKALI LIQUIDS, n.o.s.
1722	**57**	**ALLYL CHLOROCARBONATE**
1722	**57**	**ALLYL CHLOROFORMATE**
1723	29	ALLYL IODIDE
1724	29	ALLYL TRICHLOROSILANE, stabilized

ID No	Guide No	Name of Material
1725	39	ALUMINUM BROMIDE, anhydrous
1726	39	ALUMINUM CHLORIDE, anhydrous
1727	60	AMMONIUM BIFLUORIDE, solid
1727	60	AMMONIUM HYDROGEN DIFLUORIDE, solid
1727	60	AMMONIUM HYDROGEN FLUORIDE, solid
1728	29	AMYLTRICHLOROSILANE
1729	60	ANISOYL CHLORIDE
1730	60	ANTIMONY PENTACHLORIDE, liquid
1731	60	ANTIMONY PENTACHLORIDE, SOLUTION
1732	59	ANTIMONY PENTAFLUORIDE
1733	60	ANTIMONY CHLORIDE
1733	60	ANTIMONY TRICHLORIDE
1733	60	ANTIMONY TRICHLORIDE SOLUTION
1736	39	BENZOYL CHLORIDE
1737	59	BENZYL BROMIDE
1738	59	BENZYL CHLORIDE
1739	39	BENZYL CHLOROFORMATE
1740	60	Bifluorides, n.o.s.
1740	60	HYDROGENDIFLOURIDES, n.o.s., solid or solution
1741	**15**	**BORON TRICHLORIDE**
1742	59	BORON TRIFLUORIDE ACETIC ACID COMPLEX
1743	59	BORON TRIFLUORIDE PROPIONIC ACID COMPLEX
1744	**59**	**BROMINE**
1744	**59**	**BROMINE SOLUTIONS**
1745	**44**	**BROMINE PENTAFLUORIDE**
1746	**44**	**BROMINE TRIFLUORIDE**
1747	29	BUTYL TRICHLOROSILANE

ID No	Guide No	Name of Material
1748	45	CALCIUM HYPOCHLORITE, dry, including mixtures with more than 39 % available chlorine (8.8 % available oxygen)
1749	**44**	**CHLORINE TRIFLUORIDE**
1750	59	CHLOROACETIC ACID, liquid
1750	59	MONOCHLOROACETIC ACID, liquid
1751	60	CHLOROACETIC ACID, solid
1752	**59**	**CHLOROACETYL CHLORIDE**
1753	60	CHLOROPHENYL TRICHLOROSILANE
1754	**39**	**CHLOROSULFONIC ACID**
1754	**39**	**CHLOROSULFONIC ACID and SULFUR TRIOXIDE MIXTURE**
1755	60	CHROMIC ACID SOLUTION
1756	60	CHROMIC FLUORIDE, solid
1757	60	CHROMIC FLUORIDE SOLUTION
1758	39	CHROMIUM OXYCHLORIDE
1759	60	CORROSIVE SOLIDS, n.o.s.
1759	60	COSMETICS, corrosive solid, n.o.s.
1759	60	FERROUS CHLORIDE, solid
1759	60	FUNGICIDE, corrosive, n.o.s.
1759	60	MEDICINES, corrosive, solid n.o.s.
1759	60	STANNOUS CHLORIDE, solid
1760	60	ACID, liquid, n.o.s.
1760	60	ALUMINUM PHOSPHATE SOLUTION
1760	60	ALUMINUM SULFATE SOLUTION
1760	60	AMINOETHOXYETHANOL
1760	60	AMINOPROPYLDIETHANOLAMINE
1760	60	N-AMINOPROPYLMORPHOLINE
1760	60	N-AMINOPROPYLPIPERAZINE
1760	60	CAPROIC ACID (HEXANOIC ACID)
1760	60	CHEMICAL KIT
1760	60	CLEANING COMPOUND, liquid, corrosive

ID No	Guide No	Name of Material
1760	60	COMPOUNDS, cleaning liquid (corrosive)
1760	60	COMPOUNDS, TREE or WEED KILLING, liquid (corrosive)
1760	60	CORROSIVE LIQUIDS, n.o.s.
1760	60	COSMETICS, corrosive liquid, n.o.s.
1760	60	DICHLOROPROPIONIC ACID
1760	60	2,2-DICHLOROPROPIONIC ACID
1760	60	ETHYL PHOSPHONOTHIOIC DICHLORIDE, anhydrous
1760	60	ETHYL PHOSPHORODICHLORIDATE
1760	60	FERROUS CHLORIDE SOLUTION
1760	60	HEXANOIC ACID
1760	60	ISOPENTANOIC ACID
1760	60	MEDICINES, corrosive, liquid, n.o.s.
1760	60	METHYL PHOSPHONOTHIOIC DICHLORIDE
1760	60	MORPHOLINE, aqueous mixture
1760	60	NITRIC ACID, other than fuming, with not more than 40% acid
1760	60	ORM-B, n.o.s.
1760	60	PAINT, corrosive liquid
1760	60	PAINT RELATED MATERIAL, corrosive liquid
1760	60	TEXTILE TREATING COMPOUND
1760	60	TITANIUM SULFATE SOLUTION
1760	60	VALERIC ACID, (n-PENTANOIC ACID)
1761	59	CUPRIETHYLENEDIAMINE SOLUTION
1762	29	CYCLOHEXENYL TRICHLOROSILANE
1763	60	CYCLOHEXYL TRICHLOROSILANE
1764	60	DICHLOROACETIC ACID
1765	60	DICHLOROACETYL CHLORIDE
1766	60	DICHLOROPHENYL TRICHLOROSILANE

ID No	Guide No	Name of Material
1767	29	DIETHYLDICHLOROSILANE
1768	59	DIFLUOROPHOSPHORIC ACID, anhydrous
1769	29	DIPHENYLDICHLOROSILANE
1770	60	DIPHENYLMETHYL BROMIDE
1771	60	DODECYLTRICHLOROSILANE
1773	60	FERRIC CHLORIDE, anhydrous
1773	60	IRON CHLORIDE, solid
1774	60	FIRE EXTINGUISHER CHARGES, corrosive liquid
1775	60	FLUOBORIC ACID
1775	60	FLUOROBORIC ACID
1776	59	FLUOROPHOSPHORIC ACID, anhydrous
1776	59	MONOFLUOROPHOSPHORIC ACID
1777	39	FLUOROSULFONIC ACID
1778	60	FLUOROSILICIC ACID
1778	60	FLUOSILICIC ACID
1778	60	HYDROFLUOSILICIC ACID
1778	60	HYDROSILICOFLUORIC ACID
1778	60	SILICOFLUORIC ACID
1779	60	FORMIC ACID
1780	60	FUMARYL CHLORIDE
1781	60	HEXADECYLTRICHLOROSILANE
1782	59	HEXAFLUOROPHOSPHORIC ACID
1783	60	HEXAMETHYLENEDIAMINE SOLUTION
1784	29	HEXYLTRICHLOROSILANE
1786	59	ACID MIXTURE, hydrofluoric and sulfuric acids
1786	59	HYDROFLUORIC and SULFURIC ACID MIXTURES
1786	59	SULFURIC and HYDROFLUORIC ACID MIXTURE
1787	60	HYDRIODIC ACID, AND SOLUTIONS

ID No	Guide No	Name of Material
1787	60	HYDROGEN IODIDE SOLUTION
1788	60	HYDROBROMIC ACID, AND SOLUTIONS
1788	60	HYDROGEN BROMIDE SOLUTION
1789	60	HYDROCHLORIC ACID SOLUTION
1789	60	HYDROGEN CHLORIDE SOLUTION
1789	60	MURIATIC ACID
1790	59	ETCHING ACID, liquid, n.o.s.
1790	59	FLUORIC ACID
1790	59	HYDROFLUORIC ACID SOLUTION
1790	59	HYDROGEN FLUORIDE SOLUTION
1791	60	HYPOCHLORITE SOLUTION with more than 5% available chlorine
1791	60	POTASSIUM HYPOCHLORITE SOLUTION
1791	60	SODIUM HYPOCHLORITE SOLUTION
1792	59	IODINE MONOCHLORIDE
1793	60	ISOPROPYL ACID PHOSPHATE
179	46	LEAD SULFATE, with more than 3% free acid
1796	73	ACID MIXTURE, nitrating
1796	73	MIXED ACID
1796	73	NITRATING ACID
1796	73	NITRATING ACID, mixtures
1798	60	NITROHYDROCHLORIC ACID
1798	60	NITROMURIATIC ACID
1799	60	NONYLTRICHLOROSILANE
1800	39	OCTADECYLTRICHLOROSILANE
1801	60	OCTYLTRICHLOROSILANE
1802	45	PERCHLORIC ACID, not more than 50% acid, by weight
1803	60	PHENOLSULFONIC ACID, liquid
1804	39	PHENYLTRICHLOROSILANE
1805	60	PHOSPHORIC ACID

ID No	Guide No	Name of Material
1806	39	PHOSPHORUS PENTACHLORIDE
1807	39	PHOSPHORIC ANHYDRIDE
1807	39	PHOSPHORUS PENTOXIDE
1808	39	PHOSPHORUS TRIBROMIDE
1809	**39**	**CHLORIDE OF PHOSPHORUS**
1809	**39**	**PHOSPHORUS TRICHLORIDE**
1810	**39**	**PHOSPHORUS OXYCHLORIDE**
1810	**39**	**PHOSPHORYL CHLORIDE**
1811	59	POTASSIUM BIFLUORIDE
1811	59	POTASSIUM HYDROGEN DIFLUORIDE, solid or solution
1811	59	POTASSIUM HYDROGEN FLUORIDE
1812	54	POTASSIUM FLUORIDE
1813	60	BATTERY, electric storage dry, containing POTASSIUM HYDROXIDE
1813	60	CAUSTIC POTASH, dry, solid
1813	60	POTASSIUM HYDROXIDE, dry, solid
1814	60	CAUSTIC POTASH liquid or solution
1814	60	POTASSIUM HYDROXIDE SOLUTION
1815	29	PROPIONYL CHLORIDE
1816	29	PROPYL TRICHLOROSILANE
1817	39	PYROSULFURYL CHLORIDE
1818	39	SILICON CHLORIDE
1818	39	SILICON TETRACHLORIDE
1819	60	SODIUM ALUMINATE SOLUTION
1821	60	SODIUM BISULFATE, solid
1821	60	SODIUM HYDROGEN SULFATE, solid
1823	60	CAUSTIC SODA, dry, solid
1823	60	SODIUM HYDROXIDE, dry solid
1824	60	CAUSTIC SODA, solution
1824	60	CAUSTIC SODA SOLUTION

ID No	Guide No	Name of Material
1824	60	SODIUM HYDRATE
1824	60	SODIUM HYDROXIDE SOLUTION
1825	60	SODIUM MONOXIDE
1826	60	ACID MIXTURE, spent, nitrating
1826	60	MIXED ACID, spent
1826	60	NITRATING ACID MIXTURES, spent
1827	39	STANNIC CHLORIDE, anhydrous
1827	39	TIN CHLORIDE, fuming
1827	39	TIN TETRACHLORIDE
1828	**39**	**CHLORIDE OF SULFUR**
1828	**39**	**SULFUR CHLORIDES**
1829	**39**	**SULFUR TRIOXIDE**
1829	**39**	**SULFUR TRIOXIDE, inhibited**
1829	**39**	**SULFUR TRIOXIDE, uninhibited**
1829	**39**	**SULFURIC ANHYDRIDE**
1830	39	SULFURIC ACID
1831	39	OLEUM, with less than 30% free sulfur trioxide
1831	**39**	**OLEUM, with not less than 30% free sulfur trioxide**
1831	39	SULFURIC ACID, fuming with less than 30% free sulfur trioxide
1831	**39**	**SULFURIC ACID, fuming, with not less than 30% free sulfur trioxide**
1832	39	SULFURIC ACID, spent
1833	60	SULFUROUS ACID
1834	**39**	**SULFURYL CHLORIDE**
1835	60	TETRAMETHYL AMMONIUM HYDROXIDE
1836	39	THIONYL CHLORIDE
1837	60	THIOPHOSPHORYL CHLORIDE
1838	**39**	**TITANIUM TETRACHLORIDE**

ID No	Guide No	Name of Material
1839	59	TRICHLOROACETIC ACID
1840	60	ZINC CHLORIDE SOLUTION
1841	31	ACETALDEHYDE AMMONIA
1843	42	AMMONIUM DINITRO-o-CRESOLATE
1845	21	CARBON DIOXIDE, solid
1845	21	DRY ICE
1846	55	CARBON TETRACHLORIDE
1847	60	POTASSIUM SULFIDE, hydrated with not less than 30% water of hydration
1848	60	PROPANOIC ACID
1848	60	PROPIONIC ACID
1849	60	SODIUM SULFIDE, hydrated with not less than 30% water
1849	60	SODIUM SULFIDE SOLUTION
1851	55	MEDICINES, liquid, poisonous n.o.s.
1851	55	MEDICINES, liquid, toxic n.o.s.
1854	37	BARIUM ALLOYS, pyrophoric
1855	37	CALCIUM, metal and alloys pyrophoric
1855	37	CALCIUM, PYROPHORIC
1855	37	CALCIUM ALLOY, PYROPHORIC
1858	12	HEXAFLUOROPROPYLENE
1859	**16**	**SILICON TETRAFLUORIDE**
1860	17	VINYL FLUORIDE, inhibited
1862	26	ETHYL CROTONATE
1863	27	FUEL, AVIATION, turbine engine
1864	27	GAS DRIPS, hydrocarbon
1865	30	n-PROPYL NITRATE
1866	26	RESIN SOLUTION, flammable
1866	26	RESIN SOLUTION (resin compound), liquid
1867	32	CIGARETTE, self-lighting
1868	34	DECABORANE

ID No	Guide No	Name of Material
1869	76	MAGNESIUM, pellets, turnings or ribbon
1869	76	MAGNESIUM ALLOY, with more than 50% magnesium pellets, turnings or ribbon
1870	40	POTASSIUM BOROHYDRIDE
1871	32	TITANIUM HYDRIDE
1872	42	LEAD DIOXIDE
1872	42	LEAD PEROXIDE
1873	47	PERCHLORIC ACID, more than 50% but not more than 72% acid, by weight
1884	53	BARIUM OXIDE
1885	53	BENZIDINE
1886	55	BENZYLIDENE CHLORIDE
1887	58	BROMOCHLOROMETHANE
1888	55	CHLOROFORM
1889	55	CYANOGEN BROMIDE
1891	58	ETHYL BROMIDE
1892	**55**	**ETHYLDICHLOROARSINE**
1894	53	PHENYLMERCURIC HYDROXIDE
1895	53	PHENYLMERCURIC NITRATE
1897	74	PERCHLOROETHYLENE
1897	74	TETRACHLOROETHYLENE
1898	60	ACETYL IODIDE
1902	60	DI(2-ETHYLHEXYL)PHOSPHORIC ACID
1902	60	DIISOOCTYL ACID PHOSPHATE
1903	60	DISINFECTANT, liquid, corrosive, n.o.s.
1903	60	DISINFECTANTS, corrosive, liquid, n.o.s.
1905	59	SELENIC ACID
1906	60	ACID, SLUDGE
1906	60	SLUDGE ACID
1907	60	SODA LIME
1908	60	CHLORITE SOLUTION with more than 5% available chlorine

ID No	Guide No	Name of Material
1908	60	SODIUM CHLORITE SOLUTION with more than 5% available chlorine
1910	60	CALCIUM OXIDE
1911	**18**	**DIBORANE**
1911	18	DIBORANE MIXTURES
1912	22	METHYL CHLORIDE and METHYLENE CHLORIDE MIXTURES
1913	21	NEON, refrigerated liquid (cryogenic liquid)
1914	27	BUTYL PROPIONATE
1915	26	CYCLOHEXANONE
1916	55	2,2'-DICHLORODIETHYL ETHER
1916	55	DICHLOROETHYL ETHER
1917	26	ETHYL ACRYLATE, inhibited
1918	28	CUMENE
1918	28	ISOPROPYLBENZENE
1919	26	METHYL ACRYLATE, inhibited
1920	27	NONANES
1921	30	PROPYLENEIMINE, inhibited
1922	29	PYRROLIDINE
1923	37	CALCIUM DITHIONITE
1923	37	CALCIUM HYDROSULFITE
1928	37	METHYL MAGNESIUM BROMIDE in ETHYL ETHER
1929	32	POTASSIUM DITHIONITE
1929	32	POTASSIUM HYDROSULFITE
1931	32	ZINC DITHIONITE
1931	32	ZINC HYDROSULFITE
1932	32	ZIRCONIUM SCRAP
1935	55	CYANIDE SOLUTION, n.o.s.
1935	55	CYANIDE SOLUTIONS
1938	60	BROMOACETIC ACID, solid
1938	60	BROMOACETIC ACID, solution

ID No	Guide No	Name of Material
1939	39	PHOSPHORUS OXYBROMIDE, solid
1940	60	THIOGLYCOLIC ACID
1941	58	DIBROMODIFLUOROMETHANE
1942	43	AMMONIUM NITRATE, with not more than 0.2% combustible material
1942	43	AMMONIUM NITRATE, with organic coating
1944	32	MATCHES, safety
1945	32	MATCHES, wax (Vesta)
1950	12	Aerosols
1951	21	ARGON, refrigerated liquid (cryogenic liquid)
1952	12	CARBON DIOXIDE and ETHYLENE OXIDE MIXTURE, with not more than 6% ethylene oxide
1952	12	CARBON DIOXIDE and ETHYLENE OXIDE MIXTURE with not more than 9% ethylene oxide
1952	12	ETHYLENE OXIDE and CARBON DIOXIDE MIXTURE, with not more than 6% ethylene oxide
1952	12	ETHYLENE OXIDE and CARBON DIOXIDE MIXTURE with not more than 9% ethylene oxide
1953	**18**	**COMPRESSED GAS, toxic flammable, n.o.s. (Inhalation Hazard Zone A)**
1953	**18**	**COMPRESSED GAS, toxic flammable, n.o.s. (Inhalation Hazard Zone B)**
1953	**18**	**COMPRESSED GAS, toxic flammable, n.o.s. (Inhalation Hazard Zone C)**
1953	**18**	**COMPRESSED GAS, toxic flammable, n.o.s. (Inhalation Hazard Zone D)**
1953	**18**	**COMPRESSED GASES, flammable, poisonous, n.o.s.**
1953	**18**	**COMPRESSED GASES, flammable, toxic, n.o.s Inhalation Hazard Zone A)**

