

# PROPANE EMERGENCIES

## THIRD EDITION

*Developed for the emergency response community and propane industry  
in cooperation with the National Propane Gas Association and with  
funding from the Propane Education & Research Council by:*

**MICHAEL S. HILDEBRAND • GREGORY G. NOLL**

**Special Notice:** As the third edition was going to press, new information concerning the fire safety of composite propane cylinders was developed by the authors. This supplements material found on pages 61-62 of this edition. You can download more information on this issue at [www.propanesafety.com](http://www.propanesafety.com).

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Third Edition

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**ALSO AVAILABLE:** The companion Facilitator's Guide by Michael Callan and companion video for Propane Emergencies by Emergency Film Group.

For more information on how to obtain copies of these materials visit us at [www.propanesafety.com](http://www.propanesafety.com).

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# DEDICATION

This book is dedicated to the safety of America's Emergency Responders: firefighters, rescue and medical personnel, hazardous materials response teams, and law enforcement officers who serve to safeguard the public.



# NOTICE

Hazardous materials emergency response work is dangerous, and emergency responders have died or sustained serious injury and illness while attempting to mitigate emergencies. There is no possible way that this text can cover the full spectrum of problems and contingencies for dealing with every type of propane-related emergency. The user of this book is warned to exercise all necessary cautions when dealing with propane gas emergencies. Always place personal safety first when handling a propane emergency.

It is the intent of the authors that this text be a part of the user's formal training in the management of hazardous materials emergencies. Even though this book is based on commonly used practices, references, laws, regulations, and consensus standards, it is not meant to set a standard of operations for any emergency response organization. The users are directed to develop their own Standard Operating Procedures which follow all system, agency, or employer guidelines for handling hazardous materials. It is the user's sole responsibility to stay up to date with procedures, regulations, and product developments which may improve personal health and safety.

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Readers of this material should consult the law of their individual jurisdictions for codes, standards and legal requirements applicable to them. This program merely suggests methods which the reader may find useful in implementing applicable codes, standards and legal requirements. This program is not intended nor should it be construed to (1) set forth procedures which are the general custom or practice in the propane industry; (2) to establish the legal standards of care owed by propane distributors to their customers; or (3) to prevent the reader from using different methods to implement applicable codes, standards or legal requirements.

The National Propane Gas Association and the Propane Education and Research Council assume no liability for reliance on the contents of this program. It is offered as a guide only to assist expert and experienced teachers and managers in training service personnel in their organizations.

Issuance of this material is not intended to nor should it be construed as an undertaking to perform services on behalf of any party either for their protection or for the protection of third parties.



# ACKNOWLEDGMENTS

In December 1998 we were approached by Tim Ferns, Chairman of the National Propane Gas Association's Education, Training, and Safety Committee, to determine if we would work with the propane industry to develop a textbook on how to safely handle propane emergencies. Tim, a propane marketer from the northeast, a volunteer firefighter and a committed safety specialist, explained that the propane industry, using funding from the newly organized Propane Education & Research Council (PERC), was looking for a training guide on propane emergencies and would provide one copy of the text, free of charge, to every fire department in the United States. We were skeptical but quickly persuaded by a very dedicated group of industry leaders and safety professionals. Both of us came away from our initial meeting motivated by their enthusiasm. It was clear our charge was to develop a credible and balanced program on propane emergency response for every firefighter in the country.

A year later, PERC distributed the initial textbook to more than 29,000 fire departments, state fire training agencies, state fire marshals and hazardous materials teams across the country, free of charge! Since then, the propane industry has continued to demonstrate its commitment to the safety of this nation's emergency response community by allocating nearly \$4 million to provide not only Propane Emergencies, but an entire training curriculum for the fire service and propane industry based on the text. There is a companion Facilitator's Guide with a 48-minute training video now available on DVD, and a CD with interactive scenarios and ready-to-use training slides for 4-, 8-, and 24-hour classes. Trainers can access much of the program, including a student note-taking guide, at [www.propanesafety.com](http://www.propanesafety.com). To facilitate training and community relationships between the propane industry and fire service, there is also an industry-specific Marketer Outreach Toolkit specifically targeted towards propane marketers. PERC has funded more than 30 Train-the-Trainer classes across the country training certified fire instructors and propane industry trainers. The Propane Emergencies program has also been adopted in whole or in part as the official propane training curriculum by many state fire training agencies. In short, this comprehensive program has reached many, many first responders and propane industry members.

Now, eight years later, we are writing the third edition. There is updated training information, particularly in the area of rollover and recovery response, a fresh look at cylinders and tanks, and we've addressed emerging technologies within the propane industry. Our focus has always been about building consensus within the industry on technical issues and developing a credible and technically accurate text for emergency responders. To do this we once again teamed with the public safety community, including both the fire service and law enforcement, and industry specialists, some from the very first PE committee and this time led by Carlton Revere, an independent propane marketer from Virginia. Together, this team provided the knowledge and expertise a book of this caliber requires. We also relied heavily on the industry's updated and state-of-the-art Certified Employee Training Program (CETP), a wide-ranging training course for the tens of thousands of employees who handle, transport, and service propane equipment and appliances.

Propane Emergencies has evolved from a single text into a comprehensive curriculum of training, instruction, and outreach to both the fire service and propane industry. Without a doubt, this program has become the benchmark by which all

other industry hazardous materials training curriculums are measured. If you get the chance, shake the hand of a propane marketer the next time you run into one. Because of their dedication and financial commitment to safety and education, this is available. We would also like to thank, specifically, the following people who gave their time and expertise to make Propane Emergencies and the entire program the best there is.

Stay safe,

Michael Hildebrand

Greg Noll

### THIRD EDITION REWRITE TEAM

After being available for eight years, the Propane Emergencies team decided to undergo a textbook rewrite. The goal was to address in greater detail rollovers and recovery techniques, emerging technologies, and use the industry's updated graphics and information. We are grateful for the rewrite team's chairman and his leadership along with the committee's many volunteer hours without which, this rewrite would not be possible. Please notice the asterisk next to some of the names listed alphabetically below. These industry specialists also worked with us in 1998 to create the Propane Emergencies program.

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## 1998 PROPANE EMERGENCIES DEVELOPMENT TEAM

In 1998 we worked with the folks identified above (\*) as well as these industry leaders from NPGA's Education, Training and Safety Committee. We are indebted to Tim Ferns, the chairman at that time, and all of the propane industry people listed alphabetically here with their 1998 information. These pioneers, along with those who continue to work with us now, created the Propane Emergencies program.

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## THIRD PARTY REVIEWERS

We are firm believers in the process of third party review, especially when fire-fighter safety is involved. To validate the material and assure quality control, we relied on a diverse and experienced group of specialists from the emergency response community throughout all three editions of this textbook. They are listed alphabetically below.

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The PE3 Team would also like to extend our sincere thanks and appreciation to the Kings County (CA) Sheriffs Department, the Kings County (CA) Fire Department, and Epplers Towing & Recovery of Fresno, CA for their professionalism and support in filming most of the photos used in Section 9. All three organizations are a credit to their respective professions, and set a high bar of excellence.

## PRODUCTION TEAM

There is a production team behind every book and we had some of the best in the business. In 1998, Susan Spear (NPGA) was the key staff person on the project and provided regular liaison between our team and NPGA's various committees. Sue handled all of the management, administration, and logistical tasks which are critical for a project of this size. For the third edition, Elizabeth Gardner was the project coordinator for PERC and worked with us during the rewrite process. All three editions of Propane Emergencies relied on George Dodson and Kathleen Lawyer with

Red Hat Publishing and Lightworks Photography and Design for the overall direction, layout, design, art, and photography. For many years, Red Hat Publishing also provided the printing and distribution of the Propane Emergencies curriculum materials. In 1998 Patricia M. Daly provided copy editing for the text and Michael Marks, with Lightworks Interactive, designed the graphics for the scenarios in Section 8 and was the first Web Master for the program's then-dedicated Web site ([www.propanesafety.com](http://www.propanesafety.com)). Finally, our friend and colleague, Mike Callan, was and continues to be the key designer and writer of the companion Facilitator's Guide. He worked closely with us on every step of the production process.

## About the Propane Education & Research Council



The purpose of the Propane Education & Research Council (PERC) is to promote the safe, efficient use of propane as a preferred energy source. The Council receives funding by an assessment or "check-off" on each gallon of odorized propane gas. The assessment collects five-tenths of one cent per gallon and is projected to collect \$45.1 million in 2007 to fund programs and projects such as the Propane Emergencies program. Through PERC, the propane industry has committed itself to multi-year, multi-million dollar efforts to improve consumer, employee and community safety. In addition, PERC funds the research and development of new and more efficient propane equipment and works to expand public awareness of propane and its many uses and environmental advantages.

For more about the Propane Education & Research Council go to [www.propanecouncil.org](http://www.propanecouncil.org) or contact them at 1140 Connecticut Avenue, N.W., Suite 1075, Washington, D.C., 20036. The phone number is 202-452-8975.

## About the National Propane Gas Association



The National Propane Gas Association (NPGA) is the national trade association representing the U.S. propane industry. Membership includes small businesses and large corporations engaged in the retail marketing of propane gas and appliances; producers and wholesalers of propane equipment; manufacturers and distributors of propane gas appliances and equipment; fabricators of propane gas cylinders and tanks; and propane transporters.

With a membership of more than 3,500 companies in all 50 states, 38 affiliated state or regional associations, and members in 28 foreign countries, NPGA represents every segment of the propane industry. The mission of NPGA is to advance safety and increase the use of propane through sound public policy.

NPGA created the Propane Emergencies program with funding from the Propane Education & Research Council to safely train first responders in the event of an emergency.

For more information on NPGA, please visit [www.npga.org](http://www.npga.org), or contact them at 1150 17th Street, N.W., Suite 310, Washington, D.C. 20036. The phone number is 202-466-7200.

## About Hildebrand and Noll Associates, Inc.

Mike Hildebrand, CSP, and Greg Noll, CSP, have been friends, business partners, and emergency responders for over 25 years. Their consulting firm, Hildebrand and Noll Associates, Inc., specializes in hazardous materials emergency planning and response for industry, public safety, and the military. They are the authors of six books on hazardous materials emergency response.

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# HOW TO USE THIS BOOK

## ABOUT THE BOOK

**Propane Emergencies** is a comprehensive textbook which is part of a coordinated training program for emergency responders from both public safety agencies and the propane industry. The program consists of a Facilitator's Guide with instructor lesson plans, a companion CD loaded with title slides, and a companion video tape. For more information on the program visit our Propane Emergencies Web site at [www.propanesafety.com](http://www.propanesafety.com).

This book has been designed to help emergency responders develop the knowledge and skills necessary to safely and effectively manage a propane emergency in transportation or at fixed facilities. It is based upon commonly used practices, references to nationally recognized engineering practices, regulations and consensus standards, and training programs.

The Incident Management System and tactical guidelines used in this book are based upon the Eight Step Process®. The system establishes a management structure which fits any size or level of hazmat response; it provides an incident management framework with one specific goal to maximize safety for emergency response personnel and the general public.

The book is divided into ten major sections.

Section 1, *"Introduction, Scope, and Purpose,"* reviews the objectives of the book and examines current issues involving propane emergencies.

Section 2, *"Physical Properties and Characteristics of Propane,"* explains how propane is refined and processed, its physical characteristics, and various combustion characteristics.

Section 3, *"Standards, Codes, and Regulations,"* takes an in-depth look at the various consensus standards, and state and federal regulations which serve as the basis for propane storage tank design, construction, and operation.

Section 4, *"Non-Bulk Container Design and Construction Features,"* reviews the basic construction features of propane stationary tanks, mobile tanks, cylinders, and DOT portable tanks.

Section 5, *"Bulk Transportation Design and Construction,"* reviews the basic construction features of cargo tank trucks, railroad tank cars, and intermodal containers used to transport propane.

Section 6, *"Bulk Plants and Bulk Storage Tanks,"* reviews the basic layout and design of bulk storage plants and bulk storage tanks up to 60,000 gallon capacity.

Section 7, *"General Emergency Response Procedures,"* reviews the Incident Management System as it applies to propane incidents, and introduces the Eight-Step Process® as a tactical decision-making framework for managing propane emergencies.

Section 8, “*Tactical Response Guidelines for Propane Emergencies*,” provides general guidance on how to sizeup specific types of propane fires and leaks, evaluate their hazards and risks, and mitigate various types of container emergencies.

Section 9, “*Product Removal, Transfer, and Recovery Operations*,” provides some general guidance on how to evaluate damage to bulk transportation containers, site safety practices, grounding and bonding considerations, methods of product removal, and uprighting loaded cargo tank trucks.

Section 10, “*Appendices*,” includes a detailed glossary, suggested readings and references, and other support materials.

## USING THE BOOK

This book may be used on an individualized self-study basis, or as part of a formal training program offered in a plant, or at emergency services training academies. The book is supported by a companion Facilitator’s Guide, which provides guidance to the instructor on delivery of the material in a classroom in a 4, 8, and 24 hour format.

There are several features of this book you should be familiar with:

**Objectives:** At the beginning of each chapter you will find a list of educational objectives which will be covered in Sections 1 through 9. They will help you focus your studies on the most important information in the book. The objectives also help compare the information provided in the book with the Competencies for the Technician with Flammable Gases Bulk Storage Specialty Area requirements outlined in the appendix of *NEPA 472—Professional Competence of Responders to Hazardous Materials Incidents*. After you have completed the reading assignment, you should have a working knowledge of each chapter objective.

**Design:** The text is designed to assist the student by providing:

- Easy to use, 8-1/2 x 11” format.
- A “NOTES” column for personal notetaking.
- Screened information and bold printing to note important facts.
- A glossary of important terms and definitions.

**Scan Sheets:** Scan Sheets are placed throughout the text in a screened and boxed format. They include lots of detail and background information on one particular topic. You “scan” over this information if you want to know more about the topic. You can read the entire book without studying the Scan Sheets and still meet the objectives listed at the beginning of each chapter.

**Summary:** A brief statement is located at the end of each chapter which summarizes the key points and intent of that unit.

**References and Suggested Readings:** At the end of the book is a list of books, articles, videos and other related educational materials that were either referenced in writing the book or can be consulted for additional information.





## INTRODUCTION, SCOPE AND PURPOSE



## OBJECTIVES

- 1) Describe the scope and target audience for this book.
- 2) Define the key players who may become involved in a propane emergency and explain their role in resolving the emergency.

## ABBREVIATIONS AND ACRONYMS

|      |                                               |
|------|-----------------------------------------------|
| AHJ  | Authority Having Jurisdiction                 |
| API  | American Petroleum Institute                  |
| CFR  | Code of Federal Regulations                   |
| CSB  | U.S. Chemical Safety Board                    |
| EMS  | Emergency Medical Services                    |
| ERT  | Emergency Response Team                       |
| GPA  | Gas Processors Association                    |
| HMRT | Hazardous Material Response Team              |
| IC   | Incident Commander                            |
| LPG  | LP-Gas Liquefied Petroleum Gas                |
| NFPA | National Fire Protection Association          |
| NIMS | National Incident Management System           |
| OSHA | Occupational Safety and Health Administration |
| PIO  | Public Information Officer                    |
| UC   | Unified Commanders                            |

## INTRODUCTION

### SCOPE OF THIS BOOK

This book is about how to safely respond to propane emergencies. Propane is a flammable gas that is sometimes generically referred to as LP-Gas, LPG, or Liquefied Petroleum Gas. These terms are often used interchangeably and, while it is true that they have similar fire hazards, propane is only one of several constituent gases that make up Liquefied Petroleum Gas (LPG). For example, commercial grade LPG manufactured at a refinery is primarily made up of propane-butane mixtures, but might also contain small percentages of ethane, ethylene, propylene, isobutane, or butylene, all of which can cause slight variations in LPG's properties (e.g., flammable range, vapor pressure, etc.). So, while it is true that LPG is primarily a mixture of flammable gases that includes propane, the majority of the LP-Gas used in our homes and in the workplace primarily consists of propane or some combination of propane and butane mixtures. In Section 2 of this book we will get into more detail on the physical and chemical properties of LPG vs. propane and the different grades of propane.

Propane is the LP-Gas most frequently encountered by emergency responders and can be found in a wide variety of industrial, commercial, and consumer settings. Attempting to cover the numerous emergency response scenarios for the entire propane system would probably take two or three books. Therefore, the scope of this textbook will be limited to those scenarios most frequently encountered by emergency responders and involving propane in residential occupancies, the workplace, in bulk transportation and as a fuel for motor vehicles. This textbook will not deal with emergencies involving LP Gases at gas processing plants, refineries, pipelines, ships, or barges. Readers can obtain additional information on these topics from the American Petroleum Institute (API), Gas Processors Association (GPA), or the National Fire Protection Association (NFPA).

## TARGET AUDIENCE

Our primary target audience for this book is emergency responders from public safety and industrial organizations. On the public safety side, the audience primarily consists of operations and technician level responders, such as firefighters and members of Hazardous Materials Response Teams. Certain sections of the book may also be of interest to emergency medical services, rescue squads, emergency management, and law enforcement agencies. On the industrial side, the book is intended for propane marketers, propane industry product and container specialists, and private environmental or emergency response contractors.

## THE PLAYERS

Hazardous materials incidents often bring a wide variety of organizations to the scene of an incident. This is especially true at major fires or product releases at bulk plants, or at incidents involving bulk cargo tank trucks or rail cars. Personnel with different specialties and expertise must get involved to resolve the problem, and it is sometimes difficult to “identify the players without a score card.” The key to success is to have a coordinated incident management structure where all of the players integrate their resources to manage the problem in a safe and effective manner. The National Incident Management System (NIMS) serves as the baseline incident management structure within the United States (see additional information in Section 7).

Who are all of these people and what is their role in the incident? The range of participants who may get involved in a major propane emergency include:

## COMMAND PLAYERS

**The Incident Commander (Command or IC)**—The individual responsible for establishing and managing the overall incident action plan for the emergency. This process includes developing an effective organizational structure, developing an incident strategy and tactical action plan, allocating resources, making appropriate assignments, managing information, and continually attempting to achieve the basic command goals.

In most states, the Incident Commander will be a senior fire department officer or law enforcement officer from the authority having jurisdiction (AHJ) over the incident. Once the emergency phase is terminated, command may be transferred to another agency or individual. Regardless of which agency or individual is in command, he or she must be trained and qualified to assume these duties as required by OSHA under 29 CFR 1910.120 (q) (6).

**Unified Commanders (UC)**—Command-level representatives from each of the primary responding agencies who represent their agency's interests as a member of the unified command organization. Depending upon the scenario and incident timeline, they may be the lead IC or play a supporting role within the command function. The members of unified command manage their own agency's actions and ensure all efforts are coordinated through the unified command process.

**ICS General Staff**—NIMS provides a mechanism to divide and delegate tasks and develop a management structure to handle the overall control of the emergency. Section Chiefs are members of the IC's general staff and are responsible for the broad response functions of Operations, Planning, Logistics and Finance/ Administration. Individuals below the section level are front-line supervisors who implement tactical objectives to meet strategies established by the IC within a branch, group or division.



**FIGURE 1-1** Unified command is an essential element in the management of many propane emergencies.

**ICS Command Staff**—Those individuals appointed by and directly reporting to the Incident Commander. These include the Safety Officer, the Liaison Officer, and the Information Officer (PIO).

## RESPONSE PLAYERS

**Fire/Rescue/Emergency Medical Services (EMS)**—Provide resources for fire suppression, rescue, and emergency medical triage, treatment and transportation. They implement assigned tasks, provide support to specialized units, and help to coordinate the overall response efforts. Personnel are members from emergency services organizations who are normally organized into units called “companies.” They are usually organized along the lines of a paramilitary structure with a chief officer, company officers, and firefighters/EMTs.

**Emergency Response Team (ERT)**—Crews of specially trained personnel used within industrial facilities for the control and mitigation of emergency situations.

They may consist of full-time personnel, shift personnel with ERT responsibilities as part of their job assignment (e.g., plant operators), or volunteer members.

**Hazardous Materials Response Teams (HMRT)**—Crews of specially trained and medically evaluated individuals responsible for directly managing and controlling hazmat problems. They may include people from the emergency services, private industry, governmental agencies, or any combination. They generally perform more complex, technician-level tasks and skills than the fire, rescue, and EMS companies. Depending upon the jurisdiction, HMRTs may function as a technical advisory group or provide “hands-on” operational capabilities at a propane emergency.

**Law Enforcement Agencies**—Law enforcement officers representing municipal, county, or state police agencies or county and parish sheriffs departments. They enforce local laws, provide site security on public property, maintain traffic control, and sometimes take the lead in accident or fire investigations. At some incidents there may be law enforcement representatives on scene from local, county, and state agencies. This is especially the case at transportation accidents. In some states, the State Police or Highway Patrol have jurisdiction over hazardous materials incidents on interstate highways and serve as the Incident Commander.

## OTHER KEY PLAYERS

**Communications Personnel**—The central communications function for emergency services. They receive 911 calls for assistance and dispatch appropriate units to the scene of the incident. They provide a crucial link for those working on the scene by dispatching additional needed resources, including technical information specialists, product and container specialists, and chemical manufacturers.

**Propane Facility Managers**—Individuals who normally do not have an on-scene emergency response function, but who are key players within a propane company.. They are typically responsible for providing logistical support to field emergency response units and for coordinating external issues, including community liaison, media relations, and governmental notifications.

**Industrial Plant Representatives**—Within the LP-Gas industry, an industrial plant is a facility that utilizes LP-Gas incidental to plant operations, with LP-Gas storage of 2,000 gallons (7.6 m<sup>3</sup>) water capacity or more, and receives gas by means of tank car, truck transport, or truck lots. Normally LP-Gas is used through piping systems in the plant but also can be used to fill small containers, such as for engine fuel on industrial trucks (e.g., forklifts). Since only plant employees have access to these filling facilities, they are not considered to be distributing points as defined by NFPA 58—*The LP-Gas Code*. Under NFPA 58, an industrial plant is distinctly different from a Gas Plant, which produces gas in bulk quantities.

**Product and Container Specialists**—Personnel who work for propane marketers, and owners, operators, and transportation companies who handle propane gas. They have extensive training, experience and expertise in specialty areas such as container design, safety devices, off-loading techniques, and the physical and chemical properties of propane. There may be several specialists at the incident scene having different areas of expertise (container expertise vs. product expertise) and representing different owners and operators.

**Support Personnel**—Individuals who provide important support services at the incident. Public works employees, heavy equipment operators, and food service personnel are some examples.





**FIGURE 1-2** Product and container specialists can provide technical information and assistance to the Incident Commander.

**Technical Information Specialists**—Individuals who provide specific expertise to the Incident Commander either in person, by telephone, or through other means. They may represent the shipper or carrier, or be otherwise familiar with the chemicals or problems involved. Within an industrial plant, examples would include Industrial Hygiene and Environmental Affairs representatives. CHEMTREC, Professional Emergency Response Services, and the Local Emergency Planning Committee often provide an excellent way to reach information resources in any given area of expertise.

**Environmental Clean-up Contractors**—Individuals who may provide both mitigation and support services at the incident. While propane is nontoxic and does not pose an environmental hazard, contractors may perform product transfer operations, site clean-up and recovery of spills such as gasoline or diesel, and related remediation operations. Personnel should be trained to meet the training requirements of OSHA 1910.120, paragraphs (b) through (o).

**Salvage and Recovery Specialists**—Personnel skilled in the use of heavy equipment such as cranes, cables, slings, and lifting devices like air bags and mat jacks. They are an important player in safely uprighting overturned bulk transport vehicles.

**Towing Companies**—Personnel who operate heavy tow trucks, sometimes called wreckers or cranes. They usually specialize in towing wrecked vehicles and often get involved in uprighting cargo tank trucks. They should not be confused with Salvage and Recovery Specialists. The majority of towing companies do a great job and stay within their area of expertise. In some states, training and certification programs for vehicle recovery operators have been initiated by both the towing and propane industries. However, some have a reputation among Hazardous Materials Response Teams for sometimes “getting in over their head” with inadequately sized rigs and equipment as well as with personnel who are unfamiliar with the hazards of flammable gases.

**Government Officials**—Individuals who normally do not have an emergency response function, but who have a legitimate interest in the incident, its outcome, and its impact upon their constituents. Examples include mayors, city or county managers, and other elected officials. Failure to address their questions and concerns within the incident management organization can have significant political and/or organizational impacts both during and after the emergency.

**News Media**—Individuals representing various elements of the media who work to inform the public of major happenings within their community or region. Because of the unusual and often frightening nature of hazardous materials incidents, it is very important that the public be accurately informed quickly and regularly of the incident. Television and radio are excellent methods with which to coordinate and manage large-scale public protective actions activities. On-scene media may also be willing to provide quality video-tape equipment and helicopter shots for emergency service use in exchange for coverage.