ID No	Guide No	Name of Material
1953	**18**	**COMPRESSED GASES, flammable, toxic, n.o.s Inhalation Hazard Zone B)**
1953	**18**	**COMPRESSED GASES, flammable, toxic, n.o.s Inhalation Hazard Zone C)**
1953	**18**	**COMPRESSED GASES, flammable, toxic, n.o.s Inhalation Hazard Zone D)**
1953	**18**	**LIQUEFIED GASES, flammable poisonous, n.o.s.**
1953	**18**	**LIQUEFIED GASES, flammable toxic, n.o.s. (Inhalation Hazard Zone A)**
1953	**18**	**LIQUEFIED GASES, flammable toxic, n.o.s. (Inhalation Hazard Zone B)**
1953	**18**	**LIQUEFIED GASES, flammable toxic, n.o.s. (Inhalation Hazard Zone C)**
1953	**18**	**LIQUEFIED GASES, flammable toxic, n.o.s. (Inhalation Hazard Zone D)**
1954	22	COMPRESSED GASES, flammable, n.o.s.
1954	22	DISPERSANT GAS, flammable n.o.s.
1954	22	FLAMMABLE GAS, n.o.s.
1954	22	LIQUEFIED GAS, flammable n.o.s.
1954	22	REFRIGERANT GASES, flammable, n.o.s.
1954	22	REFRIGERATING MACHINES, containing flammable nonpoisonous, liquefied gas
1955	**15**	**CHLOROPICRIN and NON-FLAMMABLE COMPRESSED GAS MIXTURES**
1955	**15**	**COMPRESSED GASES, poisonous, n.o.s.**
1955	**15**	**COMPRESSED GASES, toxic n.o.s. (Inhalation Hazard Zone A)**
1955	**15**	**COMPRESSED GASES, toxic n.o.s. (Inhalation Hazard Zone B)**
1955	**15**	**COMPRESSED GASES, toxic n.o.s. (Inhalation Hazard Zone C)**
1955	**15**	**COMPRESSED GASES, toxic n.o.s. (Inhalation Hazard Zone D)**
1955	**15**	**LIQUEFIED GASES, poisonous n.o.s.**

ID No	Guide No	Name of Material
1955	**15**	**LIQUEFIED GASES, toxic, n.o.s (Inhalation Hazard Zone A)**
1955	**15**	**LIQUEFIED GASES, toxic, n.o.s (Inhalation Hazard Zone B)**
1955	**15**	**LIQUEFIED GASES, toxic, n.o.s (Inhalation Hazard Zone C)**
1955	**15**	**LIQUEFIED GASES, toxic, n.o.s (Inhalation Hazard Zone D)**
1955	**15**	**METHYL BROMIDE and NON-FLAMMABLE COMPRESSED GAS MIXTURE**
1955	**15**	**ORGANIC PHOSPHATE, mixed with COMPRESSED GAS**
1955	**15**	**ORGANIC PHOSPHATE COMPOUND, mixed with COMPRESSED GAS**
1955	**15**	**ORGANIC PHOSPHORUS COMPOUND, mixed with COMPRESSED GAS**
1956	12	ACCUMULATORS, pressurized
1956	12	COMPRESSED GASES, n.o.s.
1956	12	HEXAFLUOROPROPYLENE OXIDE
1956	12	LIQUEFIED GAS, n.o.s.
1956	12	NONFLAMMABLE GAS, n.o.s.
1957	22	DEUTERIUM
1958	12	DICHLOROTETRAFLUOROETHANE
1959	22	DIFLUOROETHYLENE
1959	22	1,1-DIFLUOROETHYLENE
1960	22	ENGINE STARTING FLUID
1961	22	ETHANE, refrigerated liquid (cryogenic liquid)
1961	22	ETHANE-PROPANE MIXTURE, refrigerated liquid (cryogenic liquid)
1962	22	ETHYLENE, compressed
1963	21	HELIUM, refrigerated liquid (cryogenic liquid)
1964	22	HYDROCARBON GAS MIXTURES, compressed, n.o.s

ID No	Guide No	Name of Material
1964	22	HYDROCARBON GASES, compressed, n.o.s.
1965	22	HYDROCARBON GAS MIXTURES, liquefied, n.o.s.
1965	22	HYDROCARBON GASES, liquefied, n.o.s.
1966	22	HYDROGEN, refrigerated liquid (cryogenic liquid)
1967	**15**	**INSECTICIDE GASES, toxic**
1967	**15**	**METHYL PARATHION and COMPRESSED GAS MIXTURE**
1967	**15**	**PARATHION and COMPRESSED GAS MIXTURE**
1968	12	INSECTICIDE GASES, n.o.s.
1969	22	ISOBUTANE or ISOBUTANE MIXTURES
1970	21	KRYPTON, refrigerated liquid (cryogenic liquid)
1971	17	METHANE, compressed
1971	17	NATURAL GAS, compressed with high METHANE content
1971	17	NATURAL GAS with high METHANE content, compressed
1972	22	LIQUEFIED NATURAL GAS
1972	22	LNG, liquefied natural gas
1972	22	METHANE, refrigerated liquid (cryogenic liquid)
1972	22	NATURAL GAS, refrigerated liquid (cryogenic liquid) with high METHANE content
1973	12	CHLORODIFLUOROMETHANE and CHLOROPENTAFLUOROETHANE MIXTURE
1974	12	CHLORODIFLUOROBROMOMETHANE
1975	**20**	**NITRIC OXIDE and DINITROGEN TETROXIDE MIXTURES**
1975	**20**	**NITRIC OXIDE and NITROGEN DIOXIDE MIXTURES**

ID No	Guide No	Name of Material
1975	**20**	**NITRIC OXIDE and NITROGEN TETROXIDE MIXTURES**
1976	12	OCTAFLUOROCYCLOBUTANE
197	72	NITROGEN, refrigerated liquid (cryogenic liquid)
1978	22	PROPANE
1978	22	PROPANE MIXTURES
1979	12	RARE GASES, MIXTURES
1980	14	HELIUM-OXYGEN MIXTURE
1980	14	RARE GASES and OXYGEN MIXTURES
1981	12	RARE GASES and NITROGEN MIXTURES
1982	12	TETRAFLUOROMETHANE
1983	12	CHLOROTRIFLUOROETHANE
1984	12	TRIFLUOROMETHANE
1986	28	ALCOHOL, denatured (toxic)
1986	28	ALCOHOLS, toxic, n.o.s.
1986	28	DENATURED ALCOHOL (toxic)
1986	28	PROPARGYL ALCOHOL
1987	26	ALCOHOL, denatured
1987	26	ALCOHOL, nontoxic, n.o.s.
1987	26	ALCOHOLS, n.o.s.
1987	26	DENATURED ALCOHOL
1988	28	ALDEHYDES, toxic, n.o.s.
1989	26	ALDEHYDES, n.o.s.
1989	26	BENZALDEHYDE
1990	26	BENZALDEHYDE
1991	30	CHLOROPRENE, inhibited
1992	28	FLAMMABLE LIQUID, toxic, n.o.s.
1992	28	FLAMMABLE LIQUIDS, poisonous, n.o.s.
1993	27	COMBUSTIBLE LIQUID, n.o.s.
1993	27	COMPOUNDS, cleaning liquid (flammable)

ID No	Guide No	Name of Material
1993	27	COMPOUNDS, TREE or WEED KILLING, liquid (flammable)
1993	27	COSMETICS, flammable liquid n.o.s.
1993	27	CREOSOTE, coal tar
1993	27	DIESEL FUEL
1993	27	ETHYL NITRATE
1993	27	FLAMMABLE LIQUIDS, n.o.s.
1993	27	FUEL OIL
1993	27	INSECTICIDE, liquid, n.o.s.
1993	27	MEDICINES, flammable, liquid n.o.s.
1993	27	REFRIGERATING MACHINE
1994	**57**	**IRON PENTACARBONYL**
1999	27	ASPHALT
1999	27	ASPHALT, CUT BACK
1999	27	ROAD ASPHALT, liquid
1999	27	TARS, liquid
2000	32	CELLULOID, in blocks, rods, rolls, sheets, tubes, etc except celluloid scrap
2001	32	COBALT NAPHTHENATES, powder
2002	33	CELLULOID SCRAP
2003	40	METAL ALKYLS, n.o.s.
2004	37	MAGNESIUM DIAMIDE
2005	40	MAGNESIUM DIPHENYL
2006	37	PLASTICS, nitrocellulose-based spontaneously combustible, n.o.s.
2008	37	ZIRCONIUM METAL, powder, dry
2008	37	ZIRCONIUM POWDER, dry
2009	37	ZIRCONIUM, dry, wire, sheet or strips
2010	40	MAGNESIUM HYDRIDE
2011	41	MAGNESIUM PHOSPHIDE
2012	41	POTASSIUM PHOSPHIDE
2013	41	STRONTIUM PHOSPHIDE

ID No	Guide No	Name of Material
2014	45	HYDROGEN PEROXIDE AQUEOUS SOLUTIONS, with not less than 20% but not more than 60% peroxide
2015	47	HYDROGEN PEROXIDE, stabilized
2015	47	HYDROGEN PEROXIDE AQUEOUS SOLUTIONS, stabilized with more than 60% hydrogen peroxide
2016	15	AMMUNITION, toxic, non-explosive
2016	15	CHEMICAL AMMUNITION, nonexplosive, with poisonous material
2016	15	GRENADE, without bursting charge, with poisonous gas
2017	58	AMMUNITION, tear producing, non-explosive
2017	58	CHEMICAL AMMUNITION, nonexplosive, with irritant
2017	58	GRENADE, tear gas
2018	53	CHLOROANILINES, solid
2019	55	CHLOROANILINES, liquid
2020	53	CHLOROPHENOLS, solid
2020	53	TRICHLOROPHENOL
2021	55	CHLOROPHENOLS, liquid
2022	55	CRESYLIC ACID
2022	55	MINING REAGENT, liquid
2023	30	EPICHLOROHYDRIN
2024	53	MERCURY COMPOUNDS, liquid, n.o.s.
2025	53	MERCURY COMPOUNDS, solid, n.o.s.
2026	53	PHENYLMERCURIC COMPOUNDS, solid, n.o.s.
2027	53	SODIUM ARSENITE, solid
2028	60	BOMBS, SMOKE, NON-EXPLOSIVE, with corrosive liquid, without initiating device
2029	28	HYDRAZINE, ANHYDROUS

ID No	Guide No	Name of Material
2029	28	HYDRAZINE AQUEOUS SOLUTIONS, with more than 64% hydrazine
2030	59	HYDRAZINE, AQUEOUS SOLUTION with not less than 37% but not more than 64% hydrazine
2030	59	HYDRAZINE AQUEOUS SOLUTION, with not more than 64% hydrazine
2030	59	HYDRAZINE HYDRATE
2030	59	HYDRAZINE HYDRATE with not less than 37% but not more than 64% hydrazine
2030	59	HYDRAZINE SOLUTION, with not more than 64% hydrazine
2031	44	NITRIC ACID, other than fuming, with more than 40% acid
2031	44	NITRIC ACID, other than red fuming with more than 70% nitric acid
2031	44	NITRIC ACID, other than red fuming with not more than 70% nitric acid
2032	**44**	**NITRIC ACID, fuming**
2032	**44**	**NITRIC ACID, red fuming**
2033	60	POTASSIUM MONOXIDE
2034	22	HYDROGEN and METHANE MIXTURES, compressed
2035	22	TRIFLUOROETHANE, compressed
2036	12	XENON
2037	17	RECEPTACLES, small, with flammable gas
2038	56	DINITROTOLUENES
2044	22	2,2-DIMETHYLPROPANE
2045	26	ISOBUTYL ALDEHYDE
2045	26	ISOBUTYRALDEHYDE
2046	27	CYMENES
2047	29	DICHLOROPROPENE
2047	29	DICHLOROPROPENE and PROPYLENE DICHLORIDE MIXTURE

ID No	Guide No	Name of Material
2047	29	DICHLOROPROPENES
2048	26	DICYCLOPENTADIENE
2049	29	DIETHYLBENZENE
2050	26	DIISOBUTYLENE, ISOMERIC COMPOUNDS
2051	29	DIMETHYLAMINOETHANOL
2051	29	2-DIMETHYLAMINOETHANOL
2051	29	DIMETHYLETHANOLAMINE
2052	27	DIPENTENE
2053	26	METHYL AMYL ALCOHOL
2053	26	METHYL ISOBUTYL CARBINOL
2054	29	MORPHOLINE
2055	27	STYRENE MONOMER, inhibited
2056	26	TETRAHYDROFURAN
2057	27	TRIPROPYLENE
2058	26	VALERALDEHYDE
2059	26	COLLODION
2059	26	NITROCELLULOSE, solution in a flammable liquid
2059	26	NITROCELLULOSE, wet with more than 40% flammable liquid
2067	43	AMMONIUM NITRATE FERTILIZER
2068	43	AMMONIUM NITRATE FERTILIZER, with calcium carbonate
2069	43	AMMONIUM NITRATE FERTILIZER, with ammonium sulfate
2069	43	AMMONIUM NITRATE MIXED FERTILIZERS
2069	43	AMMONIUM NITRATE-SULFATE MIXTURE
2070	43	AMMONIUM NITRATE FERTILIZER, with phosphate or potash
2071	35	AMMONIUM NITRATE FERTILIZER, with not more than 0.4% of combustible material

ID No	Guide No	Name of Material
2071	35	AMMONIUM NITRATE FERTILIZERS
2072	43	AMMONIUM NITRATE FERTILIZERS
2072	43	AMMONIUM NITRATE FERTILIZERS, n.o.s.
2073	15	AMMONIA SOLUTIONS, with more than 35% but not more than 50% ammonia
2074	55	ACRYLAMIDE
2075	55	CHLORAL, anhydrous, inhibited
2076	55	CRESOL (o-, m-, and p-)
2076	55	CRESOLS
2077	55	NAPHTHYLAMINE (alpha)
2078	54	TOLUENE DIISOCYANATE (T.D.I.)
2079	29	DIETHYLENETRIAMINE
2080	48	ACETYL ACETONE PEROXIDE
2081	48	ACETYL BENZOYL PEROXIDE
2082	52	ACETYL CYCLOHEXANE SULFONYL PEROXIDE
2083	52	ACETYL CYCLOHEXANE SULFONYL PEROXIDE
2084	49	ACETYL PEROXIDE
2085	49	BENZOYL PEROXIDE
2087	49	BENZOYL PEROXIDE
2088	49	BENZOYL PEROXIDE
2089	49	BENZOYL PEROXIDE
2090	49	BENZOYL PEROXIDE
2091	48	tert-BUTYL CUMENE PEROXIDE
2091	48	tert-BUTYL CUMYL PEROXIDE
2091	48	tert-BUTYL ISOPROPYL BENZENE HYDROPEROXIDE
2092	48	tert-BUTYL HYDROPEROXIDE, not more than 80% in DI-tert-BUTYL PEROXIDE and/or solvent

ID No	Guide No	Name of Material
2093	51	tert-BUTYL HYDROPEROXIDE
2094	51	tert-BUTYLHYDROPEROXIDE
2095	49	tert-BUTYLPEROXYACETATE
2096	48	tert-BUTYLPEROXYACETATE
2097	48	tert-BUTYLPEROXYBENZOATE
2098	48	tert-BUTYLPEROXYBENZOATE
2099	49	tert-BUTYL MONOPEROXYMALEATE, technical pure
2099	49	tert-BUTYL PEROXYMALEATE, technical pure
2100	48	tert-BUTYL PEROXYMALEATE, solution or paste
2101	48	tert-BUTYL PEROXYMALEATE
2102	48	DI-tert-BUTYL PEROXIDE, technical pure
2103	49	tert-BUTYL PEROXYISOPROPYL CARBONATE, technical pure
2104	48	tert-BUTYL PEROXYISONONANOATE
2104	48	tert-BUTYL PEROXY-3,5,5-TRIMETHYLHEXANOATE
2105	48	tert-BUTYL PEROXYPHTHALATE
2106	48	DI-tert-BUTYL PEROXYPHTHALATE
2107	48	DI-tert-BUTYL PEROXYPHTHALATE
2108	48	DI-tert-BUTYL PEROXYPHTHALATE
2110	52	tert-BUTYL PEROXYPIVALATE
2111	48	2,2-DI (tert-BUTYLPEROXY)-BUTANE
2112	48	DI-(2-tert-BUTYLPEROXY-ISOPROPYL) BENZENE
2112	48	1 4-DI (2-tert-BUTYLPEROXY-ISOPROPYL) BENZENE and 1,3-DI(2-tert-BUTYLPEROXY-ISOPROPYL) BENZENE
2113	48	p-CHLOROBENZOYL PEROXIDE
2114	48	p-CHLOROBENZOYL PEROXIDE

ID No	Guide No	Name of Material
2115	48	p-CHLOROBENZOYL PEROXIDE
2116	51	CUMENE HYDROPEROXIDE, technical pure
2118	51	CYCLOHEXANONE PEROXIDE, not more than 72% in solution
2119	51	CYCLOHEXANONE PEROXIDE, not more than 90%, with not less than 10% water
2120	52	DECANOYL PEROXIDE, technical pure
2121	48	DICUMYL PEROXIDE
2122	52	DI-(2-ETHYLHEXYL)PEROXY-DICARBONATE
2123	52	DI-(2-ETHYLHEXYL)PEROXY-DICARBONATE
2124	48	LAUROYL PEROXIDE, technical pure
2125	51	MENTHANE HYDROPEROXIDE, para, technical pure
2125	51	PARAMENTHANE HYDROPEROXIDE
2126	51	METHYL ISOBUTYL KETONE PEROXIDE
2128	52	ISONONANOYL PEROXIDE, technical pure or in solution
2129	52	CAPRYLYL PEROXIDE
2129	52	OCTANOYL PEROXIDE
2130	52	PELARGONYL PEROXIDE
2131	51	PERACETIC ACID, solution
2131	51	PEROXYACETIC ACID, solution
2132	52	PROPIONYL PEROXIDE
2133	52	ISOPROPYL PEROXYDICARBONATE
2134	52	ISOPROPYL PEROXYDICARBONATE
2135	49	SUCCINIC ACID PEROXIDE, technical pure
2136	48	TETRALIN HYDROPEROXIDE, technical pure
2137	48	2,4-DICHLOROBENZOYL PEROXIDE
2138	48	2,4-DICHLOROBENZOYL PEROXIDE
2139	48	2,4-DICHLOROBENZOYL PEROXIDE