**Investigators**—Individuals who are responsible for determining the origin and cause of the hazmat release. A hazmat incident is not really concluded until this investigation is complete. Future legal proceedings, possible regulatory citations or civil actions, and financial reimbursement for the time, equipment, and supplies of emergency services may well depend upon the investigators' efforts. Certain types of incidents require interaction between investigators on the federal, state, and local levels, as well as in the private sector. There may be more than one investigator representing different agencies with different missions. For example, the State Fire Marshal, the State Bureau of Motor Carriers, the National Transportation Safety Board (NTSB), the Chemical Safety and Hazard Investigation Board (CSB), insurance investigators, etc., may all be involved.

**Victims**—Individuals who may be exposed, contaminated, injured, killed or displaced as a result of the hazardous materials incident. Once emergency responders begin to provide treatment and care, they become patients. Special care should be given to their welfare, and the trend in emergency services is to treat them as "customers" of the emergency response organization providing care, not as nameless "victims."

**Spectators**—Employees of the facility and/or general public who arrive at the scene to assist or observe the incident. Since they are often difficult to control—especially during long-term campaign incidents—spectators need to be monitored and managed constantly to ensure their safety. At fixed facilities, spectators may be "evacuees" or employees who have left the facility when the emergency alarm was sounded.

**Technicians with a Flammable Gases Bulk Storage Specialty**—As defined by NFPA 472, those persons who, in incidents involving bulk flammable gas storage tanks, provide support to the hazardous materials technician and other personnel, provide strategical and tactical recommendations to the Incident Commander, provide oversight for fire control and product removal operations, and act as a liaison between technicians, firefighting personnel, and other outside resources. These technicians are expected to use appropriate personal protective clothing and equipment and specialized fire, leak, and spill control equipment.

**The Hazardous Material and the Container**—The Hazardous Material (HazMat) is a potentially harmful substance or material that has escaped or threatens to escape from its container. Whenever it has already escaped, the hazardous material should be considered a threat to all of the players. The HazMat should be treated with great

respect and carefully monitored at all times. The “Container” holds the HazMat (in our case, propane) and when stressed beyond its design limitations, can release its contents. The release can be controlled by a safety design feature or it can be uncontrolled and violent as a result of total container failure. Hazardous Materials Response Teams are trained to evaluate the hazards and risks of the HazMat and its container independently.

## SUMMARY

Propane is a flammable gas that is sometimes generically referred to as LP-Gas, LPG, or Liquefied Petroleum Gas. LPG is made up of propane-butane mixtures, but might also contain small percentages of ethane, ethylene, propylene, isobutane, or butylene, all of which can cause slight variations in LPG’s properties.

The primary target audience for this book consists of firefighters and members of Hazardous Materials Response Teams, propane marketers, propane industry product and container specialists, and private or emergency response contractors.





# PHYSICAL AND CHEMICAL PROPERTIES OF PROPANE

**OBJECTIVES**

- 1) List the two major flammable gases used in the Liquefied Petroleum Gases (LPG) industry.
- 2) Describe the two primary reasons for odorizing propane.
- 3) Identify five basic characteristics of LP-Gases.
- 4) Describe the following physical properties of propane and explain their significance in the risk assessment process at a propane incident:
  - Specific gravity
  - Vapor density
  - Boiling point
  - Expansion ratio
  - Vapor pressure
- 5) Describe the following chemical properties of propane and explain their significance in the risk assessment process at a propane incident:
  - Flammable limits
  - Ignition temperature
  - Combustion characteristics
- 6) Describe the three basic ways propane behaves when stored in a closed container.
- 7) Describe the relationship between heat, temperature, and boiling point as it relates to the storage of propane in a closed container.
- 8) List the basic products of incomplete combustion of propane.
- 9) List the five primary signs and symptoms of carbon monoxide poisoning.
- 10) Describe the basic hazards of aldehydes as they relate to incomplete combustion of propane.

**ABBREVIATIONS AND ACRONYMS**

|                       |                                                                            |
|-----------------------|----------------------------------------------------------------------------|
| ASHRAE                | American Society of Heating, Refrigeration, and Air Conditioning Engineers |
| BTU                   | British Thermal Unit                                                       |
| BTU / ft <sup>3</sup> | British Thermal Unit per Cubic Foot                                        |
| CO                    | Carbon Monoxide                                                            |
| ft <sup>3</sup>       | Cubic Feet                                                                 |
| LFL                   | Lower Flammable Limit                                                      |
| LPG                   | Liquefied Petroleum Gases                                                  |
| NFPA                  | National Fire Protection Association                                       |
| OSHA                  | Occupational Safety and Health Administration                              |
| ppb                   | Parts per Billion                                                          |
| TLV / TWA             | Threshold Limit Value—Time Weighted Average                                |
| UFL                   | Upper Flammable Limit                                                      |

## PROCESSING AND REFINING LP-GASES

Propane belongs to a family of chemical compounds known as hydrocarbons. This means they are made up of hydrogen and carbon atoms only. When looking at their chemical structure, propane is classified as a straight-chain hydrocarbon that belongs to a chemical class known as the alkanes (NOTE: All hydrocarbons in the alkane series end in ane). Commonly known alkane hydrocarbons include methane ( $\text{CH}_4$ ) (the primary component of natural gas), ethane ( $\text{C}_2\text{H}_6$ ), propane ( $\text{C}_3\text{H}_8$ ), and butane ( $\text{C}_4\text{H}_{10}$ ). Of these hydrocarbons, propane, butane, and their isomers are classified as LP-gases (liquefied petroleum gases).

Propane and butane are normally found with crude oil or natural gas. About 30% of the propane and butane produced today is extracted with and refined from crude oil, while the other 70% is processed from natural gas.

*Crude Oil Extraction and Refining*—LP-gases are processed from crude oil by heating the crude oil until it begins to boil. Boiling crude oil produces many different gaseous hydrocarbons, including propane and butane. These different gases are captured under pressure and slowly cooled. Depending on their boiling point, each of the gases will condense into a liquid, one at a time, as the temperature drops below the boiling point of each gas. Both propane and butane are captured in this manner and then stored as a liquid under pressure.

*Natural Gas Processing*—LP-gases are extracted from natural gas in several different ways. When natural gas is removed from a gas pocket, it is normally referred to as a “wet” gas. The term wet means that the gas is a mixture of hydrocarbon gases and, in some cases, liquids. Once removed from the ground, the different gases and liquids are separated, processed, and refined. Among the gases and liquids removed are methane (chief component of “natural gas” used in appliances), propane, butane, and, in many cases, natural gasolines (pentane, heptane, etc.).

The two primary sources for LP-gases are quite different. However, once refined, there is little difference between the LP-gases processed from crude oil and those processed from “wet” natural gas liquids.

## LP-GAS BLENDS

In addition to the basic differences between propane and butane, there are different types or blends that are used in the LP-gas industry. These blends are processed to meet the different needs of the many LP-gas customers. The four major blends are:

**Commercial Propane**—A type of LP-gas that consists mainly of propane and propylene (a straight-chained hydrocarbon with a double chemical bond similar to propane).

**HD5 Propane**—A type of LP-gas that consists mainly of propane with a maximum of 5% propylene.

**Commercial Butane**—A type of LP-gas that consists mainly of butane and butylene (a straight-chained hydrocarbon with a double chemical bond similar to butane).

**Butane/Propane Blends**—A mixture of both butane and propane. The blend is given in percentages, indicating the proportion of each LP-gas in the blend. A typical blend is 60/40, indicating that it is a mixture of 60% butane and 40% propane.

## LP-GAS PHYSICAL AND CHEMICAL PROPERTIES

To mount a safe and effective response to a propane incident, responders must understand (1) how the product will behave (i.e., its physical properties) and (2) how it can harm (i.e., its chemical properties). These properties are critical elements in the risk assessment process and in developing an incident action plan to control and mitigate the incident. Physical and chemical terms covered in this section may be referenced from either the Material Safety Data Sheet (MSDS) or from emergency response guidebooks.

### PHYSICAL PROPERTIES

Physical properties provide information on the behavior of a material. These properties or characteristics can be observed or measured, and provide responders with knowledge of how LP-gases will behave both within and after being released from its container.

Key physical properties common to all LP-gases include:

- They are tasteless, colorless, and usually odorless.
- LP-gases are capable of being either a liquid or gas. However, under ambient conditions, propane will be a gas.
- Most LP-gases can be stored and transported as liquids under pressure and can easily vaporize into gas under the proper conditions.
- Under normal outdoor temperatures liquid LP-gases expand rapidly into gas. One cubic foot of liquid propane will boil off and produce 270 cubic feet of propane vapor.

LP-gases will expand when heat is applied. If stored inside a container, this expansion will increase the volume of the liquid and the pressure inside the container. LP-gases are not toxic, but they present possible inhalation hazards. If released in a confined space, propane can displace oxygen and act as a simple asphyxiant.

### SPECIFIC GRAVITY AND VAPOR DENSITY

An important characteristic of propane gas is its weight and how it compares with the weights of other liquids and gases. One of the most common ways of making such a comparison is the physical property known as specific gravity.

#### SPECIFIC GRAVITY OF LIQUIDS

The specific gravity of a liquid is the comparison of the weight of a given volume of one liquid at a certain temperature with the weight of the same volume of water at the same temperature. For example, if the specific gravity of a liquid at 60°F (15.6°C) is 3.0, then a given volume of that liquid at 60°F (15.6°C) is three-times as heavy as the same volume of water at 60°F (15.6°C).

In the case of propane liquid, the average specific gravity is 0.504 at 60°F (15.6°C). (See Table 2-1.) This means that propane liquid is a little more than one-half the weight of water at 60°F (15.6°C). It is necessary to know and to understand the meaning of specific gravity of propane liquid (a) when the propane is delivered to the plant, and (b) when propane liquid is used in filling operations.

When propane is delivered to the plant, the specific gravity of propane liquid is normally marked on the bill of lading. Since different liquids have different specific gravities, this value is used to ensure that the delivery is in fact propane liquid. The specific gravity of propane liquid is also used to determine the amount of propane liquid being delivered.

The specific gravity value of propane liquid is also used during filling operations. In this case, the specific gravity is used to determine the proper filling limit for the container, ensuring that the container is properly filled.

#### PHYSICAL PROPERTIES OF PROPANE, BUTANE, AND METHANE

|                                                 | Propane                       | Butane                         | Natural Gas<br>(Methane) |
|-------------------------------------------------|-------------------------------|--------------------------------|--------------------------|
| Chemical Formula                                | C <sub>3</sub> H <sub>8</sub> | C <sub>4</sub> H <sub>10</sub> | CH <sub>4</sub>          |
| Specific Gravity (Liquid)                       | .504                          | .582                           | .3                       |
| Vapor Density                                   | 1.50                          | 2.01                           | .60                      |
| Weight Per Gallon                               | 4.20 lbs.                     | 4.86 lbs.                      | 3.55 lbs.                |
| Boiling Point (Atmospheric)                     | -44° F                        | 31° F                          | -260° F                  |
| Ignition Temperature                            | 920° F                        | 900 – 1000° F                  | 1,150° F                 |
| Maximum Flame Temperature                       | 3,595° F                      | 3,615° F                       | 3,400° F                 |
| Upper Flammable Limit                           | 9.60%                         | 8.60%                          | 14%                      |
| Lower Flammable Limit                           | 2.15%                         | 1.55%                          | 4%                       |
| Ideal Combustion Ratio<br>(Air to Gas)          | 24 to 1                       | 31 to 1                        | 10 to 1                  |
| Heat Value Per Cu. Ft.<br>(Vapor)               | 2,488 BTU                     | 3,280 BTU                      | 1,000 BTU                |
| Heat Value Per Pound (Liquid)                   | 21,548 BTU                    | 21,221 BTU                     | —                        |
| Heat Value Per Gallon<br>(Liquid)               | 91,502 BTU                    | 102,032 BTU                    | —                        |
| Cubic Feet Vapor Per Gallon                     | 36.38 Cu. Ft.                 | —                              | —                        |
| Cubic Feet Vapor Per Pound                      | 8.66 Cu. Ft.                  | —                              | —                        |
| Latent Heat of Vaporization<br>at Boiling Point |                               |                                |                          |
| Per Pound                                       | 184 BTU                       | 153.59 BTU                     | 219.22 BTU               |
| Per Gallon                                      | 773 BTU                       |                                |                          |

TABLE 2-1

## VAPOR DENSITY

Vapor density is the comparison of the weight of a given volume of a gas at a certain temperature with the same volume of air at the same temperature. Propane vapor has a vapor density of 1.52 at 60°F (15.6°C).

The important point to remember is that propane vapor is about 1.5 times heavier than air (air = 1.00). If a leak develops in a gas line or container, propane readily dissipates. However, under the right conditions, propane gas may settle in low unventilated areas and can become concentrated if there is little or no air movement. This is critical information when trying to find the source of a leak, or working in an area where a leak has occurred. See Table 2-1 for a comparison of the physical properties between propane, butane and methane.

## ODORIZATION OF PROPANE

Propane is both odorless and colorless in its natural state. In order to facilitate the detection of propane leaks, a commercial odorant is added. Effective odorization serves two primary purposes, including:

- Permits the detection of leaks before gas concentrations reach a hazardous level, and
- Reduces gas losses through early detection and repair of leaks.

NFPA 58 states that all LP-gases must be odorized prior to delivery to the bulk plant by the addition of a warning agent that can be detected by a distinct odor down to a concentration in air of not over 20% of the lower flammable limit (LFL).

Minimum safety standards have been set by the Department of Transportation (CFR 49 192.625), which states that a combustible gas in a distribution line must contain a natural odorant or be odorized so that at a concentration in air of 20% of the lower flammable limit (LFL) the gas is readily detectable by a person with a normal sense of smell.

Unodorized LP-Gas may be encountered in some response scenarios. For example, unodorized propane is often used in petrochemicals and as a propellant gas for aerosol cylinders. When transported in bulk containers such as rail cars and cargo tank trucks, both the container and shipping papers must specifically state that the LP-gas is not odorized.

Although other odorants may be used, the most commonly used is ethyl mercaptan that is added at the rate of approximately one pound per 10,000 gallons of propane. The odor threshold of the mercaptans is in the range of one part per billion (ppb).

Desirable characteristics for a gas odorant vary considerably, depending upon the gas processor's objectives and needs and geographic locations. Some of these characteristics include:

**Odor**—The odor should be unpleasant and distinctive. It should be readily identifiable as gas and dissimilar to other household odors or to odors prevailing in the area. It should not fatigue the olfactory senses unduly.

**Volatility**—Odorant should not condense out of the gas at pressures, temperatures, and odorizing rates employed.

**Inertness**—Odorant should be inert enough not to polymerize, decompose, or react with other constituents of the gas or with materials in the distribution system or appliances.



**Absorption by Soil**—Gas passing through the soil should retain sufficient odor to remain detectable.

**Corrosion**—Odorant should be non-corrosive under any conditions encountered in transmission, distribution, and utilization. This calls for both a lower sulfur content and a low reactive type of sulfur bonding in the molecule.

**Combustion Products**—Odorant should burn completely in the gas flame to form products which are not corrosive, irritating, or toxic.

## EFFECTS OF PRESSURE AND TEMPERATURE ON PROPANE

Propane behaves in different ways when it is stored in containers under varying conditions. There are three relationships concerning this behavior which must be understood: (1) the effect of heat on liquids; (2) liquids and their boiling points; and (3) storing liquids above their normal boiling points in a closed container. Before beginning the discussion about the effects of pressure and temperature on propane, the effects of pressure and temperature on liquids in general will be discussed.

### THE EFFECT OF HEAT ON LIQUIDS

Water is the best example to use to explain the effect of heat on liquids. Figure 2-1A shows one pound of water in a metal container on top of a gas burner. The burner is off and the water is at 60°F (15.6°C). As long as additional heat is not transferred to the water, the temperature will remain at 60°F (15.6°C). Figure 2-1B shows the same water after it has been heated for a period of time. In this case, energy (in the form of heat) has been added to the water. Notice three things about this example.

- The water has expanded. Whether the liquid is water or propane, heat added to a liquid will always cause it to expand. This results in an increase in the volume of the liquid.

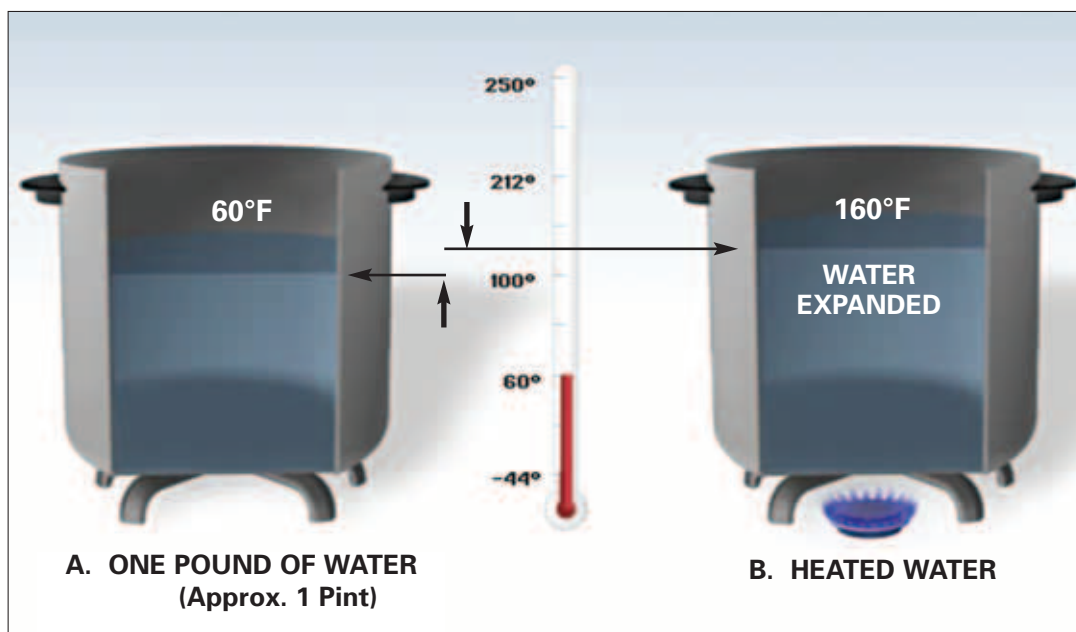


FIGURE 2-1A & B Effects of heat on water.

- The temperature of the liquid has increased. In this example, the temperature has increased to 160°F (71°C) (an increase of 100°F (37.8°C)). As long as the liquid is at a temperature below its boiling point,
- The heat energy required to increase the temperature of the water can easily be calculated. A common value used to measure heat is the British Thermal Unit (referred to as the BTU).

A BTU is the amount of heat needed to raise the temperature of one pound of water 1°F (17.22°C). In Figure 2-1B the temperature of 1 pound of water increased 100°F (37.8°C). As a result, 100 BTU's (100 X 1) were added directly to the water.

As long as the liquid is below its boiling point, the heat added can easily be calculated by knowing the liquid weight and any change in temperature. Once the normal boiling point is reached, it is not as easy to calculate the heat added to the liquid.

## LIQUIDS AND BOILING POINTS

The boiling point of a liquid is the temperature at which a liquid will change to a vapor under normal atmospheric conditions (i.e., in an open container at sea level). For example, the normal boiling point of water is 212°F (100°C). Once a liquid reaches its normal atmospheric boiling point, the relationship between heat and liquid temperature will change, as illustrated in Figure 2-2.

Figure 2-2 shows a pound of water after it has been heated to 212°F (100°C) and the water has started to boil. Notice two things about this example:

- Once the water has started to boil, the temperature of the water will remain constant at 212°F (100°C). Even if the heat added to the water is doubled, the temperature will remain constant. Increasing the heat will cause the water to boil faster, but it will not increase the temperature of the water. Any additional heat added to the boiling water is used to change the liquid into vapor (steam). Since there is no visible change in temperature, this added heat is called latent (hidden) heat of vaporization.
- The amount of heat needed to cause a liquid to boil off and become vapor is greater than the amount needed to raise the temperature of the liquid from 60°F (15.6°C) to 212°F (100°C). If, for any reason, additional heat is no longer available (i.e., burner turned down), the water will stop boiling and the temperature will drop below 212°F (100°C).

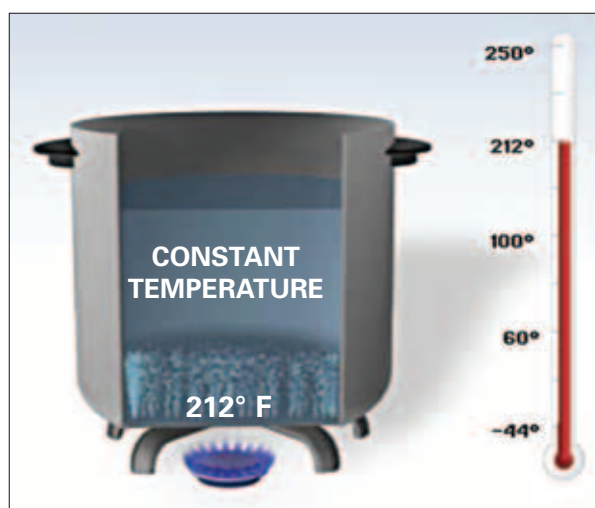


**FIGURE 2-2** Effects of temperature and pressure on boiling.

## STORING LIQUIDS ABOVE THEIR NORMAL BOILING POINTS

The examples used so far have shown the effects of adding heat to a liquid that is in an open container. As long as the container is open to the surrounding atmos-

where, the relationships between heat, temperature, and boiling points for the liquid will not be changed. However, if the liquid is placed in a closed container, these relationships will change, as illustrated in Figure 2-3.

### STORING LIQUIDS IN A CLOSED CONTAINER

The illustration in Figure 2-3 again shows a pound of water being heated by a burner. This container has been closed with a pressure cooker lid. The important fact in this example is that although the water temperature is 250°F (121°C), the water is not boiling. This change in behavior is caused by the effects of pressure on the boiling point of the water.

In this case, water has been heated past its normal boiling point. Until the water reached 212°F (100°C), the water behaved just as it did when it was heated in an open container (increase in temperature, liquid expansion, etc.). When the water reached 212°F (100°C), the liquid began to boil off into steam. Since the container is closed, the space above the liquid is pressurizing. Once the container is pressurized to the proper point, the boiling action will stop. The increased steam pressure prevents any additional water from changing into steam. At this point the liquid and steam vapor are in balance.

The important point to remember about this example is that an increase in the temperature of the liquid will cause the liquid to boil off. If additional heat is added, the water will immediately begin to boil and increase the pressure in the container. This boiling will continue until the liquid and steam vapor are again in balance.

Also, if a relief valve in the pressure cooker opens and discharges steam, the liquid will immediately boil off trying to re-establish the balance between the liquid and steam vapor. When the relief valve closes, the pressure will again increase. As soon as the vapor pressure at the surface of the liquid and the pressure in the vapor space of the container are equal, the water will again stop boiling.

### STORING PROPANE IN A CLOSED CONTAINER

Propane is affected by heat and pressure in much the same way as water. As long as propane is kept at a temperature below its normal boiling point, it will remain a liquid and can be stored in open containers.

The problem with storing propane in an open container is that it has a boiling point of -44°F (-42°C), well below the boiling point of water and normal ambient temperature. At temperatures above its boiling point, propane will usually boil off into vapor, as illustrated in Figure 2-4. However, it should be noted that propane can also pool as a liquid when released at very low ambient temperatures. In order to store propane as a liquid above its normal boiling point, it must be stored and transported in pressure-tight containers called cylinders or tanks.

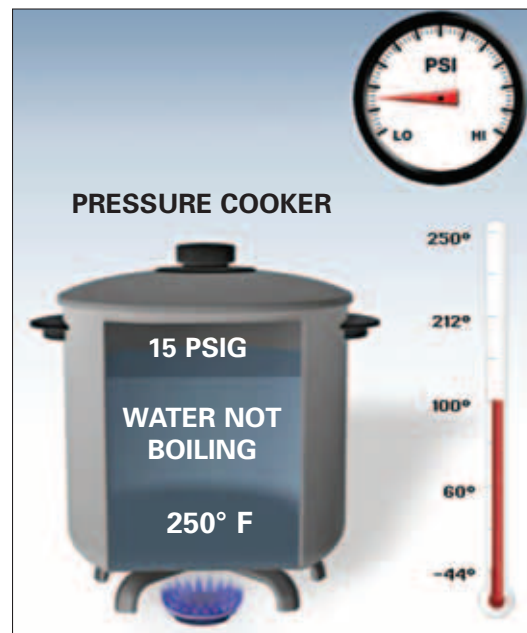


FIGURE 2-3 Temperature/Pressure equilibrium.

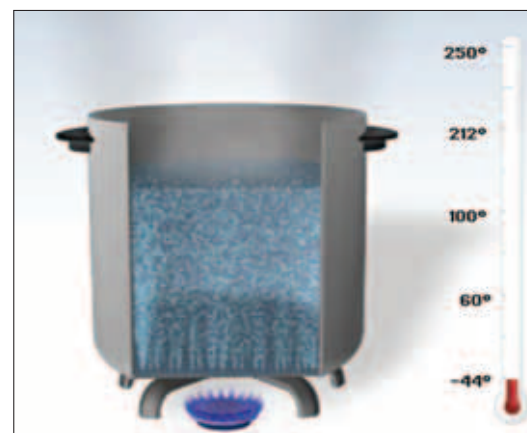


FIGURE 2-4 Normal boiling point.