ID No	Guide No	Name of Material
2140	48	n-BUTYL-4,4-DI (tert-BUTYLPEROXY) VALERATE
2141	48	n-BUTYL-4,4-DI (tert-BUTYLPEROXY) VALERATE
2142	52	tert-BUTYL PEROXYISOBUTYRATE
2143	52	tert-BUTYL PEROXY-2-ETHYL-HEXANOATE, technical pure
2144	52	tert-BUTYL PEROXYDIETHYLACETATE
2145	48	1,1-DI (tert-BUTYLPEROXY)-3,3,5-TRIMETHYLCYCLOHEXANE
2146	48	1,1-DI (tert-BUTYLPEROXY)-3,3,5-TRIMETHYLCYCLOHEXANE
2147	48	1,1-DI(tert-BUTYLPEROXY)-3,3,5-TRIMETHYLCYCLOHEXANE
2148	48	DI-(1-HYDROXYCYCLOHEXYL) PEROXIDE
2149	52	DIBENZYL PEROXYDICARBONATE
2150	52	DI-sec-BUTYL PEROXYDICARBONATE
2151	52	DI-sec-BUTYL PEROXY DICARBONATE
2152	52	DICYCLOHEXYL PEROXYDICARBONATE
2153	52	DICYCLOHEXYL PEROXYDICARBONATE
2154	52	DI(4-tert-BUTYLCYCLOHEXYL) PEROXYDICARBONATE
2155	48	2,5-DIMETHYL-2,5-DI(tert-BUTYL-PEROXY)HEXANE, technical pure
2156	48	2,5-DIMETHYL-2,5-DI (tert-BUTYL-PEROXY) HEXANE
2157	52	2,5-DIMETHYL-2,5-DI(2-ETHYL-HEXANOYLPEROXY) HEXANE, technical pure
2158	49	2,5-DIMETHYL-2,5-DI(tert-BUTYL-PEROXY) HEXYNE-3, technical pure
..2159.	48	2,5-DIMETHYL-2,5-DI(tert-BUTYL-PEROXY) HEXYNE-3, with not more than 52% peroxide in inert solid

ID No	Guide No	Name of Material
2160	48	1,1,3,3-TETRAMETHYLBUTYL-HYDROPEROXIDE, technical pure
2161	52	1,1,3,3-TETRAMETHYLBUTYLPEROXY-2-ETHYL HEXANOATE, technical pure
2162	51	PINANE HYDROPEROXIDE, technical pure
2163	52	DIACETONE ALCOHOL PEROXIDE
2164	52	DICETYL PEROXYDICARBONATE, technical pure
2165	49	3,3,6,6,9,9-HEXAMETHYL-1,2,4,5-TETRA-OXOCYCLONONANE, technical pure
2166	48	3,3,6,6,9,9-HEXAMETHYL-1,2,4,5-TETRA-OXOCYCLONONANE
2167	48	3,3,6,6,9,9-HEXAMETHYL-1,2,4,5-TETRA-OXOCYCLONONANE
2168	48	2,2-DI (4,4-DI-tert-BUTYLPEROXY-CYCLOHEXYL) PROPANE
2169	52	BUTYL PEROXYDICARBONATE
2170	52	BUTYL PEROXYDICARBONATE
2171	48	DIISOPROPYLBENZENE HYDROPEROXIDE
2172	49	2,5-DIMETHYL-2,5-DI (BENZOYL-PEROXY) HEXANE, technical pure
2173	49	2,5-DIMETHYL-2,5-DI-(BENZOYL-PEROXY) HEXANE
2174	49	2,5-DIMETHYL-2,5-DIHYDROPEROXY-HEXANE
2175	52	DIETHYLPEROXYDICARBONATE
2176	52	DI-n-PROPYL PEROXYDICARBONATE, technical pure
2177	52	tert- BUTYLPEROXYNEODECANOATE
2178	49	2,2-DIHYDROPEROXY PROPANE
2179	49	1,1-DI (tert-BUTYLPEROXY) CYCLOHEXANE
2180	49	1,1-DI(tert-BUTYLPEROXY) CYCLOHEXANE

ID No	Guide No	Name of Material
2181	48	1,2-DI (tert-BUTYLPEROXY) CYCLOHEXANE
2182	52	DIISOBUTYRYL PEROXIDE
2183	48	tert-BUTYL PEROXYCROTONATE
2184	49	ETHYL 3,3-DI (tert-BUTYL-PEROXY) BUTYRATE
2185	48	ETHYL 3,3-DI(tert-BUTYLPEROXY) BUTYRATE, not more than 77%
2186	**15**	**HYDROGEN CHLORIDE refrigerated liquid (cryogenic liquid)**
2187	21	CARBON DIOXIDE, refrigerated liquid (cryogenic liquid)
2188	**18**	**ARSINE**
2189	**19**	**DICHLOROSILANE**
2190	**20**	**OXYGEN DIFLUORIDE**
2191	**15**	**SULFURYL FLUORIDE**
2192	**18**	**GERMANE (germanium hydride)**
2193	**12**	**HEXAFLUOROETHANE**
2194	**15**	**SELENIUM HEXAFLUORIDE**
2195	**15**	**TELLURIUM HEXAFLUORIDE**
2196	**15**	**TUNGSTEN HEXAFLUORIDE**
2197	**15**	**HYDROGEN IODIDE, anhydrous**
2198	**15**	**PHOSPHORUS PENTAFLUORIDE**
2199	**18**	**PHOSPHINE**
2200	22	PROPADIENE
2200	22	PROPADIENE, inhibited
2201	23	NITROUS OXIDE, refrigerated liquid (cryogenic liquid)
2202	**13**	**HYDROGEN SELENIDE, anhydrous**
2203	17	SILANE
2204	**18**	**CARBONYL SULFIDE**
2205	55	ADIPONITRILE
2206	55	ISOCYANATE SOLUTION, toxic, n.o.s.

ID No	Guide No	Name of Material
2206	55	ISOCYANATES and solutions, n.o.s., b.p. less than 300° C
2206	55	ISOCYANATES, toxic, n.o.s.
2207	55	ISOCYANATES and solutions n.o.s., b.p. not less than 300° C
2208	35	BLEACHING POWDER
2208	35	CALCIUM HYPOCHLORITE MIXTURE, dry, with more than 10% but not more than 39% available chlorine
2209	29	FORMALDEHYDE SOLUTIONS (Formalin)
2210	37	MANEB, or MANEB PREPARATION(S) with 50% or more MANEB
2210	37	PESTICIDE, water reactive containing manganese ethylenebisdithiocarbamate (maneb)
2211	32	PLASTIC MOULDING MATERIAL, evolving flammable vapor
2211	32	POLYMERIC BEADS, expandable, evolving flammable vapor
2211	32	POLYSTYRENE BEADS, expandable, evolving a flammable vapor
2212	31	ASBESTOS
2212	31	ASBESTOS, blue or brown
2212	31	BLUE ASBESTOS
2212	31	BROWN ASBESTOS
2213	32	PARAFORMALDEHYDE
2214	60	PHTHALIC ANHYDRIDE
2215	60	MALEIC ACID
2215	60	MALEIC ANHYDRIDE
2216	31	FISH MEAL or SCRAP, stabilized
2217	73	SEED CAKE, with not more than 1.5% oil and not more than 11% moisture
2218	29	ACRYLIC ACID, inhibited
2219	29	ALLYL GLYCIDYL ETHER
2222	26	ANISOLE

ID No	Guide No	Name of Material
2224	55	BENZONITRILE
2225	59	BENZENE SULFONYL CHLORIDE
2226	60	BENZOTRICHLORIDE
2227	26	n-BUTYL METHACRYLATE
2228	55	BUTYL PHENOLS, liquid
2229	53	BUTYL PHENOLS, solid
2232	**55**	**CHLOROACETALDEHYDE**
2232	**55**	**2-CHLOROETHANAL**
2233	53	CHLOROANISIDINES
2234	27	CHLOROBENZOTRIFLUORIDES
2235	55	CHLOROBENZYLCHLORIDES
2236	55	3-CHLORO-4-METHYLPHENYL-ISOCYANATE
2237	53	CHLORONITROANILINES
2238	27	CHLOROTOLUENES
2239	55	CHLOROTOLUIDINES, liquid or solid
2240	39	CHROMOSULFURIC ACID
2241	27	CYCLOHEPTANE
2242	27	CYCLOHEPTENE
2243	27	CYCLOHEXYL ACETATE
2244	26	CYCLOPENTANOL
2245	26	CYCLOPENTANONE
2246	27	CYCLOPENTENE
2247	27	n-DECANE
2248	68	DI-n-BUTYLAMINE
2249	55	DICHLORODIMETHYL ETHER, symmetrical
2250	53	DICHLOROPHENYL ISOCYANATES
2251	26	DICYCLOHEPTADIENE
2251	26	2,5-NORBORNADIENE
2252	27	1,2-DIMETHOXYETHANE

ID No	Guide No	Name of Material
2253	57	N,N-DIMETHYLANILINE
2254	32	MATCHES, fusee
2255	48	ORGANIC PEROXIDE, sample n.o.s.
2255	48	POLYESTER RESIN KITS
2256	29	CYCLOHEXENE
2257	40	POTASSIUM
2257	40	POTASSIUM METAL
2258	29	1,2-PROPYLENEDIAMINE
2259	60	TRIETHYLENE TETRAMINE
2260	68	TRIPROPYLAMINE
2261	55	XYLENOLS
2262	60	DIMETHYLCARBAMOYL CHLORIDE
2263	27	DIMETHYLCYCLOHEXANES
2264	60	DIMETHYLCYCLOHEXYLAMINE
2265	26	N,N-DIMETHYLFORMAMIDE
2266	29	DIMETHYL-N-PROPYLAMINE
2267	59	DIMETHYL CHLOROTHIOPHOSPHATE
2267	59	DIMETHYL PHOSPHOROCHLORIDO-THIOATE
2267	59	DIMETHYLTHIOPHOSPHORYL CHLORIDE
2269	60	IMINOBISPROPYLAMINE
2269	60	3,3'-IMINODIPROPYLAMINE
2270	29	ETHYLAMINE, aqueous solution with not less than 50^% but not more than 70% ethylamine
2271	26	ETHYL AMYL KETONE
2272	55	N-ETHYLANILINE
2273	55	2-ETHYLANILINE
2274	53	N-ETHYL-N-BENZYLANILINE
2275	26	2-ETHYLBUTANOL
2276	29	2-ETHYL HEXYLAMINE
2277	26	ETHYL METHACRYLATE

ID No	Guide No	Name of Material
2278	27	n-HEPTENE
2279	55	HEXACHLOROBUTADIENE
2280	60	HEXAMETHYLENEDIAMINE, solid
2281	53	HEXAMETHYLENE DIISOCYANATE
2282	26	HEXANOLS
2283	27	ISOBUTYL METHACRYLATE
2284	28	ISOBUTYRONITRILE
2285	55	ISOCYANATOBENZOTRIFLUORIDES
2286	27	PENTAMETHYLHEPTANE
2287	27	ISOHEPTENES
2288	27	ISOHEXENES
2289	60	ISOPHORONEDIAMINE
2290	53	IPDI
2290	53	ISOPHORONE DIISOCYANATE
2291	53	LEAD CHLORIDE
2291	53	LEAD COMPOUNDS, soluble n.o.s.
2291	53	LEAD FLUOBORATE
2293	27	1-METHOXY-4-METHYL-PENTAN-2-ONE
2294	57	N-METHYLANILINE
2295	57	METHYL CHLOROACETATE
2296	27	METHYL CYCLOHEXANE
2297	26	METHYL CYCLOHEXANONE
2298	26	METHYL CYCLOPENTANE
2299	60	METHYL DICHLOROACETATE
2300	60	2-METHYL-5-ETHYLPYRIDINE
2301	26	2-METHYLFURAN
2302	26	5-METHYLHEXAN-2-ONE
2303	27	ISOPROPENYLBENZENE
2304	32	NAPHTHALENE, molten
2305	60	NITROBENZENESULFONIC ACID
2306	54	NITROBENZOTRIFLUORIDES

ID No	Guide No	Name of Material
2307	54	3-NITRO-4-CHLOROBENZOTRIFLUORIDE
2308	60	NITROSYLSULFURIC ACID
2309	27	OCTADIENE
2310	26	PENTAN-2,4-DIONE
2311	55	PHENETIDINES
2312	55	PHENOL, molten
2313	27	PICOLINES
2315	31	PCBs
2315	31	POLYCHLORINATED BIPHENYLS
2316	53	SODIUM CUPROCYANIDE, solid
2317	54	SODIUM CUPROCYANIDE SOLUTION
2318	34	SODIUM HYDROSULFIDE, solid with less than 25% water of crystallization
2319	27	TERPENE HYDROCARBONS, n.o.s.
2320	60	TETRAETHYLENEPENTAMINE
2321	54	TRICHLOROBENZENES, liquid
2322	54	TRICHLOROBUTENE
2323	26	TRIETHYL PHOSPHITE
2324	27	TRIISOBUTYLENE
2325	26	1,3,5-TRIMETHYLBENZENE
2326	29	TRIMETHYLCYCLOHEXYLAMINE
2327	60	TRIMETHYLHEXAMETHYLENE-DIAMINES
2328	53	TRIMETHYLHEXAMETHYLENE DIISOCYANATE
2329	26	TRIMETHYL PHOSPHITE
2330	27	UNDECANE
2331	60	ZINC CHLORIDE, anhydrous
2332	26	ACETALDEHYDE OXIME
2333	28	ALLYL ACETATE
2334	**28**	**ALLYLAMINE**
2335	28	ALLYL ETHYL ETHER

ID No	Guide No	Name of Material
2336	28	ALLYL FORMATE
2337	**57**	**PHENYL MERCAPTAN**
2338	28	BENZOTRIFLUORIDE
2339	27	2-BROMOBUTANE
2340	27	2-BROMOETHYL ETHYL ETHER
2341	27	1-BROMO-3-METHYLBUTANE
2342	27	BROMOMETHYLPROPANES
2343	27	2-BROMOPENTANE
2344	29	2-BROMOPROPANE
2345	29	3-BROMOPROPYNE
2346	26	BUTANEDIONE
2346	26	DIACETYL
2347	27	BUTYL MERCAPTANS
2348	26	BUTYL ACRYLATE
2350	26	BUTYL METHYL ETHER
2351	26	BUTYL NITRITES
2352	26	BUTYL VINYL ETHER, inhibited
2353	29	BUTYRYL CHLORIDE
2354	28	CHLOROMETHYL ETHYL ETHER
2356	26	2-CHLOROPROPANE
2357	68	CYCLOHEXYLAMINE
2358	27	CYCLOOCTATETRAENE
2359	29	DIALLYLAMINE
2360	28	DIALLYL ETHER
2361	68	DIISOBUTYLAMINE
2362	27	1,1-DICHLOROETHANE
2363	27	ETHYL MERCAPTAN
2364	26	n-PROPYLBENZENE
2366	26	DIETHYL CARBONATE
2367	27	METHYLVALERALDEHYDE (alpha)
2368	26	PINENE (alpha)

ID No	Guide No	Name of Material
2369	26	ETHYLENE GLYCOL MONOBUTYL ETHER
2370	27	1-HEXENE
2371	27	ISOPENTENES
2372	26	1,2-DI-(DIMETHYLAMINO)ETHANE
2373	26	DIETHOXYMETHANE
2374	26	DIETHOXYPROPENE
2375	28	DIETHYL SULFIDE
2376	26	2,3-DIHYDROPYRAN
2377	27	1,1-DIMETHOXYETHANE
2378	28	2-DIMETHYLAMINOACETONITRILE
2379	68	1,3-DIMETHYLBUTYLAMINE
2380	26	DIMETHYLDIETHOXYSILANE
2381	27	DIMETHYL DISULFIDE
2382	**57**	**DIMETHYLHYDRAZINE, symmetrical**
2383	68	DIPROPYLAMINE
2384	26	DIPROPYL ETHER
2385	26	ETHYL ISOBUTYRATE
2386	68	ETHYL PIPERIDINE
2386	68	1-ETHYLPIPERIDINE
2387	27	FLUOROBENZENE
2388	27	FLUOROTOLUENES
2389	26	FURAN
2390	26	2-IODOBUTANE
2391	26	IODOMETHYLPROPANES
2392	26	IODOPROPANES
2393	29	ISOBUTYL FORMATE
2394	26	ISOBUTYL PROPIONATE
2395	29	ISOBUTYRYL CHLORIDE
2396	28	METHACRYLALDEHYDE
2397	26	3-METHYL-2-BUTANONE

ID No	Guide No	Name of Material
2398	26	METHYL tert-BUTYL ETHER
2399	68	METHYLPIPERIDINE
2399	68	1-METHYLPIPERIDINE
2400	27	METHYL ISOVALERATE
2401	29	PIPERIDINE
2402	27	ISOPROPYL MERCAPTAN
2402	27	PROPANETHIOLS
2402	27	PROPYL MERCAPTAN
2403	26	ISOPROPENYL ACETATE
2404	28	PROPIONITRILE
2405	26	ISOPROPYL BUTYRATE
2406	28	ISOPROPYL ISOBUTYRATE
2407	**57**	**ISOPROPYL CHLOROFORMATE**
2408	27	ISOPROPYL FORMATE
2409	27	ISOPROPYL PROPIONATE
2410	26	1,2,3,6-TETRAHYDROPYRIDINE
2411	28	BUTYRONITRILE
2412	26	TETRAHYDROTHIOPHENE
2413	27	TETRAPROPYL-ortho-TITANATE
2414	27	THIOPHENE
2416	26	TRIMETHYL BORATE
2417	**15**	**CARBONYL FLUORIDE**
2418	**15**	**SULFUR TETRAFLUORIDE**
2419	17	BROMOTRIFLUOROETHYLENE
2420	**15**	**HEXAFLUOROACETONE**
2421	**20**	**NITROGEN TRIOXIDE**
2422	12	OCTAFLUOROBUT-2-ENE
2424	12	OCTAFLUOROPROPANE
2426	35	AMMONIUM NITRATE, LIQUID (hot concentrated solution)