When placed in a pressure-tight container, propane can be stored as a liquid under pressure. Figure 2-5, for example, shows propane liquid in a small cylinder at a temperature of 70°F (21°C). That temperature is 114°F (45.6°C) above its normal boiling point. In this case, as soon as the propane liquid was pumped into the cylinder, it began to boil off and pressurize the vapor space of the cylinder. Once the pressure reached 109 psig, the pressure, liquid temperature, and heat were in balance and the boiling stopped. Like water, as long as the temperature and pressure remain constant, the propane liquid will not boil.

However, if the burner shown in the illustration is ignited, the demand for gas will immediately cause a slight drop in pressure, as illustrated in Figure 2-6.

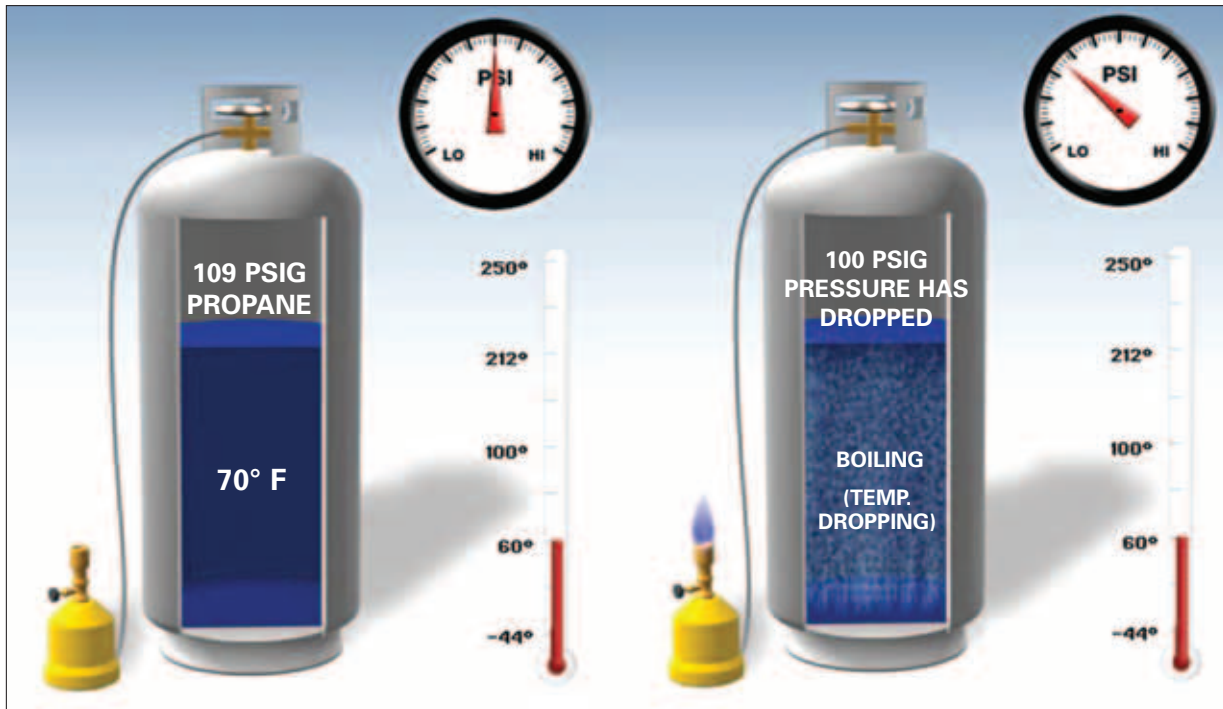


FIGURE 2-5 No demand.

FIGURE 2-6 LP-Gas and boiling points.

This drop in pressure causes the propane to boil off. If the demand is greater than the boiling rate of propane, the propane will continue to boil off, thereby supplying fuel to the burner. As soon as the boiling rate exceeds the demand (i.e. burner off), the cylinder will re-pressurize with vapor and the boiling will stop. Table 2-2 shows the vapor pressures of various LP-gases at specific temperatures.

To summarize, there are four important characteristics that need to be known and understood about propane gas when it is stored in a closed container:

1. **Heat added to propane in a tank or cylinder is transferred directly from the air surrounding the container.** Hot days, cool nights, rain, and snow are a few of the many factors that affect the temperature of the liquid. These changes in liquid temperature also cause changes in vapor pressure. As a result, it is common to see the vapor pressure in a tank or cylinder change as much as 50 psig in the course of a day, without an appliance being used.
2. **Propane, like water, will expand when heat is added to it.** The major difference is that propane will expand considerably more than water over the same change in temperature. Propane liquid will increase in volume nearly 17 times

greater than water over the same temperature increase. As a result, tanks and cylinders should not be completely filled with propane liquid. Usually tanks and cylinders are filled to about 80% of their capacity. This leaves enough space above the liquid to allow the propane to expand freely due to changes in the ambient temperature.

3. **Due to changes in liquid volume, and the high storage pressures, every propane container is equipped with at least one pressure relief valve.** If the pressure inside the container becomes too high, the pressure relief valve will discharge some vapor, reducing the internal pressure to a safe level. This ensures that the vapor pressure never reaches the design pressure of the container. **However, it is very important to note that if a container is turned on its side and is discharging liquid from the pressure relief valve, no significant internal pressure drop will occur inside the container.**
4. **Remember, liquid leaks are generally more dangerous than gas leaks.** A small volume of liquid propane can boil off into a large volume of propane vapor. One cubic foot of propane liquid, for example, will boil off into approximately 270 cubic feet of vapor. As a result, a liquid leak in any propane container, large or small, can easily lead to a flammable mixture of propane and air that may impact a large area under the right conditions.

| VAPOR PRESSURES OF LP-GASES |         |                         |        |
|-----------------------------|---------|-------------------------|--------|
| Approximate Pressure (PSIG) |         |                         |        |
| Temperature (F)             | Propane | Commercial Propane Max. | Butane |
| -40                         | 4       |                         |        |
| -30                         | 8       |                         |        |
| -10                         | 20      |                         |        |
| 0                           | 28      |                         |        |
| 10                          | 37      |                         |        |
| 20                          | 47      |                         |        |
| 30                          | 58      |                         |        |
| 40                          | 72      |                         | 3      |
| 50                          | 86      |                         | 6.9    |
| 60                          | 102     |                         | 11.5   |
| 70                          | 120     | 127                     | 17     |
| 80                          | 140     |                         | 22     |
| 90                          | 165     |                         | 29     |
| 100                         | 190     | 196                     | 37     |
| 105                         |         | 210                     | 41     |
| 110                         | 220     |                         | 46     |
| 130                         |         | 287                     | 69     |

TABLE 2-2



## CHEMICAL PROPERTIES AND COMBUSTION CHARACTERISTICS

Chemical properties are the intrinsic characteristics or properties of a substance described by its tendency to undergo chemical change. They typically provide responders with an understanding of how a material may harm. Examples include flammable or explosive range and ignition temperature.

Combustion is a chemical reaction. It is a method of changing a fuel source into a useful form of energy (e.g., heat). The three basic ingredients needed to start and sustain combustion are fuel, oxygen, and an ignition source, as illustrated in Figure 2-7. All three items must be present in the proper proportions for combustion to occur.

The combustible materials in propane are carbon and hydrogen, or hydrocarbons. The oxygen needed to burn propane vapor is obtained from the air. Air is made up of 20% oxygen, 79% nitrogen, and about 1% of other miscellaneous gases. The ignition source must provide enough heat to the mixture of fuel and oxygen to raise the temperature of the propane to its ignition temperature, which is between 920°F (493°C) and 1,120°F (604°C).

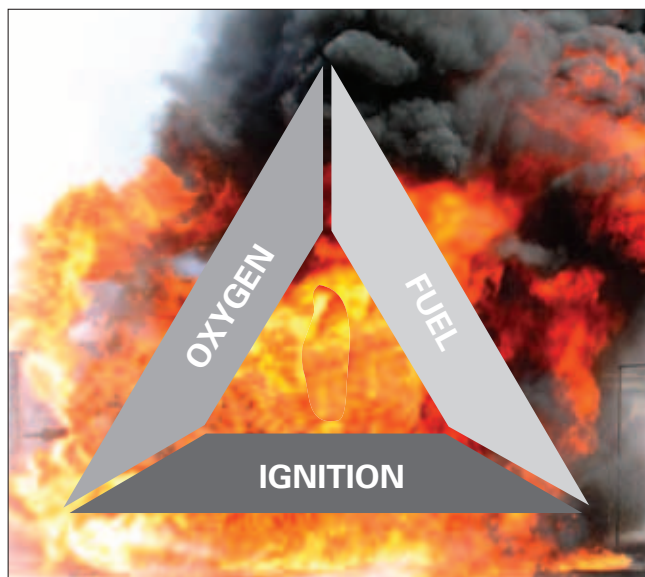


FIGURE 2-7 Combustion.

### FLAMMABLE LIMITS

Even with an abundant supply of both air and propane, combustion cannot occur unless they are mixed together in the proper proportions. The most common way of expressing the proper mixtures needed for combustion is in terms of flammability limits (also known as explosive limits).

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**NOTE:** The terms flammable limits and explosive limits are often used interchangeably. Within the propane industry, the term flammable limits is used most often in technical literature. Within emergency services, the term explosive range is most common. Both terms have the same meaning.

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A flammable limit is simply the percentage of gas needed in a gas/air mixture to support combustion. Normally, this value is given in both upper and lower limits of flammability. The upper limit is the percentage of gas in the richest (most gas) mixture that will support combustion. The lower limit is the percentage of gas in the leanest (least gas) mixture that will support combustion. The lower flammable limit (LFL) for commercial propane is 2.15%, while the upper flammable limit (UFL) is 9.60%. Refer to Table 2-1 for limits of flammability of propane, and its comparison with butane and natural gas.



## COMBUSTION RATIO

Although propane vapor will burn in any mixture within its flammability limits, combustion may not produce a “clean burn.” Insufficient heat, unburned gas, and harmful combustion by-products (i.e., carbon monoxide) are only a few of the problems that can develop from incomplete combustion. As a result, most gas appliance burners are designed and adjusted to burn a gas air mixture that is as close to ideal as possible by designing the appliances to use a very efficient gas/air ratio. This mixture is commonly referred to as the ideal combustion ratio. The ideal combustion ratio for propane is 24 parts of air (96%) to 1 part of propane (4%).

There is a very narrow range of gas/air mixtures that will support combustion. Even within this range there is only one mixture that will give efficient combustion. Although this “ideal” combustion ratio may only be possible under “ideal” conditions, gas appliances should be inspected or adjusted periodically to be sure that the appliances are as safe and efficient as possible.

## IGNITION TEMPERATURE

Even with an ideal propane and air mixture, there must still be an ignition source present for combustion to occur. Ignition sources are usually expressed as the minimum temperature needed for a mixture of propane and air to ignite. The ignition temperature of propane is approximately 920°F (493°C). While it should be noted that temperature may seem very high, the flame of a match can develop temperatures up to about 3,000°F (1,649°C).

A common ignition source for propane is another flame, such as the flame of a pilot burner, match, or cigarette lighter. Other sources of ignition that can develop enough heat to ignite a combustible mixture of air and propane include sparks from electric motors and switches, lit cigarettes, highway flares, a motor vehicle’s catalytic converter, or a static discharge.

## HEAT VALUE

The purpose of burning propane as efficiently as possible is to develop as much heat as possible per cubic foot of propane. The heat produced by burning propane is expressed in BTU’s per cubic foot of gas or in BTU’s per gallon. According to NFPA 58, Table B-1.2.1, the heating value for propane (vapor) is 2,488 BTU/ft<sup>3</sup>.

The heat value of propane is used in engineering many propane operations, including sizing distribution lines, sizing appliance orifices, and converting appliances from natural gas to propane or butane. When the rating of an appliance is known, the heat value is also useful in determining the correct size of a tank or cylinder, size and type of distribution system, and the frequency of filling the container.

## PRODUCTS OF COMPLETE COMBUSTION

When propane and air are burned in the correct ratio, (1 ft<sup>3</sup> of propane to 24 ft<sup>3</sup> of air) complete combustion takes place. Since propane is a mixture of hydrogen and carbon, certain by-products are generated when burned in the presence of oxygen. These products of combustion are water vapor and carbon dioxide. The carbon dioxide and water vapor formed in burning, plus the nitrogen in the reactants which enter with the combustion air, together are called combustion products. These products are also commonly known as flue gases.