ID No	Guide No	Name of Material
2426	35	AMMONIUM NITRATE SOLUTION, with not less than 15% water
2427	31	POTASSIUM CHLORATE, aqueous solution
2428	31	SODIUM CHLORATE, aqueous solution
2429	35	CALCIUM CHLORATE, aqueous solution
2430	55	ALKYLPHENOLS, solid, n.o.s.
2431	55	ANISIDINES
2432	57	N,N-DIETHYL ANILINE
2433	53	CHLORONITROTOLUENES
2434	60	DIBENZYLDICHLOROSILANE
2435	39	ETHYL PHENYL DICHLOROSILANE
2436	26	THIOACETIC ACID
2437	29	METHYLPHENYLDICHLOROSILANE
2438	**29**	**TRIMETHYLACETYL CHLORIDE**
2439	60	SODIUM BIFLUORIDE, solid
2439	60	SODIUM BIFLUORIDE SOLUTION
2439	60	SODIUM HYDROGEN FLUORIDE
2439	60	SODIUM HYDROGENDIFLUORIDE
2440	60	STANNIC CHLORIDE, hydrated
2441	37	TITANIUM TRICHLORIDE, pyrophoric
2441	37	TITANIUM TRICHLORIDE MIXTURES, pyrophoric
2442	**59**	**TRICHLOROACETYL CHLORIDE**
2443	39	VANADIUM OXYTRICHLORIDE
2443	39	VANADIUM OXYTRICHLORIDE and TITANIUM TETRACHLORIDE MIXTURE
2444	39	VANADIUM TETRACHLORIDE
2445	40	LITHIUM ALKYLS
2446	55	NITROCRESOLS
2447	38	PHOSPHORUS, white, molten
2448	32	SULFUR, molten
2449	54	AMMONIUM OXALATE

ID No	Guide No	Name of Material
2449	54	OXALATES, water soluble
2451	15	NITROGEN TRIFLUORIDE
2452	17	ETHYL ACETYLENE, inhibited
2453	12	ETHYL FLUORIDE
2454	22	METHYL FLUORIDE
2455	17	METHYL NITRITE
2456	27	2-CHLOROPROPENE
2457	27	2,3-DIMETHYLBUTANE
2458	29	HEXADIENES
2459	26	2-METHYL-1-BUTENE
2460	26	METHYLBUTENE
2460	26	2-METHYL-2-BUTENE
2461	26	METHYLPENTADIENES
2462	26	METHYLPENTANE
2463	40	ALUMINUM HYDRIDE
2464	42	BERYLLIUM NITRATE
2465	45	DICHLOROISOCYANURIC ACID, and its salts, dry
2465	45	DICHLORO-S-TRIAZINETRIONE and its salts, dry
2465	45	POTASSIUM DICHLORO-S-TRIAZINE-TRIONE
2465	45	SODIUM DICHLOROISOCYANURATE
2465	45	SODIUM DICHLORO-S-TRIAZINETRIONE
2466	47	POTASSIUM SUPEROXIDE
2467	35	SODIUM PERCARBONATE
2468	45	MONO-(TRICHLORO)-TETRA (MONO-POTASSIUM DICHLORO)-PENTA-S-TRIAZINETRIONE, dry
2468	45	TRICHLOROISOCYANURIC ACID, dry
2468	45	TRICHLORO-S-TRIAZINETRIONE, dry
2469	35	ZINC BROMATE

ID No	Guide No	Name of Material
2470	55	PHENYLACETONITRILE, liquid
2471	55	OSMIUM TETROXIDE
2473	53	SODIUM ARSANILATE
2474	**55**	**THIOPHOSGENE**
2475	60	VANADIUM TRICHLORIDE
2477	**28**	**METHYL ISOTHIOCYANATE**
2478	28	ISOCYANATE SOLUTION, flammable, toxic, n.o.s.
2478	28	ISOCYANATES and solutions, n.o.s. (flammable)
2478	28	ISOCYANATES, flammable toxic, n.o.s.
2480	**30**	**METHYL ISOCYANATE**
2481	**28**	**ETHYL ISOCYANATE**
2482	**28**	**n-PROPYL ISOCYANATE**
2483	**28**	**ISOPROPYL ISOCYANATE**
2484	**57**	**tert-BUTYL ISOCYANATE**
2485	**57**	**n-BUTYL ISOCYANATE**
2486	**57**	**ISOBUTYL ISOCYANATE**
2487	**55**	**PHENYL ISOCYANATE**
2488	**57**	**CYCLOHEXYL ISOCYANATE**
2489	54	DIPHENYLMETHANE-4,4'-DIISO-CYANATE (MDI)
2489	54	METHYLENE BIS(4-PHENYLISO-CYANATE) (MDI)
2490	59	DICHLOROISOPROPYL ETHER
2491	60	ETHANOLAMINE, and solutions
2491	60	MONOETHANOLAMINE
2493	29	HEXAMETHYLENEIMINE
2495	44	IODINE PENTAFLUORIDE
2496	29	PROPIONIC ANHYDRIDE
2497	60	SODIUM PHENOLATE, solid
2498	29	1,2,3,6-TETRAHYDROBENZALDEHYDE

ID No	Guide No	Name of Material
2501	55	1-AZIRIDINYL PHOSPHINE OXIDE (TRIS)
2501	55	PHOSPHORIC ACID TRIETHYLENEIMINE
2501	55	TRI (1-AZIRIDINYL) PHOSPHINE OXIDE
2501	55	TRIS(I-AZIRIDINYL)-PHOSPHINE OXIDE
2502	29	VALERYL CHLORIDE
2503	39	ZIRCONIUM TETRACHLORIDE
2504	58	ACETYLENE TETRABROMIDE
2504	58	TETRABROMOETHANE
2505	54	AMMONIUM FLUORIDE
2506	60	AMMONIUM HYDROGEN SULFATE
2507	60	CHLOROPLATINIC ACID, solid
2508	60	MOLYBDENUM PENTACHLORIDE
2509	60	POTASSIUM BISULFATE
2509	60	POTASSIUM HYDROGEN SULFATE
2511	60	alpha-CHLOROPROPIONIC ACID
2511	60	2-CHLOROPROPIONIC ACID
2512	55	AMINOPHENOLS (o-, m-, p-)
2513	60	BROMOACETYL BROMIDE
2514	26	BROMOBENZENE
2515	58	BROMOFORM
2516	53	CARBON TETRABROMIDE
2517	22	1-CHLORO-1,1-DIFLUOROETHANE
2517	22	CHLORODIFLUOROETHANES
2517	22	DIFLUOROCHLOROETHANES
2518	59	1,5,9-CYCLODODECATRIENE
2520	27	CYCLOOCTADIENES
2521	**57**	**DIKETENE**
2522	55	DIMETHYLAMINOETHYL METHACRYLATE
2524	26	ETHYL ORTHOFORMATE
2525	54	ETHYL OXALATE

ID No	Guide No	Name of Material
2526	28	FURFURYLAMINE
2527	27	ISOBUTYL ACRYLATE
2528	26	ISOBUTYL ISOBUTYRATE
2529	29	ISOBUTYRIC ACID
2530	29	ISOBUTYRIC ANHYDRIDE
2531	60	METHACRYLIC ACID, inhibited
2533	53	METHYL TRICHLOROACETATE
2534	**18**	**METHYLCHLOROSILANE**
2535	29	METHYLMORPHOLINE
2536	26	METHYLTETRAHYDROFURAN
2538	32	NITRONAPHTHALENE
2541	27	TERPINOLENE
2542	68	TRIBUTYLAMINE
2545	40	HAFNIUM powder, dry
2546	37	TITANIUM, metal, powder, dry
2546	37	TITANIUM POWDER, dry
2547	47	SODIUM SUPEROXIDE
2548	**44**	**CHLORINE PENTAFLUORIDE**
2550	51	ETHYL METHYL KETONE PEROXIDE
2550	51	METHYL ETHYL KETONE PEROXIDE
2551	48	tert-BUTYLPEROXYDIETHYLACETATE with tert-BUTYLPEROXYBENZOATE
2552	55	HEXAFLUOROACETONE HYDRATE
2553	27	COAL TAR NAPHTHA
2553	27	NAPHTHA
2554	26	METHYL ALLYL CHLORIDE
2555	33	NITROCELLULOSE, wet with not less than 20% water
2556	33	NITROCELLULOSE, wet with not less than 25% alcohol
2557	32	LACQUER BASE, dry

ID No	Guide No	Name of Material
2557	32	NITROCELLULOSE with not more than 12.6% nitrogen, by dry mass, mixture, with or without plasticizer or with pigment
2557	32	NITROCELLULOSE, with plasticizing substance
2558	57	EPIBROMOHYDRIN
2560	26	2-METHYLPENTAN-2-OL
2561	26	3-METHYL-1-BUTENE
2562	52	tert -BUTYL PEROXYISOBUTYRATE
2564	59	TRICHLOROACETIC ACID SOLUTION
2565	60	DICYCLOHEXYLAMINE
2567	53	SODIUM PENTACHLOROPHENATE
2570	53	CADMIUM COMPOUNDS
2571	60	ALKYLSULFURIC ACIDS
2571	60	ETHYLSULFURIC ACID
2572	53	PHENYLHYDRAZINE
2573	42	THALLIUM CHLORATE
2574	55	TRICRESYLPHOSPHATE
2576	39	PHOSPHORUS OXYBROMIDE, molten
2577	60	PHENYLACETYL CHLORIDE
2578	60	PHOSPHORUS TRIOXIDE
2579	60	PIPERAZINE
2580	60	ALUMINUM BROMIDE, SOLUTION
2581	60	ALUMINUM CHLORIDE, SOLUTION
2582	60	FERRIC CHLORIDE SOLUTION
2582	60	IRON CHLORIDE SOLUTION
2583	60	ALKYLSULFONIC ACIDS, solid with more than 5% free sulfuric acid
2583	60	ARYLSULFONIC ACIDS, solid with more than 5% free sulfuric acid
2583	60	TOLUENE SULFONIC ACID, solid with more than 5% free sulfuric acid

ID No	Guide No	Name of Material
2584	60	ALKYLSULFONIC ACIDS, liquid with more than 5% free sulfuric acid
2584	60	ARYLSULFONIC ACIDS, liquid with more than 5% free sulfuric acid
2584	60	DODECYLBENZENESULFONIC ACID
2584	60	TOLUENE SULFONIC ACID, liquid with more than 5% free sulfuric acid
2585	60	ALKYLSULFONIC ACIDS, solid with not more than 5% free sulfuric acid
2585	60	ARYLSULFONIC ACIDS, solid with not more than 5% free sulfuric acid
2585	60	TOLUENE SULFONIC ACID, solid with not more than 5% free sulfuric acid
2586	60	ALKYLSULFONIC ACIDS, liquid with not more than 5% free sulfuric acid
2586	60	ARYLSULFONIC ACIDS, liquid with not more than 5% free sulfuric acid
2586	60	TOLUENE SULFONIC ACID, liquid with not more than 5 % free sulfuric acid
2587	55	BENZOQUINONE
2588	55	INSECTICIDE, dry, n.o.s.
2588	55	PESTICIDES, solid, toxic n.o.s.
2589	57	VINYL CHLOROACETATE
2590	31	ASBESTOS, white
2590	31	WHITE ASBESTOS
2591	21	XENON, refrigerated liquid (cryogenic liquid)
2592	48	DISTEARYL PEROXYDICARBONATE
2593	52	DI (2-METHYLBENZOYL) PEROXIDE
2594	52	tert-BUTYLPEROXYNEODECANOATE
2595	52	DIMYRISTYL PEROXYDICARBONATE
2596	48	tert-BUTYL PEROXY-3-PHENYLPHTHALIDE
2597	52	DI(3,5,5-TRIMETHYL-1,2-DIOXOL-ANYL-3) PEROXIDE

ID No	Guide No	Name of Material
2598	48	ETHYL 3,3-DI(tert-BUTYLPEROXY) BUTYRATE
2599	12	CHLOROTRIFLUOROMETHANE and TRIFLUOROMETHANE MIXTURE
2599	12	TRIFLUOROMETHANE and CHLOROTRIFLUOROMETHANE MIXTURE
2600	**18**	**CARBON MONOXIDE and HYDROGEN MIXTURE**
2601	22	CYCLOBUTANE
2602	12	DICHLORODIFLUOROMETHANE and DIFLUOROETHANE AZEOTROPIC MIXTURE
2603	28	CYCLOHEPTATRIENE
2604	29	BORON TRIFLUORIDE DIETHYL ETHERATE
2605	**57**	**METHOXYMETHYL ISOCYANATE**
2606	**57**	**METHYL ORTHOSILICATE**
2607	26	ACROLEIN DIMER, stabilized
2608	26	NITROPROPANES
2609	55	TRIALLYL BORATE
2610	29	TRIALLYL AMINE
2611	57	PROPYLENE CHLOROHYDRIN
2612	26	METHYL PROPYL ETHER
2614	26	METHALLYL ALCOHOL
2615	26	ETHYL PROPYL ETHER
2616	26	TRIISOPROPYL BORATE
2617	26	METHYL CYCLOHEXANOL
2617	26	METHYLCYCLOHEXANOLS, flammable
2618	27	VINYL TOLUENE, inhibited
2619	68	BENZYLDIMETHYLAMINE
2620	27	AMYL BUTYRATES
2621	26	ACETYL METHYL CARBINOL

ID No	Guide No	Name of Material
2622	28	GLYCIDALDEHYDE
2623	32	FIRE LIGHTERS, solid with flammable liquid
2624	40	MAGNESIUM SILICIDE
2626	35	CHLORIC ACID, aqueous solution
2627	35	NITRITES, inorganic, n.o.s.
2628	53	POTASSIUM FLUOROACETATE
2629	53	SODIUM FLUOROACETATE
2630	53	SELENATES and SELENITES
2630	53	SODIUM SELENITE
2642	59	FLUOROACETIC ACID
2643	58	METHYL BROMOACETATE
2644	**55**	**METHYL IODIDE**
2645	55	PHENACYL BROMIDE
2646	**55**	**HEXACHLOROCYCLOPENTADIENE**
2647	53	MALONONITRILE
2648	55	1,2-DIBROMOBUTAN-3-ONE
2649	55	1,3-DICHLOROACETONE
2650	57	1,1-DICHLORO-1-NITROETHANE
2651	53	4,4'-DIAMINODIPHENYL METHANE
2653	53	BENZYL IODIDE
2655	53	POTASSIUM FLUOROSILICATE, solid
2656	29	QUINOLINE
2657	55	SELENIUM DISULFIDE
2658	53	SELENIUM, powder
2659	53	SODIUM CHLOROACETATE
2660	55	NITROTOLUIDINES (mono)
2661	54	HEXACHLOROACETONE
2662	53	HYDROQUINONE
2664	74	DIBROMOMETHANE
2666	55	ETHYL CYANOACETATE
2667	27	BUTYLTOLUENES

ID No	Guide No	Name of Material
2668	**57**	**CHLOROACETONITRILE**
2669	55	CHLOROCRESOLS
2670	60	CYANURIC CHLORIDE
2671	55	AMINOPYRIDINES (o-, m-, p-)
2672	60	AMMONIA SOLUTIONS with more than 10% but not more than 35 % ammonia
2672	60	AMMONIUM HYDROXIDE
2673	53	2-AMINO-4-CHLOROPHENOL
2674	53	SODIUM FLUOROSILICATE
2676	**18**	**STIBINE**
2677	60	RUBIDIUM HYDROXIDE SOLUTION
2678	60	RUBIDIUM HYDROXIDE, solid
2679	60	LITHIUM HYDROXIDE SOLUTION
2680	60	LITHIUM HYDROXIDE, solid
2680	60	LITHIUM HYDROXIDE MONOHYDRATE
2681	60	CAESIUM HYDROXIDE SOLUTION
2681	60	CESIUM HYDROXIDE SOLUTION
2682	60	CAESIUM HYDROXIDE
2682	60	CESIUM HYDROXIDE
2683	28	AMMONIUM HYDROSULFIDE SOLUTION
2683	28	AMMONIUM SULFIDE SOLUTION
2684	29	DIETHYLAMINOPROPYLAMINE
2685	29	N,N-DIETHYLETHYLENEDIAMINE
2686	29	DIETHYLAMINOETHANOL
2687	53	DICYCLOHEXYLAMMONIUM NITRITE
2688	58	1-CHLORO-3-BROMOPROPANE
2689	55	GLYCEROL-alpha-MONOCHLOROHYDRIN
2690	55	N-n-BUTYL IMIDAZOLE
2691	39	PHOSPHORUS PENTABROMIDE
2692	**59**	**BORON TRIBROMIDE**
2693	60	AMMONIUM BISULFITE, solid

ID No	Guide No	Name of Material
2693	60	AMMONIUM BISULFITE SOLUTION
2693	60	BISULFITES, aqueous solution, n.o.s.
2693	60	BISULFITES, inorganic, aqueous solution, n.o.s.
2693	60	CALCIUM BISULFITE SOLUTION
2693	60	CALCIUM HYDROGEN SULFITE SOLUTION
2693	60	POTASSIUM BISULFITE SOLUTION
2693	60	SODIUM BISULFITE SOLUTION
2698	60	TETRAHYDROPHTHALIC ANHYDRIDES
2699	60	TRIFLUOROACETIC ACID
2705	60	1-PENTOL
2707	27	DIMETHYLDIOXANES
2708	26	BUTOXYL
2709	27	BUTYL BENZENES
2710	26	DIPROPYL KETONE
2711	26	DIBROMOBENZENE
2713	32	ACRIDINE
2714	32	ZINC RESINATE
2715	32	ALUMINUM RESINATE
2716	55	1,4-BUTYNEDIOL
2717	32	CAMPHOR
2717	32	CAMPHOR, synthetic
2719	42	BARIUM BROMATE
2720	35	CHROMIUM NITRATE
2721	35	COPPER CHLORATE
2722	35	LITHIUM NITRATE
2723	35	MAGNESIUM CHLORATE
2724	35	MANGANESE NITRATE
2725	35	NICKEL NITRATE
2726	35	NICKEL NITRITE
2727	42	THALLIUM NITRATE

ID No	Guide No	Name of Material
2728	35	ZIRCONIUM NITRATE
2729	53	HEXACHLOROBENZENE
2730	55	NITROANISOLE
2732	55	NITROBROMOBENZENES
2733	29	ALKYLAMINES, n.o.s.
2733	29	AMINES, flammable, corrosive n.o.s.
2733	29	POLYALKYLAMINES, flammable, corrosive, n.o.s.
2733	29	POLYALKYLAMINES, n.o.s.
2733	29	POLYAMINES, flammable, corrosive, n.o.s.
2734	29	ALKYLAMINES, n.o.s.
2734	29	AMINES, liquid, corrosive, flammable, n.o.s.
2734	29	POLYALKYLAMINES, corrosive, flammable, n.o.s.
2734	29	POLYAMINES, liquid, corrosive, flammable, n.o.s.
2735	60	ALKYLAMINES, n.o.s.
2735	60	AMINES, liquid, corrosive, n.o.s.
2735	60	POLYALKYLAMINES, corrosive, n.o.s.
2735	60	POLYALKYLAMINES, n.o.s.
2735	60	POLYAMINES, liquid, corrosive, n.o.s.
2738	55	N-BUTYLANILINE
2739	60	BUTYRIC ANHYDRIDE
2740	**57**	**n-PROPYL CHLOROFORMATE**
2741	45	BARIUM HYPOCHLORITE
2742	**57**	**sec-BUTYL CHLOROFORMATE**
2742	57	CHLOROFORMATES, n.o.s.
2742	57	CHLOROFORMATES, toxic, corrosive, flammable, n.o.s.
2742	**57**	**ISOBUTYL CHLOROFORMATE**
2743	**57**	**n-BUTYL CHLOROFORMATE**
2744	57	CYCLOBUTYLCHLOROFORMATE

ID No	Guide No	Name of Material
2745	55	CHLOROMETHYL CHLORO-FORMATE
2746	55	PHENYL CHLOROFORMATE
2747	55	tert -BUTYLCYCLOHEXYL CHLOROFORMATE
2748	55	2-ETHYLHEXYL CHLOROFORMATE
2749	29	TETRAMETHYLSILANE
2750	55	L3-DICHLOROPROPANOL-2
2751	59	DIETHYLTHIOPHOSPHORYL CHLORIDE
2752	26	L2-EPOXY-3-ETHOXYPROPANE
2753	53	N-ETHYLBENZYLTOLUIDINES
2754	55	N-ETHYLTOLUIDINES
2755	49	3-CHLOROPEROXYBENZOIC ACID
2756	52	ORGANIC PEROXIDE MIXTURE
2757	55	CARBAMATE PESTICIDES, solid, toxic, n.o.s.
2757	55	CARBARYL
2757	55	CARBOFURAN
2757	55	MEXACARBATE
2758	28	CARBAMATE PESTICIDES, liquid, flammable, toxic, n.o.s.
2759	55	ARSENICAL PESTICIDES, solid, toxic, n.o.s.
2759	55	BORDEAUX ARSENITE, liquid or solid
2760	28	ARSENICAL PESTICIDES, liquid, flammable, toxic, n.o.s.
2761	55	ALDRIN and its mixtures
2761	55	DDT
2761	55	DICHLORODIPHENYL TRICHLOROETHANE, DDT
2761	55	DIELDRIN
2761	55	ENDOSULFAN
2761	55	ENDRIN MIXTURE, dry or liquid
2761	55	LINDANE

ID No	Guide No	Name of Material
2761	55	ORGANOCHLORINE PESTICIDES, solid, toxic n.o.s.
2761	55	TDE (1,1-Dichloro-2,2-bis (p-chlorophenyl) ethane)
2761	55	TOXAPHENE
2762	28	CHLORDANE, flammable liquid
2762	28	ORGANOCHLORINE PESTICIDES, liquid, flammable, toxic, n.o.s.
2763	55	TRIAZINE PESTICIDES, solid, toxic, n.o.s.
2764	28	TRIAZINE PESTICIDES, liquid, flammable, toxic, n.o.s.
2765	55	2,4-D
2765	55	2,4-DICHLOROPHENOXYACETIC ACID
2765	55	PHENOXY PESTICIDES, solid, toxic, n.o.s.
2765	55	2,4,5-T
2765	55	2,4,5-TP
2765	55	2,4,5-TRICHLOROPHENOXYACETIC ACID
2765	55	2,4,5-TRICHLOROPHENOXYPROPIONIC ACID
2766	28	PHENOXY PESTICIDES, liquid, flammable, toxic, n.o.s.
2767	55	PHENYL UREA PESTICIDES solid, toxic, n.o.s.
2768	28	PHENYL UREA PESTICIDES, liquid, flammable, toxic n.o.s.
2769	55	BENZOIC DERIVATIVE PESTICIDES, solid, toxic n.o.s.
2770	28	BENZOIC DERIVATIVE PESTICIDES, liquid, flammable, toxic, n.o.s.
2771	55	DITHIOCARBAMATE PESTICIDES, solid, toxic, n.o.s.
2771	55	THIRAM
2772	28	DITHIOCARBAMATE PESTICIDES, liquid, flammable, toxic, n.o.s.

ID No	Guide No	Name of Material
2773	55	PHTHALIMIDE DERIVATIVE PESTICIDES, solid, toxic n.o.s.
2774	28	PHTHALIMIDE DERIVATIVE PESTICIDES, liquid, flammable, toxic, n.o.s.
2775	53	COPPER-BASED PESTICIDES, solid, toxic, n.o.s.
2776	28	COPPER-BASED PESTICIDES, liquid, flammable, toxic, n.o.s.
2777	55	MERCURY-BASED PESTICIDES, solid, toxic, n.o.s.
2778	28	MERCURY-BASED PESTICIDES, liquid, flammable, toxic, n.o.s.
2779	53	SUBSTITUTED NITROPHENOL PESTICIDES, solid, toxic, n.o.s.
2780	28	SUBSTITUTED NITROPHENOL PESTICIDES, liquid, flammable, toxic, n.o.s.
2781	55	BIPYRIDILIUM PESTICIDES, solid, toxic, n.o.s.
2782	28	BIPYRIDILIUM PESTICIDES, liquid, flammable, toxic n.o.s.
2783	55	AZINPHOS METHYL (Guthion)
2783	55	CHLORPYRIFOS
2783	55	COUMAPHOS
2783	55	DIAZINON
2783	55	DICHLORVOS
2783	55	DISULFOTON
2783	55	ETHION
2783	55	GUTHION
2783	55	HEXAETHYL TETRAPHOSPHATE MIXTURE
2783	55	MALATHION
2783	55	METHYL PARATHION, liquid
2783	55	METHYL PARATHION MIXTURE, dry
2783	55	MEVINPHOS

ID No	Guide No	Name of Material
2783	55	ORGANIC PHOSPHATE COMPOUND, and mixtures, liquid
2783	55	ORGANIC PHOSPHATE COMPOUND, and mixtures, solid
2783	55	ORGANOPHOSPHORUS PESTICIDES, solid, toxic, n.o.s.
2783	55	PARATHION MIXTURE, liquid or dry
2783	55	TETRAETHYL PYROPHOSPHATE, solid
2783	55	TRICHLORFON
2784	28	ORGANOPHOSPHORUS PESTICIDES, liquid, flammable toxic, n.o.s.
2785	55	THIA-4-PENTANAL
2785	55	4-THIAPENTANAL
2786	55	ORGANOTIN PESTICIDES, solid, toxic, n.o.s.
2787	28	ORGANOTIN PESTICIDES, liquid, flammable, toxic n.o.s.
2788	55	ORGANOTIN COMPOUNDS, liquid, n.o.s.
2789	29	ACETIC ACID, GLACIAL
2789	29	ACETIC ACID SOLUTION, more than 80% acid
2790	60	ACETIC ACID SOLUTION, more than 10% but not more than 80% acid
2793	32	FERROUS METAL, borings, cuttings, shavings, or turnings
2794	60	BATTERIES, electric storage wet, filled with acid
2794	60	BATTERIES, wet, filled with acid (electric storage)
2795	60	BATTERIES, electric storage, wet, filled with alkali
2795	60	BATTERIES, wet, filled with alkali (electric storage)
2796	39	BATTERY FLUID, acid
2796	39	ELECTROLYTE, BATTERY FLUID acid

ID No	Guide No	Name of Material
2796	39	SULFURIC ACID with not more than 51% acid
2797	60	BATTERY FLUID, alkali
2797	60	BATTERY FLUID, alkali, with battery
2797	60	BATTERY FLUID, alkali, with electronic equipment or actuating device
2798	39	BENZENE PHOSPHORUS DICHLORIDE
2798	39	PHENYL PHOSPHORUS DICHLORIDE
2799	39	BENZENE PHOSPHORUS THIODICHLORIDE
2799	39	PHENYL PHOSPHORUS THIODICHLORIDE
2800	60	BATTERIES, dry, containing POTASSIUM HYDROXIDE solid (electric storage)
2800	60	BATTERIES, electric storage, wet, nonspillable
2800	60	BATTERIES, wet, nonspillable (electric storage)
2801	60	DYE, liquid, corrosive, n.o.s.
2801	60	DYE, liquid, n.o.s. (corrosive)
2801	60	DYE INTERMEDIATE, liquid, corrosive, n.o.s.
2801	60	DYE INTERMEDIATE, liquid n.o.s. (corrosive)
2802	60	COPPER CHLORIDE
2803	60	GALLIUM
2803	60	GALLIUM, metal
2805	40	LITHIUM HYDRIDE, fused, solid
2806	37	LITHIUM NITRIDE
2807	31	MAGNETIZED MATERIAL
2809	60	MERCURY
2809	60	MERCURY METAL
2810	55	COMPOUNDS TREE or WEED KILLING, liquid (poisonous)

ID No	Guide No	Name of Material
2810	55	MEDICINES, poisonous, liquid, n.o.s.
2810	55	POISON B, LIQUID, n.o.s.
2810	55	POISONOUS LIQUIDS, n.o.s.
2810	**55**	**POISONOUS LIQUIDS, n.o.s (Inhalation Hazard Zone A)**
2810	**55**	**POISONOUS LIQUIDS, n.o.s. (Inhalation Hazard Zone B)**
2810	**55**	**TOXIC LIQUID, organic, n.o.s.**
2811	53	FLUE DUST, poisonous
2811	53	LEAD FLUORIDE
2811	53	MEDICINES, poisonous, solid n.o.s.
2811	53	POISON B, SOLID, n.o.s.
2811	53	POISONOUS SOLIDS, n.o.s.
2811	53	SELENIUM OXIDE
2811	53	TOXIC SOLID, organic, n.o.s.
2812	60	SODIUM ALUMINATE, solid
2813	40	LITHIUM ACETYLIDE-ETHYLENEDIAMINE COMPLEX
2813	40	SUBSTANCES, which, when in contact with water, emit flammable gases, solid n.o.s.
2813	40	WATER REACTIVE SOLID, n.o.s.
2814	24	ETIOLOGIC AGENT, n.o.s.
2814	24	INFECTIOUS SUBSTANCES, affecting humans
2815	60	N-AMINOETHYLPIPERAZINE
2817	60	AMMONIUM BIFLUORIDE, solution
2817	60	AMMONIUM HYDROGENDIFLUORIDE SOLUTION
2817	60	AMMONIUM HYDROGEN FLUORIDE SOLUTION
2818	60	AMMONIUM POLYSULFIDE SOLUTION
2819	60	AMYL ACID PHOSPHATE
2820	60	BUTYRIC ACID

ID No	Guide No	Name of Material
2821	55	PHENOL SOLUTIONS
2822	54	2-CHLOROPYRIDINE
2823	60	CROTONIC ACID
2826	**59**	**ETHYL CHLOROTHIOFORMATE**
2829	60	CAPROIC ACID
2830	41	LITHIUM FERROSILICON
2831	74	METHYL CHLOROFORM
2831	74	1,1,1-TRICHLOROETHANE
2834	60	PHOSPHOROUS ACID
2834	60	PHOSPHOROUS ACID, ortho
2835	40	SODIUM ALUMINUM HYDRIDE
2837	60	BISULFATES, aqueous solution
2837	60	SODIUM BISULFATE SOLUTION
2837	60	SODIUM HYDROGEN SULFATE SOLUTION
2838	26	VINYL BUTYRATE, inhibited
2839	55	ALDOL
2840	26	BUTYRALDOXIME
2841	68	DI-N-AMYLAMINE
2842	26	NITROETHANE
2844	40	CALCIUM MANGANESE SILICON
2845	40	ALUMINUM ALKYL
2845	**40**	**ETHYL PHOSPHONOUS DICHLORIDE, anhydrous**
2845	**40**	**METHYL PHOSPHONOUS DICHLORIDE**
2845	40	PYROPHORIC LIQUID, organic n.o.s.
2845	40	PYROPHORIC LIQUIDS, n.o.s.
2846	37	PYROPHORIC SOLID, organic n.o.s.
2846	37	PYROPHORIC SOLIDS, n.o.s.
2849	53	3-CHLOROPROPANOL-1
2850	27	PROPYLENE TETRAMER

ID No	Guide No	Name of Material
2851	59	BORON TRIFLUORIDE DIHYDRATE
2852	33	DIPICRYL SULFIDE, wetted with not less than 10% water
2853	53	MAGNESIUM FLUOROSILICATE
2854	53	AMMONIUM FLUOROSILICATE
2854	53	AMMONIUM SILICOFLUORIDE, solid
2855	53	ZINC FLUOROSILICATE
2856	53	FLUOROSILICATES, n.o.s.
2857	21	REFRIGERATING MACHINES, containing non-flammable, non-poisonous, liquefied gas
2857	21	REFRIGERATING MACHINES, containing non-flammable non-toxic, liquefied gas or ammonia solutions (2073)
2858	32	ZIRCONIUM, dry, wire, sheet or strips (thinner than 254 microns but not thinner than 18 microns)
2859	53	AMMONIUM METAVANADATE
2860	53	VANADIUM TRIOXIDE
2861	55	AMMONIUM POLYVANADATE
2862	53	VANADIUM PENTOXIDE
2863	53	SODIUM AMMONIUM VANADATE
2864	53	POTASSIUM METAVANADATE
2865	60	HYDROXYLAMINE SULFATE
2869	60	TITANIUM TRICHLORIDE MIXTURES
2870	37	ALUMINUM BOROHYDRIDE
2870	37	ALUMINUM BOROHYDRIDE IN DEVICES
2871	53	ANTIMONY, powder
2871	53	ANTIMONY POWDER
2872	58	DIBROMOCHLOROPROPANES
2873	55	DIBUTYLAMINOETHANOL
2874	55	FURFURYL ALCOHOL
2875	53	HEXACHLOROPHENE
2876	55	RESORCINOL

ID No	Guide No	Name of Material
2878	32	TITANIUM SPONGE, granules or powder
2879	59	SELENIUM OXYCHLORIDE
2880	45	CALCIUM HYPOCHLORITE, hydrated, including mixtures with not less than 5.5% but not more than 10% water
2881	37	METAL CATALYST, dry
2881	37	NICKEL CATALYST, dry
2883	48	2,2-DI (tert-BUTYLPEROXY)-PROPANE
2884	48	2,2-DI (tert-BUTYLPEROXY)-PROPANE
2885	48	1,1-DI (tert-BUTYLPEROXY) CYCLOHEXANE
2886	48	tert-BUTYL PEROXY-2-ETHYL-HEXANOATE, with 2,2-DI-(tert-BUTYL-PEROXY) BUTANE
2887	48	tert-BUTYL PEROXY-2-ETHYL-HEXANOATE, with 2,2-DI-(tert-BUTYL-PEROXY)BUTANE
2888	52	tert-BUTYL PEROXY-2-ETHYL-HEXANOATE, not more than 50%, with phlegmatizer
2889	52	DIISOTRIDECYLPEROXYDICARBONATE
2890	48	tert-BUTYL PEROXYBENZOATE
2891	52	tert -AMYL PEROXYNEODECANOATE
2892	52	DIMYRISTYL PEROXYDICARBONATE, not more than 42% in water
2893	48	LAUROYL PEROXIDE, not more than 42%
2894	52	DI(4-tert-BUTYLCYCLOHEXYL) PEROXYDICARBONATE
2895	52	DICETYLPEROXYDICARBONATE, not more than 42%
2896	51	CYCLOHEXANONE PEROXIDE, not more than 72% as a paste
2897	48	1,1-DI(tert-BUTYLPEROXY) CYCLOHEXANE
2898	52	tert-AMYL PEROXY-2-ETHYL HEXANOATE

ID No	Guide No	Name of Material
2899	52	ORGANIC PEROXIDE, n.o.s. (including trial quantities)
2900	24	INFECTIOUS SUBSTANCES, affecting animals only
2901	**20**	**BROMINE CHLORIDE**
2902	55	ALLETHRIN
2902	55	FUNGICIDE, poisonous, n.o.s.
2902	55	INSECTICIDE, liquid poisonous, n.o.s.
2902	55	PESTICIDES, liquid, toxic n.o.s.
2903	28	PESTICIDES, liquid, toxic flammable, n.o.s.
2904	55	CHLOROPHENATES, liquid
2904	55	CHLOROPHENOLATES, liquid
2904	55	PHENOLATES, liquid
2905	53	CHLOROPHENATES, solid
2905	53	CHLOROPHENOLATES, solid
2905	53	PHENOLATES, solid
2906	26	TRIISOCYANATOISOCYANURATE of ISOPHORONEDIISOCYANATE, 70% solution
2907	32	ISOSORBIDE DINITRATE MIXTURE
2909	6	RADIOACTIVE MATERIAL, articles manufactured from natural or depleted uranium or natural thorium
2910	6	RADIOACTIVE MATERIAL, empty package-articles manufactured from natural or depleted uranium or thorium
2910	6	RADIOACTIVE MATERIAL, excepted package-articles manufactured from natural or depleted uranium or natural thorium
2910	61	RADIOACTIVE MATERIAL, excepted package-empty packaging
2910	61	RADIOACTIVE MATERIAL excepted package-instruments or articles
2910	61	RADIOACTIVE MATERIAL, excepted package-limited quantity of material