## PRODUCTS OF INCOMPLETE COMBUSTION

When combustion is incomplete harmful products can be generated. To obtain complete combustion, enough air must be supplied to the combustion process. If not enough air is supplied, other products will be generated, including carbon monoxide, excessive water vapor, aldehydes, and soot.

### CARBON MONOXIDE (CO)

Because carbon monoxide (CO) gas is odorless, colorless, and tasteless, it cannot be detected by the body. Carbon monoxide can only enter the body through the respiratory system. Inhaled carbon monoxide is absorbed into the blood and then combines with the hemoglobin of the blood to exclude the oxygen. Symptoms of exposure include headache, nausea, chronic fatigue, confusion, and dizziness. The harmful effects of CO exposure depend on the concentration of the gas in the air, exposure time, and factors such as age, health, size, and sex.

According to the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) (Ventilation Standard 62-89), a concentration of no more than 9 parts per million (ppm) of CO is permissible in residential living spaces. In addition the Occupational Safety and Health Administration (OSHA) has established an 8-hour time-weighted threshold limit value (TLV/TWA) at 35 ppm. See Table 2-3 for additional information.

Emergency responders and propane marketers who respond to carbon monoxide incidents must be properly trained in the hazards of CO and have the proper protective clothing, equipment, and detection and monitoring instruments. A written Standard Operating Procedure for handling carbon monoxide emergencies is recommended.

### SULFURIC ACID

Water vapor is also produced as a normal by-product of combustion. If sulfur impurities exist in the propane, sulfur deposits may also be produced. As a result, the condensed water will combine with the sulfur deposits to form sulfuric acid, which may be harmful to appliances and piping.

### ALDEHYDES

Another class of compounds, known as aldehydes, may also be formed in incomplete combustion. While carbon monoxide is odorless, aldehydes have a sharp, penetrating odor. They are readily detected by smell even at very low concentrations. The odor of aldehydes differs from odorants added to propane, and the two should not be confused. The absence of aldehydes does not assure that carbon monoxide is not present in flue products. However, if the odor of aldehydes is present, then carbon monoxide almost always will be present. Aldehydes by themselves are also toxic.

## SUMMARY

Propane and butane are the two major LP-gases extracted and used in the gases industry. About 70% of propane is processed from natural gas. LP-gases are processed from crude oil by heating the crude oil until it begins to boil. Because propane is odorless and colorless in its natural state, a commercial odorant is added

## CONCENTRATION LEVELS AND PHYSIOLOGICAL EFFECTS OF CARBON MONOXIDE

| Concentrations of<br>CO in Air                | Physiological Effects                                                                                                                    |
|-----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| 9 ppm (0.0009%)                               | The maximum allowable concentration for short-term exposure in a living area according to ASHRAE. No effects detected.                   |
| 35 ppm (0.0035%)                              | The maximum allowable concentration for continuous exposure in any 8-hour period, according to federal law.                              |
| 200 ppm (0.02%)                               | Slight headache, tiredness, dizziness, nausea after 2–3 hours.                                                                           |
| 400 ppm (0.04%)                               | Frontal headaches within 1–2 hours, life-threatening after 3 hours, also maximum parts per million in flue gas according to EPA and AGA. |
| 800 ppm (0.08%)                               | Dizziness, nausea, and convulsions within 45 minutes. Unconsciousness within 2 hours. Death within 2–3 hours.                            |
| 1,600 ppm (0.16%)                             | Headache, dizziness, and nausea within 20 minutes. Death within 1 hour.                                                                  |
| 3,200 ppm (0.32%)                             | Headache, dizziness, and nausea within 5–10 minutes. Death within 30 minutes.                                                            |
| 6,400 ppm (0.64%)                             | Headache, dizziness, and nausea within 1–2 minutes. Death within 10–15 minutes.                                                          |
| 12,800 ppm (1.28%)                            | Death within 1–3 minutes.                                                                                                                |
| 10,000 ppm (parts per million) = 1% by volume |                                                                                                                                          |

TABLE 2-3

so it may be detected if it leaks from its container. The most commonly used odorant is ethyl mercaptan.

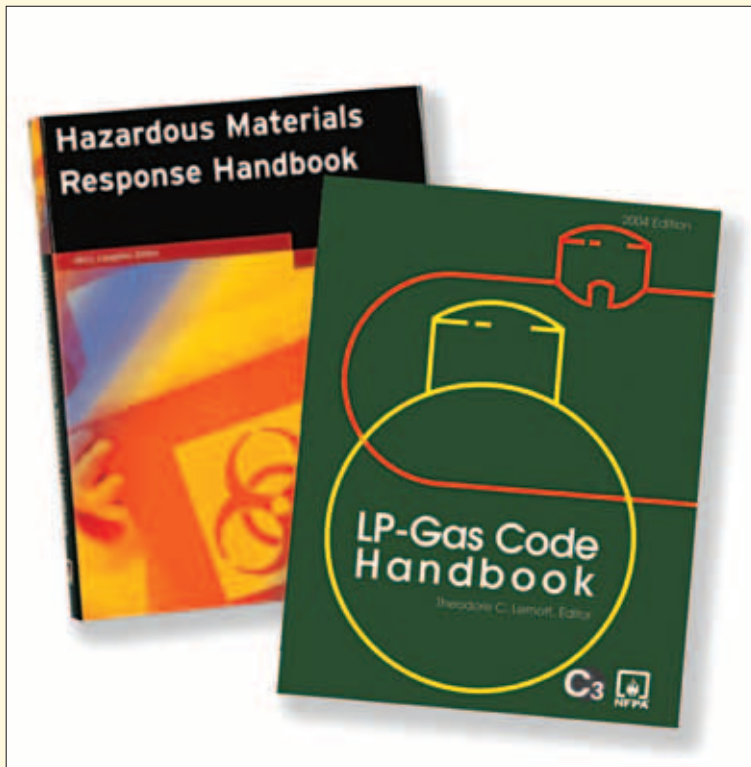
LP-gases belong to a family of chemical compounds known as alkane hydrocarbons. This means they are made up of hydrogen and carbon atoms only. Under normal ambient temperatures liquid propane ( $C_3H_8$ ) will expand rapidly into gas. One cubic foot of liquid propane will boil-off and produce 270 cubic feet of propane vapor. When mixed with the proper amount of air, LP-gases can burn.

Propane vapor has a vapor density of 1.52 at 60°F (15.6°F). The important point to remember is that propane vapor is about 1.5 times heavier than air (air = 1.00). If a leak develops in a gas line or container propane readily dissipates.

Even with an abundant supply of both air and propane, combustion cannot occur unless they are mixed together in the proper proportions. The most common way of expressing the proper mixtures needed for combustion is in terms of flammability

limits. The flammability limits for propane are 2.15% for the lower limit (LFL) and 9.60 for the upper limit (UFL). The ignition temperature of propane is between 920°F (493°C) and 1,120°F (604°C).

When combustion is incomplete, harmful products can be generated. The most hazardous of these by-products is carbon monoxide. Carbon monoxide gas is odorless, colorless, and tasteless. When inhaled, carbon monoxide is absorbed into the blood and combines with the hemoglobin of the blood to exclude the oxygen. Symptoms of exposure include headache, nausea, chronic fatigue, confusion, and dizziness. Prolonged exposure can result in death.



## STANDARDS, CODES AND REGULATIONS

OBJECTIVES

- 1) Define the term voluntary consensus standard as applied to propane safety and fire protection.
- 2) Describe the general scope of *ANSI Z223.1—The National Fuel Gas Code*.
- 3) Describe the general scope of *ASME Unfired Boiler and Pressure Vessel Code* (Division I, Section VIII).
- 4) Describe the general scope of *NFPA 58—The LP-Gas Code*.
- 5) Describe the role of independent testing laboratories in ensuring technical consistency and safety in the propane industry.
- 6) List and describe the role of industry trade associations in ensuring safety in the propane industry.
- 7) List and describe the role of the two primary federal agencies that regulate LP-Gases in the United States.
- 8) Describe the role of state and local governments in adopting voluntary consensus standards related to propane safety and fire protection.

ABBREVIATIONS AND ACRONYMS

|          |                                                        |
|----------|--------------------------------------------------------|
| ANSI     | American National Standards Institute                  |
| API      | American Petroleum Institute                           |
| ASTM     | American Society of Testing and Materials              |
| ASME     | American Society of Mechanical Engineers               |
| CETP     | Certified Employee Training Program                    |
| CFR      | Code of Federal Regulations                            |
| DOL      | Department of Labor                                    |
| DOT      | Department of Transportation                           |
| EPA      | Environmental Protection Agency                        |
| GAMA     | Gas Appliance Manufacturers Association                |
| HAZWOPER | Hazardous Waste Operations and Emergency Response      |
| ICC      | International Code Council                             |
| NASFM    | National Association of State Fire Marshals            |
| NFPA     | National Fire Protection Association                   |
| NPGA     | National Propane Gas Association                       |
| OSHA     | Occupational Safety and Health Administration          |
| PERC     | Propane Education & Research Council                   |
| PHMSA    | Pipeline and Hazardous Materials Safety Administration |
| SARA     | Superfund Amendments and Reauthorization Act of 1986   |



## STANDARDS AND CODES

There are many different types of propane tanks, pressure regulators, gas appliances, and industrial gas equipment available in the United States. LP-Gas equipment has literally thousands of applications in the home, on the farm, and in the workplace. Because of the potential fire hazards of LP-Gas fueled equipment, special safety standards have been created to safeguard employees, the public, and emergency responders. Two of the most important types of standards that are developed and used by the propane industry are (1) manufacturing and equipment standards, and (2) fire prevention and operational safety standards. This section will provide an overview of these standards by explaining who develops them and their general scope.

### VOLUNTARY CONSENSUS STANDARDS

LP-Gas standards must be constantly updated to meet the changing needs and technology of the propane industry. In order to accomplish this task, the propane industry relies upon and supports many organizations whose sole purpose is to organize, and develop and certify standards.

Voluntary consensus standards are normally developed through professional organizations or trade associations as a method of improving the individual quality of a product or system. In the United States, standards are developed primarily through a consensus process whereby a committee of specialists representing varied interests writes the first draft of the standard. The document is then submitted to either a larger body of specialists or to the general public, who then may amend, vote on, and approve the standard for publication. This procedure is known as the Voluntary Consensus Standards Process.

When a consensus standard is completed, it may be voluntarily adopted by government agencies, individual corporations, or organizations. Many safety-related consensus standards are also adopted as a reference in a governmental regulation. In effect, when a federal, state, or municipal government adopts a consensus standard, by reference the document becomes a regulation.

Standards developed through the voluntary consensus process play an important role in increasing both workplace and public safety. Historically, a voluntary standard improves over time as each revision reflects recent field experience and new developments in technology. As users of the standard adopt it as a way of doing business, the level of safety gradually improves over time.

In many respects, a voluntary consensus standard provides a way for individual organizations and corporations to self-regulate their business or profession. All of the national fire codes in the United States are developed through the voluntary consensus standards process, with the two key players being the National Fire Protection Association (NFPA) and Western Fire Chiefs Association. Standards developed by these two organizations address many flammable gas issues including propane storage tank design, safe operating practices, and facility layout.

### AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)



The American National Standards Institute (ANSI) is one of the most respected standards organizations in the world. Headquartered in Washington, DC, ANSI is a federation comprised of industrial, trade, technical, labor, governmental, con-

sumer, and professional organizations. It's primary function is to coordinate the development of both manufacturing and operational standards.

ANSI establishes processes and procedural requirements for the standards development process in the United States and accredits standards development organizations that meet these requirements. For example, the NFPA and the American Petroleum Institute (API) are accredited as meeting ANSI's due process requirements for standards development. Once NFPA and API standards are approved through their respective process, they can be submitted to ANSI for approval as American National Standards. An example is ANSI Z223.1—The National Fuel Gas Code.

Originally published as NFPA 54, the National Fuel Gas Code is one of the most important safety standards used in the propane industry, and is used as a guideline for appliance installation in nearly every state in the U.S.A. The National Fuel Gas Code covers both fire prevention and installation standards for fuel gases (natural and LP-gases), including installation of piping and appliances for both residential and commercial applications.

Additional information on ANSI can be found at [www.ansi.org](http://www.ansi.org).

### AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)



The American Society of Mechanical Engineers (ASME) is a professional organization promoting the art, science and practice of mechanical and multidisciplinary engineering and allied sciences. ASME develops international codes and standards that enhance public safety, offers lifelong learning opportunities, and contributes to research and technical exchange benefiting the engineering and technology community.

One of the objectives of ASME is the coordination and development of manufacturing standards for pressure vessels (tanks) used in LP-gas service. The ASME standard for tanks is Section VIII, Division 1 of the *ASME Unfired Boiler and Pressure Vessel Code*.