ID No	Guide No	Name of Material
2910	61	RADIOACTIVE MATERIAL, limited quantity, n.o.s.
2911	61	RADIOACTIVE MATERIAL, instruments and articles
2912	62	RADIOACTIVE MATERIAL, low specific activity (LSA), n.o.s.
2913	62	RADIOACTIVE MATERIAL, surface contaminated objects (SCO)
2918	65	RADIOACTIVE MATERIAL, fissile, n.o.s.
2920	29	CORROSIVE LIQUIDS, flammable, n.o.s.
2920	29	DICHLOROBUTENE
2921	34	CORROSIVE SOLIDS, flammable, n.o.s.
2922	59	CORROSIVE LIQUID, toxic n.o.s.
2922	59	CORROSIVE LIQUIDS, poisonous, n.o.s.
2922	59	SODIUM HYDROSULFIDE SOLUTION
2923	59	CORROSIVE SOLID, toxic n.o.s.
2923	59	CORROSIVE SOLIDS, poisonous n.o.s.
2923	59	SODIUM HYDROSULFIDE, solid with not less than 25% water of crystallization
2924	29	DICHLOROBUTENE
2924	29	FLAMMABLE LIQUIDS, corrosive, n.o.s.
2925	34	FLAMMABLE SOLID, corrosive, n.o.s.
2925	34	FLAMMABLE SOLID, corrosive, organic, n.o.s.
2926	34	FLAMMABLE SOLID, poisonous, n.o.s.
2926	34	FLAMMABLE SOLID, toxic, organic, n.o.s.
2927	**59**	**ETHYL PHOSPHONOTHIOIC DICHLORIDE, anhydrous**
2927	**59**	**ETHYL PHOSPHORODICHLORIDATE**
2927	59	POISONOUS LIQUID, corrosive, n.o.s.
2927	**59**	**POISONOUS LIQUIDS, corrosive, n.o.s. (Inhalation Hazard Zone A)**
2927	**59**	**POISONOUS LIQUIDS, corrosive, n.o.s. (Inhalation Hazard Zone B)**

ID No	Guide No	Name of Material
2927	**59**	**TOXIC LIQUID, corrosive, organic, n.o.s.**
2928	59	POISONOUS SOLIDS, corrosive, n.o.s.
2928	59	TOXIC SOLID, corrosive, organic, n.o.s.
2929	57	CHLOROPICRIN MIXTURE, FLAMMABLE
2929	57	POISONOUS LIQUIDS, flammable, n.o.s.
2929	57	POISONOUS LIQUIDS flammable, n.o.s. (Inhalation Hazard Zone A)
2929	57	POISONOUS LIQUIDS flammable, n.o.s. (Inhalation Hazard Zone B)
2929	57	TOXIC LIQUID, flammable organic, n.o.s.
2930	34	POISONOUS SOLIDS flammable, n.o.s.
2930	34	TOXIC SOLID, flammable organic, n.o.s.
2931	55	VANADYL SULFATE
2933	29	METHYL 2-CHLOROPROPIONATE
2934	29	ISOPROPYL2-CHLOROPROPIONATE
2935	29	ETHYL 2-CHLOROPROPIONATE
2936	59	THIOLACTIC ACID
2937	55	METHYLBENZYL ALCOHOL (alpha)
2938	31	METHYL BENZOATE
2940	37	CYCLOOCTADIENE PHOSPHINES
2940	37	9-PHOSPHABICYCLONONANES
2941	55	FLUOROANILINES
2942	55	2-TRIFLUOROMETHYLANILINE
2943	26	TETRAHYDROFURFURYLAMINE
2945	29	N-METHYLBUTYLAMINE
2946	31	2-AMINO-5-DIETHYLAMINOPENTANE
2947	29	ISOPROPYL CHLOROACETATE
2948	55	3-TRIFLUOROMETHYLANILINE
2949	59	SODIUM HYDROSULFIDE, with not less than 25% water of crystallization
2949	59	SODIUM HYDROSULFIDE SOLUTION
2950	40	MAGNESIUM GRANULES, coated

ID No	Guide No	Name of Material
2951	72	DIPHENYLOXIDE-4,4'-DISULFO-HYDRAZIDE
2952	70	AZODIISOBUTYRONITRILE
2953	70	2,2'-AZODI-(2,4-DIMETHYLVALERO-NITRILE)
2954	72	1,1'-AZODI(HEXAHYDROBENZO-NITRILE)
2955	70	2,2'-AZODI-(2,4-DIMETHYL-4-METHOXY VALERONITRILE)
2956	32	5-tert-BUTYL-2,4,6-TRINITRO-m-XYLENE
2956	32	MUSK XYLENE
2965	29	BORON TRIFLUORIDE DIMETHYL ETHERATE
2966	53	THIOGLYCOL
2967	60	SULFAMIC ACID
2968	37	MANEB, or MANEB PREPARATION(S), stabilized against self-heating
2969	31	CASTOR BEANS, MEAL, POMACE or FLAKE
2970	72	BENZENE SULFOHYDRAZIDE
2971	72	BENZENE-1,3-DISULFOHYDRAZIDE
2972	71	N,N'-DINITROSOPENTAMETHYLENE TETRAMINE
2973	71	N,N'-DINITROSO-N,N'-DIMETHYL TEREPHTHALAMIDE
2974	64	RADIOACTIVE MATERIAL, special form, n.o.s.
2975	61	THORIUM METAL, pyrophoric
2976	61	THORIUM NITRATE, solid
2977	66	URANIUM HEXAFLUORIDE, fissile (containing more than 1.0% U-235)
2978	66	URANIUM HEXAFLUORIDE, fissile excepted or non-fissile
2978	66	URANIUM HEXAFLUORIDE, low specific activity

ID No	Guide No	Name of Material
2979	61	URANIUM METAL, pyrophoric
2980	61	URANIUM NITRATE HEXAHYDRATE SOLUTION
2981	61	URANYL NITRATE, solid
2982	63	RADIOACTIVE MATERIAL, n.o.s.
2983	26	ETHYLENE OXIDE and PROPYLENE OXIDE MIXTURES
2984	45	HYDROGEN PEROXIDE AQUEOUS SOLUTIONS with not less than 8% but less than 20% peroxide
2985	29	CHLOROSILANES, flammable, corrosive, n.o.s.
2985	29	CHLOROSILANES, n.o.s (flammable, corrosive)
2986	29	CHLOROSILANES, corrosive, flammable, n.o.s.
2986	29	CHLOROSILANES, n.o.s (flammable, corrosive)
2987	60	CHLOROSILANES, corrosive, n.o.s.
2987	60	CHLOROSILANES, n.o.s (corrosive)
2988	40	CHLOROSILANES, n.o.s. (emits flammable gas when wet)
2988	40	CHLOROSILANES, water-reactive, flammable, corrosive, n.o.s.
2989	32	LEAD PHOSPHITE, dibasic
2990	31	LIFE-SAVING APPLIANCES, SELF-INFLATING
2991	28	CARBAMATE PESTICIDES, liquid, toxic, flammable, n.o.s.
2992	55	CARBAMATE PESTICIDES, liquid, toxic, n.o.s.
2993	28	ARSENICAL PESTICIDES, liquid, toxic, flammable, n.o.s.
2994	55	ARSENICAL PESTICIDES, liquid,, toxic, n.o.s.

ID No	Guide No	Name of Material
2995	28	ORGANOCHLORINE PESTICIDES, liquid, toxic, flammable, n.o.s.
2996	55	ORGANOCHLORINE PESTICIDES, liquid, toxic, n.o.s.
2997	28	TRIAZINE PESTICIDES, liquid, toxic, flammable, n.o.s.
2998	55	TRIAZINE PESTICIDES, liquid, toxic, n.o.s.
2999	28	PHENOXY PESTICIDES, liquid, toxic, flammable, n.o.s.
3000	55	PHENOXY PESTICIDES, liquid, toxic, n.o.s.
3001	28	PHENYL UREA PESTICIDES, liquid, toxic, flammable, n.o.s.
3002	55	PHENYL UREA PESTICIDES, liquid, toxic, n.o.s.
3003	28	BENZOIC DERIVATIVE PESTICIDES, liquid, toxic, flammable, n.o.s.
3004	55	BENZOIC DERIVATIVE PESTICIDES, liquid, toxic, n.o.s.
3005	28	DITHIOCARBAMATE PESTICIDES, liquid, toxic, flammable, n.o.s.
3006	55	DITHIOCARBAMATE PESTICIDES, liquid, toxic, n.o.s.
3007	2	PHTHALIMIDE DERIVATIVE PESTICIDES, liquid, toxic, flammable, n.o.s.
3008	55	PHTHALIMIDE DERIVATIVE PESTICIDES, liquid, toxic, n.o.s.
3009	28	COPPER-BASED PESTICIDES liquid, toxic, flammable, n.o.s.
3010	55	COPPER-BASED PESTICIDES, liquid, toxic, n.o.s.
3011	28	MERCURY-BASED PESTICIDES, liquid, toxic, flammable n.o.s.
3012	55	MERCURY-BASED PESTICIDES, liquid, toxic, n.o.s.
3013	28	SUBSTITUTED NITROPHENOL PESTICIDES, liquid, toxic, flammable, n.o.s.

ID No	Guide No	Name of Material
3014	55	SUBSTITUTED NITROPHENOL PESTICIDES, liquid, toxic n.o.s.
3015	28	BIPYRIDILIUM PESTICIDES, liquid, toxic, flammable, n.o.s.
3016	55	BIPYRIDILIUM PESTICIDES, liquid, toxic, n.o.s.
3017	28	ORGANOPHOSPHORUS PESTICIDES, liquid, toxic, flammable, n.o.s.
3018	55	ORGANOPHOSPHORUS, PESTICIDES, liquid, toxic, n.o.s.
3018	55	TETRAETHYL PYROPHOSPHATE, liquid
3019	28	ORGANOTIN PESTICIDES, liquid, toxic, flammable, n.o.s.
3020	55	ORGANOTIN PESTICIDES, liquid, toxic, n.o.s.
3021	28	PESTICIDES, liquid, flammable toxic, n.o.s.
3022	26	1,2-BUTYLENE OXIDE, stabilized
3023	**57**	**tert-OCTYL MERCAPTAN**
3024	28	COUMARIN DERIVATIVE PESTICIDES, liquid, flammable, toxic, n.o.s.
3025	28	COUMARIN DERIVATIVE PESTICIDES, liquid, toxic, flammable, n.o.s.
3026	55	COUMARIN DERIVATIVE PESTICIDES, liquid, toxic, n.o.s.
3027	55	COUMARIN DERIVATIVE PESTICIDES, solid, toxic, n.o.s.
3028	60	BATTERIES, electric storage, dry, containing POTASSIUM HYDROXIDE
3030	70	2,2'-AZODI-(2-METHYL-BUTYRO-NITRILE)
3031	71	SELF-REACTIVE SUBSTANCES, samples, n.o.s.
3032	71	SELF-REACTIVE SUBSTANCES, trial quantities, n.o.s.
3033	72	3-CHLORO-4-DIETHYLAMINOBENZENE-DIAZONIUM ZINC CHLORIDE

ID No	Guide No	Name of Material
3034	72	4-DIPROPYLAMINOBENZENE-DIAZONIUM ZINC CHLORIDE
3035	70	3-(2-HYDROXYETHOXY)-4-PYRROLIDIN-1-YLBENZENEDIAZONIUM ZINC CHLORIDE
3036	72	2,5-DIETHOXY-4-MORPHOLINOBENZENE DIAZONIUM ZINC CHLORIDE
3037	70	4-(BENZYL(ETHYL)AMINO)-3-ETHOXY-BENZENEDIAZONIUM ZINC CHLORIDE
3038	70	4-(BENZYL(METHYL)AMINO)-3-ETHOXY BENZENEDIAZONIUM ZINC CHLORIDE
3039	70	4-DIMETHYLAMINO-6 (2-DIMETHYLAMINOETHOXY) TOLUENE-2-DIAZONIUM ZINC CHLORIDE
3040	72	SODIUM 2-DIAZO-1-NAPHTHOL-4-SULFONATE
3041	72	SODIUM 2-DIAZO-1-NAPHTHOL-5-SULFONATE
3042	71	2-DIAZO-1-NAPHTHOL-4-SULFO-CHLORIDE
3043	71	2-DIAZO-1-NAPHTHOL-5-SULFO-CHLORIDE
3048	53	ALUMINUM PHOSPHIDE PESTICIDES
3049	40	METAL ALKYL HALIDES, n.o.s.
3050	40	METAL ALKYL HYDRIDES, n.o.s.
3051	40	ALUMINUM ALKYLS
3052	40	ALUMINUM ALKYL HALIDES
3053	40	MAGNESIUM ALKYLS
3054	28	CYCLOHEXYL MERCAPTAN
3055	60	2-(2-AMINOETHOXY)ETHANOL
3056	26	n-HEPTALDEHYDE
3057	**16**	**TRIFLUOROACETYL CHLORIDE**
3064	26	NITROGLYCERIN, SOLUTION in ALCOHOL, with more than 1 % but not more than 5% nitroglycerin

ID No	Guide No	Name of Material
3065	26	ALCOHOLIC BEVERAGES
3066	60	PAINT, corrosive liquid
3066	60	PAINT RELATED MATERIAL, corrosive liquid
3070	12	DICHLORODIFLUOROMETHANE and ETHYLENE OXIDE MIXTURE with not more than 12% ETHYLENE OXIDE
3070	12	ETHYLENE OXIDE and DICHLORODIFLUOROMETHANE MIXTURE with not more than 12% ethylene oxide
3070	12	ETHYLENE OXIDE and DICHLORODIFLUOROMETHANE MIXTURE, with not more than 12.5% ethylene oxide
3071	28	MERCAPTAN MIXTURE, liquid toxic, flammable, n.o.s.
3071	28	MERCAPTAN MIXTURES, liquid, n.o.s.
3071	28	MERCAPTANS, liquid, n.o.s.
3071	28	MERCAPTANS, liquid, toxic, flammable, n.o.s.
3072	31	LIFE-SAVING APPLIANCES NOT SELF-INFLATING
3073	57	VINYL PYRIDINES, inhibited
3076	40	ALUMINUM ALKYL HYDRIDES
3077	31	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, solid, n.o.s.
3077	31	HAZARDOUS WASTE, solid n.o.s.
3077	31	OTHER REGULATED SUBSTANCES, solid, n.o.s.
3078	40	CERIUM, turnings or gritty powder
3079	**28**	**METHACRYLONITRILE, inhibited**
3080	28	ISOCYANATE SOLUTIONS, n.o.s.
3080	28	ISOCYANATE SOLUTIONS, toxic, flammable, n.o.s.
3080	28	ISOCYANATES, n.o.s.

ID No	Guide No	Name of Material
3080	28	ISOCYANATES, toxic, flammable, n.o.s.
3082	31	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, liquid, n.o.s.
3082	31	HAZARDOUS WASTE, liquid, n.o.s.
3082	31	OTHER REGULATED SUBSTANCES, liquid, n.o.s.
3083	**20**	**PERCHLORYL FLUORIDE**
3084	35	CORROSIVE SOLIDS, oxidizing, n.o.s.
3085	42	OXIDIZING SOLID, corrosive, n.o.s.
3085	42	OXIDIZING SUBSTANCES, solid, corrosive, n.o.s.
3086	42	POISONOUS SOLIDS, oxidizing, n.o.s.
3086	42	TOXIC SOLID, oxidizing, n.o.s.
3087	44	OXIDIZING SOLID, toxic, n.o.s.
3087	44	OXIDIZING SUBSTANCES, solid, poisonous, n.o.s.
3088	37	SELF-HEATING SOLID, organic, n.o.s.
3088	37	SELF-HEATING SUBSTANCES, solid, n.o.s.
3089	32	METAL POWDER, flammable, n.o.s.
3090	40	LITHIUM BATTERY
3091	40	LITHIUM BATTERIES, contained in equipment
3091	40	LITHIUM BATTERIES, packed with equipment
3092	26	1-METHOXY-2-PROPANOL
3093	45	CORROSIVE LIQUIDS, oxidizing, n.o.s.
3094	39	CORROSIVE LIQUIDS water-reactive, n.o.s.
3094	39	CORROSIVE LIQUIDS, which in contact with water emit FLAMMABLE GASES, n.o.s.
3095	37	CORROSIVE SOLIDS, self-heating, n.o.s.
3096	40	CORROSIVE SOLIDS, water-reactive, n.o.s.
3096	40	CORROSIVE SOLIDS, which in contact with water emit FLAMMABLE GASES, n.o.s.