Since this code was first published in 1911, the ASME Pressure Vessel Code has been revised many times and issued in 28 books. During this period thousands of propane tanks ranging in size from 5-gallons to 120,000 gallons water capacity have been built in accordance with this code. These tanks are used in various propane applications and range in size from 5 gallons to 120,000 gallons water capacity.

In addition to tank standards, ASME also develops standards for pressure relief valves. Relief valves built according to this code are used in many ASME tanks for propane service.

Tanks and pressure relief valves that are built according to the ASME code are usually marked with a special ASME stamp as illustrated in Figure 3-1A and 3-1B. The ASME "cloverleaf" is stamped directly on the tank, (Figure 3-1A) or the pressure relief valve, (Figure 3-1B) shows that the tank or valve meets certain minimum design and performance standards. When you are working with tanks and relief valves, you will often see the ASME cloverleaf. Additional information on ASME can be found at [www.asme.org](http://www.asme.org).



The International Fire Code® and the International Fuel Gas Code® are those parts of the International Code process that specifically impact the design and installation of propane fuel gas systems and gas-fired appliances through performance-based requirements. Additional information on the ICC can be found at [www.iccsafe.org](http://www.iccsafe.org).



NFPA's hazardous materials and flammable gas standards are widely used by both industry and public safety organizations as recommended practices for design and construction, inspection, safe handling and installation, etc. They do not have

the force of law unless they are adopted by a government agency. For example, state governments which have approved state OSHA plans under Section (18b) of the Occupational Safety and Health Act of 1970 must adopt standards to enforce requirements which are at least as effective as Federal Requirements. While NFPA does not specifically write regulations, NFPA standards often end up as law through an adoption process at the federal and state level.

The NFPA has no enforcement power—its standards are merely advisory. However, the Association enjoys a unique reputation for its technical accuracy and procedural fairness. Consequently, for many years all levels of government have adopted NFPA standards, giving many of them the force of law. The goal of the NFPA Standards Program is “the development, publication and dissemination of timely consensus standards that are responsive to the needs of society, which are produced through a democratic, dynamic, expeditious system, and...are based on performance criteria.” Additional information on NFPA can be found at [www.nfpa.org](http://www.nfpa.org).

### NFPA LP-GAS STANDARDS

The National Fire Protection Association has over 70 individual voluntary consensus standards addressing hazardous materials. At least 8 of these deal specifically with flammable gas issues, with the *NFPA 58—Liquefied Petroleum Gas Code* being the primary technical standard that which addresses propane. NFPA standards are developed through the committee consensus standards process according to NFPA rules and procedures and are typically frequently revised on a 5-year interval.

#### NFPA 58—LIQUEFIED PETROLEUM GAS CODE

NFPA 58 is the primary LP-Gas code in the United States. The scope of NFPA 58 applies to LP-Gas systems, including the following:

- Containers, piping, and associated equipment, when delivering LP-Gas to a building for use as a fuel gas.
- Highway transportation of LP-Gas.
- The design, construction, installation, and operation of marine terminals whose primary purpose is the receipt of LP-Gas for delivery of transporters, distributors, or users. The exception to this is that the code does not apply to marine terminals associated with refineries, petrochemical, or gas plants. The code also does not apply to marine terminals associated with refineries, petrochemicals, gas plants and marine terminals whose sole purpose is to deliver gas to marine vessels.
- The design, construction, installation, and operation of pipeline terminals that receive LP-Gas from pipelines under the jurisdiction of the U.S. Department of Transportation, whose primary purpose is the receipt of LP Gas for delivery to transporters, distributors, or users. Coverage of the code in these situations begins downstream of the last pipeline valve or tank manifold inlet.

NFPA 58 does not apply to the following areas:

- Frozen ground containers and underground storage in caverns, including associated piping and appurtenances used for storage of LP-Gas.
- Natural gas processing plants, refineries, and petrochemical plants.



- LP-Gas, including refrigerated storage, at utility gas plants. In these situations, *NFPA 59—Standard for the Storage and Handling of Liquefied Petroleum Gases at Utility Plants* applies.
- Chemical plants where specific approval of construction and installation plans, based on substantially similar requirements, is obtained from the authority having jurisdiction.
- LP-Gas used with oxygen or those portions of the LP-Gas systems already covered by *NFPA 54—National Fuel Gas Code*.
- Transportation by air, including hot air balloons, rail, or water under the jurisdiction of the U.S. Department of Transportation (DOT).
- Marine fire protection.
- Refrigeration cycle equipment and LP-Gas used as a refrigerant in a closed cycle.
- The manufacturing requirements for recreational vehicle LP-Gas systems that are addressed by *NFPA 1192—Standard on Recreational Vehicles*.
- Propane dispensers located at multiple fuel refueling stations. These shall comply with the requirements of *NFPA 30A—Code for Motor Fuel Dispensing Facilities and Repair Garages*.

NFPA 58 includes separate comprehensive chapters on the following topics:

- Chapter 1—*General Provisions Administration*—including definitions, scope, purpose, application, etc.
- Chapter 2—*Referenced Publications*—including other NFPA publications and standards, industry publications (e.g., ASME, ASTM), and U.S. government publications.
- Chapter 3—*Definitions*—includes both NFPA official definitions and general definitions used throughout the standard.
- Chapter 4—*General Requirements*—covers general requirements that apply to the entire code, including acceptance of equipment and systems, LP-Gas odorization, notification of installations and qualification of personnel.
- Chapter 5—*LP-Gas Equipment and Appliances*—including standards for tanks, cylinders, valves, container appurtenances, piping, equipment (i.e., pumps, compressors, meters, etc) and appliances (i.e., vaporizers).
- Chapter 6—*Installation of LP-Gas Systems*—provides all information needed for the installation of the most commonly encountered LP-Gas systems and individual components, including guidelines for installing equipment in bulk plants, cylinder filling stations, and on industrial and road vehicles. Topics of specific interest to the fire service include the fire protection requirements and the product release prevention and incident preparedness review.
- Chapter 7—*LP-Gas Liquid Transfer*—covers requirements for the transfer of LP-Gas to or from stationary storage containers, highway and rail transportation vehicles, and portable containers. including guidelines for filling tanks and cylinders.
- Chapter 8—*Storage of Portable Containers Cylinders Awaiting Use, or Resale or Exchange*—including scope, general provisions, storage, and fire protection.

provides interior and exterior storage requirements for portable containers (1,000 lb (454 kg) water capacity or less) awaiting use, resale or exchange. This would include consumer sites or dispensing stations, as well as resale or exchange sites.

- Chapter 9—*Vehicular Transportation of LP-Gas*—provides requirements for the highway transportation of portable containers and cargo tank trucks containing LP-Gases. including scope, transportation modes, and parking and garaging vehicles.
- Chapter 10—*Buildings or Structures Housing LP-Gas Distribution Facilities*—provides requirements for buildings or structures that house specific LP-Gas systems or activities involved with the distribution of LP-Gas. Specific attention is given to the construction, ventilation and heating of such structures including scope, separate and attached structures.
- Chapter 11—*Engine Fuel Systems*—applies to fuel systems using LP-Gas as a fuel for internal combustion engines, including vehicles, forklifts, portable engines (e.g., floor sweepers and buffers) and stationary engines. including application, general purpose and industrial vehicles, engine installation, and garaging of vehicles.
- Chapter 12—*Refrigerated Containers Storage*—provides requirements for the design, construction, siting, inspection of refrigerated LP-Gas storage containers and systems including containers, impoundment, and locating aboveground containers.
- Chapter 13—*Marine Shipping and Receiving*—including piers, pipelines, and actions prior to transfer provides requirements for the design and construction of piers, requirements for conducting transfer operations, and pre-transfer inspections. This information is an outgrowth of the NFPA 30—*Flammable and Combustible Liquids Code* and NFPA 59—*Utility LP-Gas Plant Code* requirements and reflect the experiences and practices of the marine industry.
- Chapter 14—*Operations and Maintenance*—provides requirements related to the operations and maintenance of bulk plant, industrial plant, refrigerated, marine and pipeline LP-Gas Gas systems. This chapter was created to locate operating and maintenance requirements for the installations covered by NFPA 58 in a single location within the standard.
- Chapter 15—*Pipe and Tubing Sizing Tables*—provides pipe sizing tables needed by code users who size LP-Gas vapor piping systems that are used between first- and second-state regulators, and between the second stage pressure regulator and the appliances.

#### OTHER LP-GAS STANDARDS

NFPA 58 is not the only standard published by NFPA that is used in the propane industry. Table 3-1 summarizes these standards.



## NFPA STANDARDS USED IN THE PROPANE INDUSTRY

| Standard Number   | Standard Title                                                                        | Application                                                                                                        |
|-------------------|---------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| #54 (ANSI Z223.1) | NATIONAL FUEL GAS CODE                                                                | Standards covering installation of gas piping and appliances in residential and commercial buildings.              |
| #58               | LP-GAS CODE                                                                           | Standards covering the storage, handling and transportation of propane.                                            |
| #59               | LIQUEFIED PETROLEUM GASES AT UTILITY GAS PLANTS                                       | Standards covering construction and operation of propane equipment at plants owned by natural gas utilities.       |
| #302              | PLEASURE AND COMMERCIAL MOTOR CRAFT                                                   | Standards covering fire protection for pleasure and commercial boats, including propane systems and appliances.    |
| #501A             | INSTALLATION OF MOBILE HOMES                                                          | Standards covering mobile home park design, installation of plumbing, fuel supply, and electrical systems.         |
| #1192C            | RECREATIONAL VEHICLES (Travel Trailers, Motor Homes, Truck Campers, Camping Trailers) | Standards covering installation of gas piping and appliances in RVs.                                               |
| #1193D            | RECREATIONAL VEHICLE PARKS                                                            | Similar to 501A covering only RV parks.                                                                            |
| #505              | INDUSTRIAL TRUCKS                                                                     | Standards covering type designation, areas of use, maintenance and operation of propane-powered industrial trucks. |

**TABLE 3-1**

# SCAN SHEET 3-A

## PROPANE GAS INDUSTRY VOLUNTARY INITIATIVES FOR IMPROVING PUBLIC SAFETY

### LIQUEFIED PETROLEUM GAS CODE—NFPA 58

Over the last 50 years there have been continuing improvements in propane safety which have undoubtedly saved many lives. The most significant of these has been through the ongoing efforts of the propane industry and the fire service to upgrade and improve the *NFPA 58—The Liquefied Petroleum Gas Code—NFPA 58*.

Interestingly, one of the most significant of these improvements has been organizing the NFPA 58 standard so that it is easier for users to relate the hazards of LP-Gas to proper handling and installation. For example, from 1940 to 1969, NFPA 58 consisted of a chapter entitled Basic Rules, which was followed by a number of chapters and appendices. The Basic Rules section of the standard included all of the material which was common to all applications. The eight chapters in the standard sometimes modified the Basic Rules for specific applications, based on the types of containers and their application in a particular environment. When a new application was developed, it was simply treated as a package and added as a new division within the standard. This made inserting the new material in the standard easy, but over time, as new applications were inserted, it became obvious that similar hazards were being treated differently in various sections of the standard. The effect was that the Basic Rules were becoming less and less basic.

In the late 1960s, the National Propane Gas Association's (NPGA) Technology and Standards Committee helped the NFPA 58 committee address this problem by developing and proposing that NFPA adopt a format that would provide consistency in hazard evaluation. The objective was to reduce the need for users of the standard to read the entire document to determine how the standard applied to their interests. For example, in the 1960s it was recognized by NPGA and NFPA that propane fire incidents were often due to the failure to comply with one or more provisions in the standard, and many of these failures were the result of confusion between manufacturers and installers as to who should do what. To help reduce this confusion the standard was reorganized.

The current edition of NFPA 58 Chapter 5—LP-Gas Equipment and Appliances (standards for tanks, cylinders, valves, piping, and appliances) and Chapter 6—Installation of LP-Gas Systems (guidelines for installing equipment in bulk plants, in cylinder filling stations, and on industrial and road vehicles) focuses on the equipment manufacture and the installer. Other chapters within NFPA 58 have been similarly organized to make it easier for the user to find relevant sections within the standard and understand how the standards applies to them.

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**NOTE:** For more information on the history of NFPA 58, see the *NFPA LP-Gas Code Handbook*, 7th edition (2004) by Theodore C. Lemoff. The Handbook is an excellent resource for firefighters, fire and explosion investigators, code enforcement personnel, and members of the propane industry.

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The inauguration of the GAS Check™ program in 1985 signified the beginning of a voluntary industry-wide effort to help reduce residential accidents involving propane. The leadership of NPGA and GAMA (the Gas Appliance Manufacturers Association) studied safety problems in residential propane use and reviewed the causes of propane accidents. Today, the GAS Check™ program remains a valuable safety program enabling propane industry marketers to systematically inspect customer installations for hazards and provide important safety information.