ID No	Guide No	Name of Material
3097	32	FLAMMABLE SOLID, oxidizing, n.o.s.
3098	45	OXIDIZING LIQUID, corrosive n.o.s.
3098	45	OXIDIZING SUBSTANCES, liquid, corrosive, n.o.s.
3099	44	OXIDIZING LIQUID, poisonous, n.o.s.
3099	44	OXIDIZING LIQUID, toxic ,n.o.s.
3099	44	OXIDIZING SUBSTANCES, liquid, poisonous, n.o.s.
3100	43	OXIDIZING SOLID, self-heating, n.o.s.
3100	43	OXIDIZING SUBSTANCES, solid, self-heating,, n.o.s.
3101	49	ORGANIC PEROXIDE TYPE B, liquid
3102	49	ORGANIC PEROXIDE TYPE B, solid
3103	48	ORGANIC PEROXIDE TYPE C, liquid
3104	48	ORGANIC PEROXIDE TYPE C, solid
3105	48	ORGANIC PEROXIDE TYPE D, liquid
3106	48	ORGANIC PEROXIDE TYPE D, solid
3107	48	ORGANIC PEROXIDE TYPE E, liquid
3108	48	ORGANIC PEROXIDE TYPE E, solid
3109	48	ORGANIC PEROXIDE TYPE F, liquid
3110	48	ORGANIC PEROXIDE TYPE F, solid
3111	52	ORGANIC PEROXIDE TYPE B, liquid, temperature controlled
3112	52	ORGANIC PEROXIDE TYPE B, solid, temperature controlled
3113	52	ORGANIC PEROXIDE TYPE C, liquid, temperature controlled
3114	52	ORGANIC PEROXIDE TYPE C, solid, temperature controlled
3115	52	0RGANIC PEROXIDE TYPE D, liquid, temperature controlled
3116	52	ORGANIC PEROXIDE TYPE D, solid, temperature controlled

ID No	Guide No	Name of Material
3117	52	ORGANIC PEROXIDE TYPE E, liquid, temperature controlled
3118	52	ORGANIC PEROXIDE TYPE E, solid, temperature controlled
3119	52	ORGANIC PEROXIDE TYPE F, liquid, temperature controlled
3120	52	ORGANIC PEROXIDE TYPE F, solid, temperature controlled
3121	43	OXIDIZING SOLID, water-reactive, n.o.s.
3121	43	OXIDIZING SUBSTANCES, solid which in contact with water emit FLAMMABLE GASES, n.o.s.
3122	44	POISONOUS LIQUIDS, oxidizing, n.o.s.
3122	**44**	**POISONOUS LIQUIDS, oxidizing, n.o.s. (Inhalation Hazard Zone A)**
3122	**44**	**POISONOUS LIQUIDS, oxidizing, n.o.s. (Inhalation Hazard Lone B)**
3122	**44**	**TOXIC LIQUID, oxidizing, n.o.s.**
3123	40	POISONOUS LIQUIDS, water-reactive, n.o.s.
3123	40	POISONOUS LIQUIDS, which in contact with water emit FLAMMABLE GASES, n.o.s.
3123	**40**	**POISONOUS LIQUIDS, which in contact with water emit FLAMMABLE GASES, n.o.s (Inhalation Hazard Zone A)**
3123	**40**	**POISONOUS LIQUIDS, which in contact with water emit FLAMMABLE GASES, n.o.s (Inhalation Hazard Zone B)**
3123	**40**	**TOXIC LIQUID, water-reactive n.o.s.**
3124	34	POISONOUS SOLIDS, self-heating, n.o.s.
3124	34	TOXIC SOLID, self-heating, n.o.s.
3125	34	POISONOUS SOLIDS, water-reactive, n.o.s.
3125	34	POISONOUS SOLIDS, which in contact with water emit FLAMMABLE GASES, n.o.s.
3125	34	TOXIC SOLID, water-reactive n.o.s.
3126	47	SELF-HEATING SOLID, corrosive, organic, n.o.s.

ID No	Guide No	Name of Material
3126	47	SELF-HEATING SUBSTANCE, solid, corrosive, n.o.s.
3127	47	SELF-HEATING SOLID, oxidizing, n.o.s.
3127	47	SELF-HEATING SUBSTANCE, solid, oxidizing, n.o.s.
3128	34	SELF-HEATING SOLID, organic, poisonous, n.o.s.
3128	34	SELF-HEATING SOLID, toxic, organic, n.o.s.
3128	34	SELF-HEATING SUBSTANCE ,solid, poisonous, n.o.s.
3129	39	SUBSTANCES which in contact with water emit FLAMMABLE GASES, liquid, corrosive n.o.s.
3129	39	WATER-REACTIVE LIQUID, corrosive, n.o.s.
3130	39	SUBSTANCES, which in contact with water emit FLAMMABLE GASES, liquid, poisonous n.o.s.
3130	39	WATER-REACTIVE LIQUID, poisonous, n.o.s.
3130	39	WATER-REACTIVE LIQUID, toxic, n.o.s.
3131	40	SUBSTANCES which in contact with water emit FLAMMABLE GASES, solid, corrosive n.o.s.
3131	40	WATER-REACTIVE SOLID, corrosive, n.o.s.
3132	40	SUBSTANCES which in contact with water emit FLAMMABLE GASES, solid, flammable n.o.s.
3132	40	WATER-REACTIVE SOLID, flammable, n.o.s.
3133	40	SUBSTANCES which in contact with water emit FLAMMABLE GASES, solid, oxidizing n.o.s.
3133	40	WATER-REACTIVE SOLID, oxidizing, n.o.s.

ID No	Guide No	Name of Material
3134	40	SUBSTANCES which in contact with water emit FLAMMABLE GASES, solid, poisonous n.o.s.
3134	40	WATER-REACTIVE SOLID, poisonous, n.o.s.
3134	40	WATER-REACTIVE SOLID, toxic n.o.s.
3135	40	SUBSTANCES which in contact with water emit FLAMMABLE GASES, solid, self-heating n.o.s.
3135	40	WATER-REACTIVE SOLID, self-heating, n.o.s.
3136	21	TRIFLUOROMETHANE, refrigerated liquid (cryogenic liquid)
3137	35	OXIDIZING SUBSTANCES, solid, flammable, n.o.s.
3138	17	ETHYLENE, ACETYLENE and PROPYLENE MIXTURE, refrigerated liquid (cryogenic liquid), containing at least 71..5% ETHYLENE with not more than 22.5% ACETYLENE and not more than 6% PROPYLENE
3139	35	OXIDIZING SUBSTANCES, liquid, n.o.s.
3140	53	ALKALOID SALTS, liquid, n.o.s., poisonous
3140	53	ALKALOIDS, liquid, n.o.s, poisonous
3141	53	ANTIMONY COMPOUNDS, inorganic, liquid, n.o.s.
3142	55	DISINFECTANTS, liquid, n.o.s, poisonous
3142	55	DISINFECTANTS, liquid, toxic, n.o.s.
3143	55	DYE, solid, n.o.s. or DYE INTERMEDIATE, solid, n.o.s poisonous
3143	55	DYE, solid, toxic, n.o.s.
3143	55	DYE INTERMEDIATE, solid, toxic, n.o.s
3144	55	NICOTINE COMPOUND, liquid, n.o.s.
3144	55	NICOTINE PREPARATION, liquid, n.o.s.
3145	55	ALKYL PHENOLS, liquid, n.o.s.
3146	55	ORGANOTIN COMPOUNDS, solid, n.o.s.

ID No	Guide No	Name of Material
3147	60	DYE, solid, corrosive, n.o.s
3147	60	DYE, solid, n.o.s. or DYE INTERMEDIATE, solid, n.o.s, corrosive
3147	60	DYE INTERMEDIATE, solid, corrosive, n.o.s.
3148	40	SUBSTANCES which in contact with water emit FLAMMABLE GASES, liquid, n.o.s.
3148	40	WATER-REACTIVE LIQUID ,n.o.s.
3149	45	HYDROGEN PEROXIDE - PEROXYACETIC ACID MIXTURES, with acid(s), water and not more than 5% PEROXYACETIC acid stabilized
3150	22	DEVICES, small, HYDROCARBON GAS powered, with release device
3150	22	HYDROCARBON GAS REFILLS for small devices, with release device
3151	31	POLYHALOGENATED BIPHENYLS, liquid
3151	31	POLYHALOGENATED TERPHENYLS, liquid
3152	31	POLYHALOGENATED BIPHENYLS, solid
3152	31	POLYHALOGENATED TERPHENYLS, solid
3153	22	PERFLUOROMETHYLVINYL ETHER
3154	22	PERFLUOROETHYLVINYL ETHER
3155	55	PENTACHLOROPHENOL
3156	14	COMPRESSED GAS, oxidizing, n.o.s.
3157	14	LIQUEFIED GAS, oxidizing, n.o.s.
3158	21	GAS, refrigerated liquid, n.o.s.
3159	12	TETRAFLUOROETHANE
3159	12	1,1,1,2-TETRAFLUOROETHANE
3160	**18**	**LIQUEFIED GAS, toxic, flammable, n.o.s.**
3161	22	LIQUEFIED GAS, flammable, n.o.s.
3162	**15**	**LIQUEFIED GAS, toxic, n.o.s.**
3163	12	LIQUEFIED GAS, n.o.s.

ID No	Guide No	Name of Material
3164	12	ARTICLES, pressurized pneumatic or hydraulic (containing non-flammable gas)
3165	28	AIRCRAFT HYDRAULIC POWER TANK
3166	27	ENGINES, internal combustion including when fitted in machinery or vehicles
3167	22	GAS SAMPLE, non-pressurized flammable, n.o.s., not refrigerated liquid
3167	22	GAS SAMPLES, non-pressurized flammable, n.o.s., not deeply refrigerated
3168	18	GAS SAMPLE, non-pressurized, toxic, flammable, n.o.s., not refrigerated liquid
3168	18	GAS SAMPLES, non-pressurized, toxic, flammable, n.o.s., not deeply refrigerated
3169	15	GAS SAMPLE, non-pressurized, toxic, n.o.s., not refrigerated liquid
3169	15	GAS SAMPLES, non-pressurized, toxic, n.o.s., not deeply refrigerated
3170	40	ALUMINUM DROSS
3170	40	ALUMINUM PROCESSING BY-PRODUCTS
3171	60	BATTERY-POWERED EQUIPMENT (wet battery)
3171	60	BATTERY-POWERED VEHICLE (wet battery)
3171	60	WHEELCHAIR, ELECTRIC with batteries
3172	55	TOXINS, extracted from living sources, n.o.s.
3174	37	TITANIUM DISULFIDE
3175	32	SOLIDS CONTAINING FLAMMABLE LIQUID, n.o.s.
3176	32	FLAMMABLE SOLID, organic molten, n.o.s.
3178	32	FLAMMABLE SOLID, inorganic, n.o.s.
3179	34	FLAMMABLE SOLID, inorganic, poisonous, n.o.s.
3179	34	FLAMMABLE SOLID, toxic, inorganic, n.o.s.

ID No	Guide No	Name of Material
3180	34	FLAMMABLE SOLID, corrosive, inorganic, n.o.s.
3180	34	FLAMMABLE SOLID, inorganic, corrosive, n.o.s.
3181	32	METAL SALTS OF ORGANIC COMPOUNDS, flammable n.o.s.
3182	32	METAL HYDRIDES, flammable n. o. s.
3183	37	SELF-HEATING LIQUID, organic, n.o.s.
3184	38	SELF-HEATING LIQUID, organic, poisonous, n.o.s.
3184	38	SELF-HEATING LIQUID, toxic, organic, n.o.s.
3185	38	SELF-HEATING LIQUID, corrosive, organic, n.o.s.
3185	38	SELF-HEATING LIQUID, organic, corrosive, n.o.s.
3186	37	SELF-HEATING LIQUID, inorganic, n.o.s.
3187	38	SELF-HEATING LIQUID, inorganic, poisonous, n.o.s.
3187	38	SELF-HEATING LIQUID, toxic, inorganic, n.o.s.
3188	38	SELF-HEATING LIQUID, corrosive, inorganic, n.o.s.
3188	38	SELF-HEATING LIQUID, inorganic, corrosive, n.o.s.
3189	37	METAL POWDER, self-heating n.o.s.
3189	37	SELF-HEATING METAL POWDER, n.o.s.
3190	37	SELF-HEATING SOLID, inorganic, n.o.s.
3191	38	SELF-HEATING SOLID, inorganic, poisonous, n.o.s.
3191	38	SELF-HEATING SOLID, toxic, inorganic, n.o.s.
3192	38	SELF-HEATING SOLID, corrosive, inorganic, n.o.s.
3192	38	SELF-HEATING SOLID, inorganic, corrosive, n.o.s.

ID No	Guide No	Name of Material
3194	37	PYROPHORIC LIQUID, inorganic, n.o.s.
3200	37	PYROPHORIC SOLID, inorganic, n.o.s.
3203	37	PYROPHORIC ORGANOMETALLIC COMPOUNDS, n.o.s.
3205	37	ALKALINE EARTH METAL ALCOHOLATES, n.o.s.
3206	38	ALKALI METAL ALCOHOLATES, n.o.s.
3206	38	ALKALI METAL ALCOHOLATES, self-heating, corrosive n.o.s.
3207	40	ORGANOMETALLIC COMPOUND, wafer-reactive, flammable, n.o.s.
3207	40	ORGANOMETALLIC DISPERSION, water-reactive, flammable, n.o.s.
3207	40	ORGANOMETALLIC SOLUTION, water-reactive, flammable n.o.s.
3208	40	METALLIC SUBSTANCE, water-reactive, n.o.s.
3209	40	METALLIC SUBSTANCE, water-reactive, self-heating, n.o.s.
3210	35	CHLORATES, inorganic, aqueous solution, n.o.s.
3211	35	PERCHLORATES, inorganic, aqueous solution, n.o.s.
3212	35	HYPOCHLORITES, inorganic n.o.s.
3213	35	BROMATES, inorganic, aqueous solution, n.o.s.
3214	35	PERMANGANATES, inorganic, aqueous solution, n.o.s.
3215	35	PERSULFATES, inorganic, n.o.s.
3216	35	PERSULFATES, inorganic, aqueous solution, n.o.s.
3217	35	PERCARBONATES, inorganic n.o.s.
3218	35	NITRATES, inorganic, aqueous solution, n.o.s.
3219	35	NITRITES, inorganic, aqueous solutions, n.o.s.

ID No	Guide No	Name of Material
3220	12	PENTAFLUOROETHANE
3221	49	SELF-REACTIVE LIQUID TYPE B
3222	49	SELF-REACTIVE SOLID TYPE B
3223	49	SELF-REACTIVE LIQUID TYPE C
3224	49	SELF-REACTIVE SOLID TYPE C
3225	48	SELF-REACTIVE LIQUID TYPE D
3226	48	SELF-REACTIVE SOLID TYPE D
3227	48	SELF-REACTIVE LIQUID TYPE E
3228	48	SELF-REACTIVE SOLID TYPE E
3229	48	SELF-REACTIVE LIQUID TYPE F
3230	48	SELF-REACTIVE SOLID TYPE F
3231	52	SELF-REACTIVE LIQUID TYPE B, temperature controlled
3232	52	SELF-REACTIVE SOLID TYPE B, temperature controlled
3233	52	SELF-REACTIVE LIQUID TYPE C, temperature controlled
3234	52	SELF-REACTIVE SOLID TYPE C, temperature controlled
3235	52	SELF-REACTIVE LIQUID TYPE D, temperature controlled
3236	52	SELF-REACTIVE SOLID TYPE D, temperature controlled
3237	52	SELF-REACTIVE LIQUID TYPE E, temperature controlled
3238	52	SELF-REACTIVE SOLID TYPE E, temperature controlled
3239	52	SELF-REACTIVE LIQUID TYPE F, temperature controlled
3240	52	SELF-REACTIVE SOLID TYPE F, temperature controlled
3241	53	2-BROMO-2-NITROPROPANE-1,3-DIOL
3242	32	AZODICARBONAMIDE

ID No	Guide No	Name of Material
3243	55	SOLIDS CONTAINING POISONOUS LIQUID,.n.o.s.
3243	55	SOLIDS CONTAINING TOXIC LIQUID, n.o.s.
3244	60	SOLIDS CONTAINING CORROSIVE LIQUID, n.o.s.
3245	31	GENETICALLY MODIFIED MICROORGANISMS
3246	**59**	**METHANESULFONYL CHLORIDE**
3247	35	SODIUM PEROXOBORATE, ANHYDROUS
3248	28	MEDICINES, liquid, flammable, poisonous, n.o.s.
3248	28	MEDICINES, liquid, flammable, toxic, n.o.s.
3249	55	MEDICINES, solid, poisonous, n.o.s.
3249	55	MEDICINES, solid, toxic, n.o.s.
3250	59	CHLOROACETIC ACID, molten
3251	32	ISOSORBIDE-5-MONONITRATE
3252	22	DIFLOUROMETHANE
3253	60	DISODIUM TRIOXOSILICATE, pentahydrate
3254	37	TRIBUTYLPHOSPHANE
3255	37	tert-BUTYL HYPOCHLORITE
3256	27	ELEVATED TEMPERATURE LIQUID, flammable, n.o.s, with flash point above 60..5°C, at or above its flash point
3257	27	ELEVATED TEMPERATURE LIQUID, n.o.s, at or above 100°C and below its flash point
3258	31	ELEVATED TEMPERATURE SOLID, n.o.s., at or above 240°C
3259	60	AMINES, solid, corrosive n.o.s.
3259	60	POLYAMINES, solid, corrosive, n.o.s.
3260	60	CORROSIVE SOLID, acidic inorganic, n.o.s.
3261	60	CORROSIVE SOLID, acidic organic, n.o.s.
3262	60	CORROSIVE SOLID, basic inorganic, n.o.s.

ID No	Guide No	Name of Material
3263	60	CORROSIVE SOLID, basic organic, n.o.s.
3264	60	CORROSIVE LIQUID, acidic inorganic, n.o.s.
3265	60	CORROSIVE LIQUID, acidic organic, n.o.s.
3266	60	CORROSIVE LIQUID, basic, inorganic, n.o.s.
3267	60	CORROSIVE LIQUID, basic, organic, n.o.s.
3268	31	AIR BAG INFLATORS
3268	31	AIR BAG MODULES
3268	31	SEAT-BELT MODULES
3268	31	SEAT-BELT PRE-TENSIONERS
3269	26	POLYESTER RESIN KIT
3270	32	NITROCELLULOSE MEMBRANE FILTERS
3271	26	ETHERS, n.o.s.
3272	26	ESTERS, n.o.s.
3273	28	NITRILES, flammable, toxic n.o.s.
3274	26	ALCOHOLATES SOLUTION, n.o.s. in alcohol
3275	**57**	**NITRILES, toxic, flammable, n.o.s.**
3276	55	NITRILES, toxic, n.o.s (liquid)
3276	55	NITRILES, toxic, n.o.s, (solid)
3277	59	CHLOROFORMATES, toxic, corrosive, n.o.s.
3278	55	ORGANOPHOSPHORUS COMPOUND, toxic, n.o.s. (liquid)
3278	55	ORGANOPHOSPHORUS COMPOUND, toxic, n.o.s. (solid)
3279	**28**	**ORGANOPHOSPHORUS COMPOUND, toxic, flammable, n.o.s.**
3280	55	ORGANOARSENIC COMPOUND, toxic, n.o.s.
3281	55	METAL CARBONYLS, toxic, n.o.s.
3282	55	ORGANOMETALLIC COMPOUND, toxic, n.o.s.

ID No	Guide No	Name of Material
3283	55	SELENIUM COMPOUND, toxic, n.o.s.
3284	55	TELLURIUM COMPOUND, toxic, n.o.s.
3285	55	VANADIUM COMPOUND, toxic, n.o.s.
3286	28	FLAMMABLE LIQUID, toxic, corrosive, n.o.s.
3287	55	TOXIC LIQUID, inorganic, n.o.s.
3288	53	TOXIC SOLID, inorganic, n.o.s.
3289	**59**	**TOXIC LIQUID, corrosive, inorganic, n.o.s.**
3290	59	TOXIC SOLID, corrosive, inorganic, n.o.s.
3291	24	BIOMEDICAL WASTE, n.o.s.
3291	24	CLINICAL WASTE, unspecified n.o.s.
3291	24	MEDICAL WASTE, n.o.s.
3291	24	REGULATED MEDICAL WASTE, n.o.s.
3292	40	BATTERIES, containing SODIUM
3292	40	CELLS, containing SODIUM
3293	53	HYDRAZINE, AQUEOUS SOLUTIONS, with not more than 37% hydrazine
3294	**28**	**HYDROGEN CYANIDE, solution in alcohol with not more than 45% hydrogen cyanide**
3295	27	HYROCARBONS, LIQUID n.o.s.
3296	12	HEPTAFLUOROPROPANE
3297	12	ETHYLENE OXIDE and CHLOROTETRAFLUOROETHANE MIXTURES, with not more than 8.8% ethylene oxide
3298	12	ETHYLENE OXIDE and PENTAFLUOROETHANE MIXTURES, with not more than 7..9% ethylene oxide
3299	12	ETHYLENE OXIDE and TETRAFLUOROETHANE MIXTURES, with not more than 5.6% ethylene oxide
3300	**18**	**ETHYLENE OXIDE and CARBON DIOXIDE MIXTURE, with more than 87% ethylene oxide**
3301	37	CORROSIVE LIQUID, self-heating, n.o.s.

ID No	Guide No	Name of Material
9011	58	CAMPHENE
9018	74	DICHLORODIFLUOROETHYLENE
9026	53	DINITROCYCLOHEXYL PHENOL
9035	15	GAS IDENTIFICATION SET
9037	53	HEXACHLOROETHANE
9069	29	TETRAMETHYLMETHYLENEDIAMINE
9083	31	AMMONIUM CARBAMATE
9084	31	AMMONIUM CARBONATE
9088	31	AMMONIUM FLUOBORATE
9163	31	ZIRCONIUM SULFATE
9180	62	URANYL ACETATE
9183	52	ORGANIC PEROXIDE, liquid or solution, n.o.s.
9187	52	ORGANIC PEROXIDE, solid, n.o.s.
9188	31	HAZARDOUS SUBSTANCE, liquid or solid, n.o.s.
9188	31	ORM-E, liquid or solid, n.o.s.
9189	31	HAZARDOUS WASTE, liquid or solid, n.o.s.
9190	43	AMMONIUM PERMANGANATE
9191	47	CHLORINE DIOXIDE HYDRATE, frozen
9192	25	FLUORINE, refrigerated liquid (cryogenic liquid)
9193	45	OXIDIZER, corrosive liquid, n.o.s.
9194	45	OXIDIZER, corrosive solid, n.o.s.
9195	40	METAL ALKYL SOLUTION, n.o.s.
9199	44	OXIDIZER, poisonous, liquid, n.o.s.
9200	42	OXIDIZER, poisonous, solid, n.o.s.
9202	**67**	**CARBON MONOXIDE, refrigerated liquid (cryogenic liquid)**
9206	**39**	**METHYL PHOSPHONIC DICHLORIDE**
9259	27	ELEVATED TEMPERATURE MATERIAL, liquid, n.o.s. (at or above 100° C (212° F) and below its flash point)

ID No	Guide No	Name of Material
9260	77	ALUMINUM, molten
9263	**59**	**CHLOROPIVALOYL CHLORIDE**
9264	**5**	**3,5-DICHLORO-2,4,6-TRIFLUORO YRIDINE**
9269	**57**	**TRIMETHOXYSILANE**
9274	74	1,1-DICHLORO-1-FLUOROETHANE
9275	24	REGULATED MEDICAL WASTE, n.o.s.
9276	27	FLAMMABLE LIQUIDS, elevated temperature material, n.o.s.
9277	31	OIL, n.o.s, flash point not less than 93° C
9278	31	GENETICALLY MODIFIED ORGANISMS

Index

A
absorbing agents 414
acentric factor 173
acetaldehyde 41
acetylene 30
acrolein 41
adsorbing agents 414
alarm receiving equipment 5
alcohol 38, 41, 42, 399, 413
alcohol-resistant foam 69, 413
aldehydes 41
alkane series 23, 24, 29, 30
alkenes 28, 34
alkyl halides 36, 42
alkyl radicals 36
alkynes 30
amine radical 35
amines 42
ammonia 44
anesthetic 37, 40
antifreezes 38
aqueous film forming foam 75, 76, 413
area securement 395
aromatic hydrocarbon derivatives 36
aromatic hydrocarbons 32, 35
aromatics 34, 91, 161
arson investigation 8
atmospheric conditions 399, 403
atmospheric temperatures 399
auto-ignition 57
automatic sprinkler systems 5

B
"backdraft" explosion 47
benzene 32, 33, 36, 67
benzene rings 33
blanketing 398
blast hazard 397
blasting agents 397
BLEVE 10
block off operations 74
block valves 401
boiling point 10, 135
boilover 10, 18, 72
bond breakage 45
branched hydrocarbons 22, 25
branching effect 25
bromine 35
building codes 4
bulk storage plant 401
bulk storage terminals 398
butane 23, 24
butene 27
butylene 28
butylaldehyde 41

C
candle wax 24
carbohydrates 43
carbon dioxide 66
carbon monoxide 44
carbon tetrachloride 37
carbonyl group 35, 41
carboxyl group 35
carcinogens 38
catalyst carrier 36

cellophane 39
cellulose 43
chain reaction of burning 45
chemical activity 28
chemical compatibility 364
chemical dispersants 400
chemical energy 47
chemical extinguishing agents 69
chemical foam 75
chemical handling facilities 401
chemical plants 56
chemicals 219
CHEMTREC 56, 78, 396
chlorinated hydrocarbons 36
chlorination of methane 37
chlorine 35
chloroethane 37
chloroform 36, 37
chloromethane 36
clean-up contingency plans 399
clean-up equipment 399
cloud point 129
combustible gas 60
combustible liquids 11, 48, 60, 70, 72, 398
combustible materials 395
combustion 28
combustion characteristics 39
compressed gas 11, 403
compressed gas cylinder 403
compressibility data 135
compression 200
conduction 45, 50
container labels 398
continuous inspections 3
convalent bonds 23
convection 45, 50
corrective action 3, 8
corrosive gas 397
corrosive liquids 414
corrosive material 397
covalent bonding 18
covalent bonds 22, 27, 44

critical properties 135, 147
critical temperature 147
crude fractions 128
crude fractions, classification 128
crude oil 18, 71, 72
crude-oil storage tanks 72
cutting 4
cyclical hydrocarbons 34, 35

D
dangerous when wet materials 397
decane 24
degreaser 36
denaturant 38
denatured alcohol 38
density 79
density, of hydrocarbons 91
Department of Transportation 48, 283, 395, 401
depressant drugs 38
detection systems 4
dichloromethane 36
diethyl sulfide 147
diffusion flame 47
dimethyl ether 40
dimethyl ketone 41
diolefins 91
dispensing equipment 401
dispersants 400
dispersion modeling 403
dispersion models 403
distribution system 4
downwind protective action distance 404
dust explosions 4

E
educational programs 1
effective pressure 205
embalming fluid 41
emergency response forces 398
emergency response guidelines 403
emergency response information 219
endothermic 44
energy 43
enforcement functions 1

enthalpy 162, 171, 173
enthalpy, of light hydrocarbons 161
enthalpy, of petroleum fractions 172
environmental damage 399
environmental regulatory agencies 395
Environmental Protection Agency 399
esters 42
ethane 23, 27
ethanol 38
ethene 27
ethers 40
ethyl alcohol 38, 39
ethyl chloride 37
ethylene 28, 34, 66
ethylene dibromide 38
ethylene dichloride 37
ethylene glycol 39
ethyne 30
evacuation alarm systems 4
evaporation 403
exothermic chemical reactions 44
expansion waves 59
explosimeter 55
explosions 219, 397
explosion hazards 40, 364
explosive range 12, 55-57, 71
explosives 397
explosivity limits 59
exposure hazards 413
extinguishing agents 72, 77, 400, 413
extinguishing systems 2
extinguishing techniques 54

F

feedstock chemicals 34
fermentation, of wood 38
fire 397, 413
fire alarm 4
fire characteristics 69
fire codes 2
fire control 413
fire extinguishing agents 413
fire extinguishing systems 5
fire extinguishment 49
fire fighting forces 400
fire fighting guidelines 219
fire flow requirements 4
fire hazards 2, 23, 48, 219, 364, 397
fire inspections 2, 4
fire investigations 7, 8
fire point 49, 54
fire prevention 1, 3
fire protection 4
fire protection problems 7
fire protection program 1
fire protection specialist 1
fire protection systems 1, 2
fire pumps 4
fire reports 8
fire safe buildings 2
fire safety 3, 7
fire safety inspections 3
fire triangle 42, 43
fire-control practices 57
fire-extinguishing agents 37, 38, 50
firefighting foam 413, 414
first aid 219
first responders 74, 397, 414
flame impingement 71
flame length 59
flammability 42
flammable gases 24, 59, 397
flammable limits, calculation of 67
flammable limits, for hydrogen 64
flammable liquid fires 413
flammable liquids 4, 13, 38, 48, 69, 397, 398-400, 413
flammable range 47
flammable solids 397
flammable vapors 414
flash point 26, 32, 47, 49, 51, 53, 55, 70, 134, 398, 399
flash point temperature 13, 57
flashover 13

"flooding" rate 414
fluorine 35
fluoroprotein 413
foams 74, 400, 401
foam blanket 70, 74
foam coverage 399
forms of energy 30
frothover 18
fuel oil 52
fumigant 37
functional group 35, 36

G
gasoline 71
gasoline additives 38
glycerol 39
glycol 39
grain fumigant 38

H
halogenated hydrocarbons 35-38
halogens 35, 36
halon gases 77
hazard class 397
hazard materials incident 395, 396, 399
hazardous chemical spill 395
hazardous materials 29, 30, 34, 39
hazardous materials incident 395
hazardous materials response team 414
hazardous materials shipments 396
health effects 404
health hazards 219
heat content 161
heat detection systems 5
heat of ignition 7
heat of the reaction 7
heat wave 18, 71, 72
heats of combustion 79
heats of vaporization 79
heptadecane 26
heptane 24
hexane 24
high-expansion foam 76, 77
hose systems 5
housekeeping 4
hydrocarbon backbones 35, 36
hydrocarbon compounds 29
hydrocarbon derivative 15, 35
hydrocarbon vapors 148
hydrocarbons 22, 23, 35, 43
hydrogen cyanide 44
hydrogen sulfide 71
hydrogen 35
hydroxyl group 38
hydroxyl radical 35, 37, 38

I
ignition point 47, 49
ignition sources 49, 56
ignition temperature 15, 24, 32, 36, 39, 40, 47, 56
in-line proportioners 401
incendiary fires. 8
inert gases 205
infectious substance 397
ingestion exposure hazards 364
inhalation hazards 399
initial isolation zone 402, 404
initial response phase 395
insecticides 37
insensitive detonating substances 397
insensitive explosives 397
inspection practices 3
inspection programs 3
inspection properties 129
inspection reports 7
insurance carrier requirements 2
intermittent inspections 3
iodine 35
iodoform 37
isobutane 24
isolation distances 219, 399, 402
isomers 16, 22, 37, 28, 29, 35
isomers of the alkenes 29
isopentane 25
isopropyl alcohol 39

isothermal compression 200, 201

K
kerosine 57
ketones 41, 413

L
latent heat of vaporization 16, 50, 51 161
leaks 219, 395, 397, 400
lethal chemicals 397
lethal concentrations 403
life cycle of fire theory 46
life safety requirements 4
light hydrocarbons 161
light-ends processing operations 79
liquid pool evaporation rates 403
liquified gas 23, 40
liquified petroleum gases 23
low-boiling hydrocarbons 91
low-boiling paraffins 161
low-temperature polymerization 36
low-temperature solvents 36
lower explosion limit 16, 58, 364

M
mass explosion hazards 397
mechanical foam 75
mechanical-type foaming agents 76
melting point 79
meteorological conditions 402
meteorological data 403
methane 23, 28, 31, 66
methanol 38, 57
methyl alcohol 38
methyl amine 42
methyl bromide 37
methyl butane 31
methyl chloride 36
methyl ether 40
methyl ethyl ether 40
methyl ethyl ketone 41
methyl fluoride 37
methyl propane 31
methyl radical 31
methylene chloride 36
mixture rule 61
mixtures of hydrocarbons 205
molecular weights 79, 134, 135 202
Mollier diagrams 208
monomers 34, 42

N
naphthalene 52
naphthas 56
narcotic 36, 37
National Fire Protection Association 48
natural gas 23
neopentane 25
neutralizing agents 414
NFPA standards 2
nighttime atmospheric conditions 403
non-fire spills 400
non-flammable liquids 36
non-poisonous compressed gas 397
nonane 24
normal pentane 25

O
octane 24
octet rule 23, 27
olefins 91, 217
organic chemicals 28
organic chemistry 22
organic compounds 44
organic peroxide 40, 397
organic synthesis 39
OSHA regulations 2
OSHA standards 19,48
oxidation reaction 42
oxide radicals 45
oxidizer 43
oxidizing agents 47
oxygen-regulated fires 46

P
P-V-T relations, of hydrocarbon vapors 91
paint spraying operations 4
paper 43
paraffin hydrocarbons 65
paraffin series 24
paraffins 24, 91
pentane 24, 28
pentene 27
periodic inspections 3
peroxide radical 35
peroxides 42
personal safety equipment 5
petroleum 400
petroleum ethers 57
petroleum fractions 134
petroleum liquids 48, 51, 57
petroleum products 68, 79, 413
phenyl radical 36
physical constants 79
Pitot tube 5
placards 398
plant fire hazards 4
plastics 40, 44
plastics processing applications 36
plume dispersion 403
poison hazards 413
poisonous materials 397
polar solvents 413
polyester resins 39
polymerization 28, 40, 364
polymerization stabilizer 40
portable fire extinguishers 5
pour point 129
precipitation 414
pressure 79
process hazards 2
propane 23, 27
propanone 41
propellant for sprays 40
propene 27
properties of alkanes 26, 29
propionaldehyde 41
propylene 28, 34
propylene glycol 39
protective action distances 401, 402, 403
protective action guidance 403
protective action zone 402, 404
protective actions 395, 402
protective clothing 414
protective equipment 398
pseudo-critical temperature 173
public relations 3
public sewer system 398
pumping stations 401
pure compounds 135
pure hydrocarbons 135, 217
pyrolysis 18, 42

R
radiant heat 71
radiation 18, 45, 50
radiation heat 18
radicals 31, 35, 36
radioactive materials 397
rail cars 401
reactive materials 4
refined petroleum products 71
refrigerants 37
"regular" foam 413
regulatory agency 399
resonance 33
rubber 44
rubbing alcohol 39
rust 42

S
saturated hydrocarbons 23, 24, 28
sewer systems 398
shipping number designation 219
shipping papers 396, 398
shock waves 59
short term exposure limit (STEL) 19
site entry 398
slopover 18, 72
smothering-type extinguishing agents 54
solvent extractor 36

solvents 38
source term modeling 403
sources of ignition 398, 400
specific gravity 19, 57, 68, 79, 91, 399
specific heat 19, 50, 148
spill control 413
spill fires 400, 413
spill-containment team 399
spills 219, 395, 397, 399, 400
spontaneous combustion 49
spontaneously combustible material 397
stand-by equipment 399
static electricity 44, 45
steam explosion 72
storage facilities 414
storage hazards 2
storage vessel 395
straight-chain hydrocarbons 25, 27, 30, 32, 37
strong oxidizers 364
structural effect 19
structural formulas 24, 28, 29
subsonic jets 59
substituted hydrocarbons 35, 39
surface tension 50

T
tank car emergencies 401
tank trucks 401
temperature 79
tetrabromide 37
tetraethyl lead 37
tetrafluoride 37
tetrahedron of fire, theory 42, 45
tetraiodide 37
thermal degradation 19
thermal expansion, of liquid petroleum fractions 91
thermal properties 148
threshold limit value (TLV) 19
toluene 33
toxicological exposure guidelines 403
toxicological short-term exposure guidelines 403
transportation safety regulations 396

U
underground pipelines 401
unsaturated hydrocarbons 27, 30, 35
upper explosion limit 20, 364
U.S. Coast Guard 399

V
vapor clouds 400
vapor concentrations 403, 414
vapor control 414
vapor control agent 414
vapor density 20, 57, 63
vapor pressure 20
velocity 399
venting devices 20
vertical storage tanks 73
vinyl ether 40
vinyl radical 36
viscous petroleum fractions 135

W
water flow requirements 73
water flow tests 5
water reactive materials 413
water solubility 20, 57, 68, 399
water spray 414
water supplies 2, 4
water supply networks 2
water-reactive chemicals 414
water vapor 66
waterways 398, 399
welding 4
wind direction 399
wood 43
wood alcohol 38
wood spirits 38
wool 44

X
xylene 33