The GAS Check™ program is currently being updated to include two types of inspections: a GAS System Check and a Gas Appliance System Check, dependent upon the employee's experience. The GAS System Check can be completed on the gas delivery system, while the Gas Appliance System Check can be completed on both the gas delivery system and all propane-burning appliances.

Since its inception, over 3 million GAS Check™ inspections have been performed nationwide. The program has also been awarded the National Fire Protection Association's Member Award for the best example of a Public Safety Education Program. Additional information on the GAS Check™ program can be referenced at [www.propanesafety.com](http://www.propanesafety.com).

### CERTIFIED EMPLOYEE TRAINING PROGRAM® (CETP)

NPGA and the Propane Education & Research Council (PERC) have also been a leaders in promoting safe work practices and quality service to customers by encouraging employees from member companies to participate in the voluntary Certified Employee Training Program (CETP). Since its inception in 1988, the CETP has provided a comprehensive training curriculum to thousands of employees in the propane industry. CETP provides employers with a tool for satisfying one of their most basic responsibilities, employee training, coupled with verifiable third party documentation of that training. Today, CETP can be delivered in several different training formats, including the traditional classroom, CD-Rom based training, and e-learning strategies incorporating the use of the Internet.

The CETP program has provided training to more than 60,000 propane industry employees. Well-trained and certified propane industry employees working in the field on a daily basis are a key component of the propane industry's safety and fire protection program. Additional information on CETP can be referenced at [www.propanesafety.com](http://www.propanesafety.com).

**PROpane education & research COUNCIL**

**MODULE 1 INTRODUCTION TO BASIC PRINCIPLES AND PRACTICES OF PROPANE**

LESSON 1 COURSE OVERVIEW AND OBJECTIVES

PAGE 2 WHO SHOULD TAKE THIS COURSE

**Who Should Take This Course**

Since safety and reliability are everyone's business, employees throughout the propane industry will find this training useful—maybe even life saving. This course is designed to train various types of propane employees including:

- Field personnel & delivery drivers
- Customer relations & office personnel
- Installation & service personnel
- Sales personnel
- Plant personnel

## NFPA HAZMAT EMERGENCY RESPONSE STANDARDS

NFPA publishes three major documents which are widely adopted by emergency response organizations who respond to hazardous materials emergencies. These include:

- NFPA 471—Recommended Practice for Responding to Hazardous Material Incidents
- NFPA 472—Standard for Professional Competence of Responders to Hazardous Material Incidents
- NFPA 473—Standard for Professional Competence of EMS Personnel Responding to Hazardous Material Incidents

It is important to recognize that these standards are written for emergency response personnel and make no distinction between public safety, military, or industrial emergency responders. Essentially, the standard applies equally across the board to all hazardous materials emergency response personnel. The standards recognize that there are varying levels of competency required to respond safely to an incident, and the standard is organized around these competencies.

### NFPA 471—RECOMMENDED PRACTICE FOR RESPONDING TO HAZARDOUS MATERIAL INCIDENTS

NFPA 471 is a recommended practice that covers planning, procedures, policies, and application of procedures for incident levels, personal protective clothing and equipment, of decontamination, safety, and communications. The purpose of NFPA 471 is to outline the minimum requirements that should be considered when dealing with responses to hazmat incidents, and to specify operating guidelines.

### NFPA 472—STANDARD FOR PROFESSIONAL COMPETENCE OF RESPONDERS TO HAZARDOUS MATERIAL INCIDENTS

NFPA 472 is a technical standard that specifies the minimum competencies for those who will respond to hazardous material incidents. The overall objective is to reduce the number of accidents, injuries, and illnesses during response to hazmat incidents, and to prevent exposure to hazmats to reduce the possibility of fatalities, illnesses, and disabilities affecting emergency responders.

It is important to recognize that NFPA 472 covers all hazmat emergency responders from both the public and private sector. This includes members of emergency response teams, individuals who may work at LP-Gas plants or propane bulk plants, and individuals who represent the propane gas industry as cargo tank specialists.

NFPA 472 provides competencies for the following levels of hazmat responders. These levels parallel those listed within OSHA 1910.120 (q), with the exception that the Hazardous Materials Specialist has been deleted from NFPA 472 and the Specialist Employee has been expanded into various specialty areas. The following information summarizes the various competency levels in the standard:

**Awareness Level Personnel**—Those persons who, in the course of their normal duties, could encounter an emergency involving hazardous materials/ weapons of mass destruction (WMD) and who are expected to recognize the presence of the hazardous materials/ weapons of mass destruction (WMD), protect themselves, call for trained personnel, and secure the scene. Under 29 CFR 1910.120, this person is identified as the First Responder at the Awareness Level).

**Operations Level Responders**—Those persons who respond to hazardous materials/weapons of mass destruction (WMD) incidents for the purpose of protecting nearby persons, the environment, or property from the effects of the release. These persons may have additional competencies that are specific to their response mission, expected tasks, and equipment and training as determined by the authority having jurisdiction. Under 29 CFR 1910.120 this person is identified as a First Responder at the Operations Level.

Under NFPA 472, operations level responder competencies broken into two categories: (1) core competencies that are required of all emergency responders regardless of agency affiliation or job requirements, and (2) and mission-specific competencies, as determined by the responder's employer or authority having jurisdiction. Examples of mission specific tasks include the use of chemical protective clothing and respiratory protection, decontamination, product control, evidence preservation, and sampling.

**Hazardous Materials Technician**—Those persons who respond to hazardous materials/weapons of mass destruction (WMD) incidents using a risk based response process with the ability to analyze a problem involving hazardous materials/weapons of mass destruction (WMD), select appropriate decontamination procedures, and control a release using specialized protective clothing and control equipment. These persons may have additional competencies that are specific to their response mission, expected tasks, and equipment and training as determined by the authority having jurisdiction

**Incident Commander**—The individual responsible for all incident activities, including the development of strategies and tactics and the ordering and the release of resources. The IC has overall authority and responsibility for conducting incident operations and is responsible for the management of all incident operations at the incident site.

**Specialist Employees**—These are individuals who, in the course of their regular job duties, work with or are trained in the hazards of specific materials and/or containers. In response to incidents involving chemicals, they may be called upon to provide technical advice or assistance to the Incident Commander relative to their area of specialization. Under NFPA 472, there are three levels of specialist employee:

- Level C are those persons who may respond to incidents involving chemicals and/or containers within their organization's area of specialization. They may be called upon to gather and record information, provide technical advice, and/or arrange for technical assistance consistent with their organization's emergency response plan and standard operating procedures. The individual is not expected to enter the hot/warm zone at an incident. Most propane industry responders would fall into this category.
- Level B are those persons who, in the course of their regular job duties, work with or are trained in the hazards of specific chemicals or containers within their organization's area of specialization. Because of their education, training or work experience, they may be called upon to respond to incidents involving chemicals. The Level B employee may be used to gather and record information, provide technical advice, and provide technical assistance (including working within the hot zone) at the incident consistent with his or her organization's emergency response plan and standard operating procedures, and the local emergency operations plan.



- Level A are those persons who are specifically trained to handle incidents involving chemicals and/or containers for chemicals used in their organization's area of specialization. Consistent with his or her organization's emergency response plan and standard operating procedures, the Level A employee is able to analyze an incident involving chemicals (in this case, propane) within his or her organization's area of specialization, plan a response to that incident, implement the planned response within the capabilities of the resources available, and evaluate the progress of the planned response.

### COMPETENCIES FOR TECHNICIANS WITH SPECIALTY AREAS

NFPA 472 outlines non-mandatory competencies for emergency responders who are already hazardous materials technicians and want to develop a specialty in a specific container or product area. Specialty areas which may apply to the LP-Gas industry include:

- **Tank Car Specialty**—Technicians who provide support to the hazardous materials technician, provide oversight for product removal and movement of damaged tank cars (e.g. DOT-112), and act as a liaison between technicians and other outside resources. These technicians are expected to use specialized protective clothing and specialized control equipment.
- **Cargo Tank Specialty**—Technicians who provide support to the hazardous materials technician, provide oversight for product removal and movement of damaged cargo tank trucks (e.g., MC-331), and act as a liaison between technicians and other outside resources. These technicians are expected to use specialized protective clothing and specialized control equipment.
- **Intermodal Tank Specialty**—Technicians who provide support to the hazardous materials technician, provide oversight for product removal and movement of damaged intermodal tanks (e.g., IMO Type 5 and DOT Spec-51), and act as a liaison between technicians and other outside resources. These technicians are expected to use specialized protective clothing and specialized control equipment.
- **Flammable Gas Bulk Storage Specialty**—Technicians who, in incidents involving bulk flammable gas storage tanks, provide the support to the hazardous materials technician and other personnel, provide strategical and tactical recommendations to the on-scene Incident Commander, provide oversight for fire control and product removal operations, and act as a liaison between technicians, firefighting personnel, and other outside resources. These technicians are expected to use specialized protective clothing and specialized control equipment.



FIGURE 3-2



## NFPA 473—STANDARD FOR PROFESSIONAL COMPETENCE OF EMS PERSONNEL RESPONDING TO HAZARDOUS MATERIAL INCIDENTS

NFPA 473 is a technical standard that specifies minimum requirements of competence to enhance the safety and protection of response personnel and all components of the emergency medical services system. The overall objective is to reduce the number of EMS personnel accidents, exposures, and injuries and illnesses resulting from hazmat incidents. Under NFPA 473, there are two levels of EMS/HM responders:

- **EMS/HM Level I**—Persons who, in the course of their normal duties, may be called on to perform patient care activities in the cold zone at a hazmat incident. EMS/HM Level I responders provide care to only those individuals who no longer pose a significant risk of secondary contamination. Level I includes different competency requirements for Basic (BLS) and Advanced Life Support (ALS) personnel.
- **EMS/HM Level II**—Persons who, in the course of their normal duties, may be called on to perform patient care activities in the warm zone at a hazmat incident. EMS/HM Level II responders may provide care to those individuals who still pose a significant risk of secondary contamination. In addition, personnel at this level shall be able to coordinate EMS activities at a hazmat incident and provide medical support for hazmat response personnel. Level II includes different competency requirements for Basic (BLS) and Advanced Life Support (ALS) personnel.

### TESTING LABORATORIES

The development of standards is only one part of the job of ensuring consistency and safety in the propane industry. This is especially true in the development of manufacturing standards for LP-Gas containers, equipment and appliances. To ensure that these rigorous safety standards are met, samples of equipment must be tested by third party, independent testing laboratories before they can be sold to the public. The equipment must be tested both for safe operation and proper performance.

To ensure that the testing is fair and objective, the equipment is normally sent to one or more independent testing laboratories to certify that the equipment meets the required standards. Numerous independent testing laboratories are used in the propane industry.

## REGULATIONS

### FEDERAL REGULATIONS

Industry consensus standards and independent laboratory testing results are necessary and valuable safeguards for safe, efficient, and reliable propane equipment and operations. However, if these standards and testing requirements are not enforced, they can easily lose their effectiveness. The job of enforcement is the responsibility of federal, state, county, and local municipal governments.

Remember that a voluntary consensus standard is a voluntary guide and is not mandatory for use by an industry. However, when a government agency adopts a consensus standard such as NFPA 58, that standard then becomes a regulation or

law, under the jurisdiction of that agency or authority having jurisdiction. Depending upon the law and any related infractions, The agency must enforce the law. In many cases, enforcement can result in civil fines or even criminal penalties to both companies and individuals that do not follow the regulations.

Section 12 of the federal National Technology Transfer and Achievement Act of 1995 states that “all federal agencies and departments shall use technical standards that are adopted by voluntary consensus standards as a means to carry out policy objectives or activities determined by the agencies or departments.” Under the Act, technical standards are defined as “performance-based or design-specific technical specifications and related management system practices.” Consequently, the basis for many federal regulations comes directly from the adoption of a voluntary consensus standard.

## CODE OF FEDERAL REGULATIONS

There are many important federal regulations that apply to all employees and operators in the propane industry. Federal regulations are published in a series of documents called *The Code of Federal Regulations* (CFR). The CFR is a publication of all rules and regulations enforced by various federal departments and agencies.

The CFR is organized into 50 groups or “titles.” Each Title of the CFR is further organized into separate books that contain the rules and regulations pertaining to a specific agency or department. Notices of proposed CFR changes, revisions and related activity are published daily by the U.S. Government Printing Office in the *Federal Register*.

There are two federal departments in particular whose regulations apply to most propane operations and employees and emergency responders. These are the U.S. Department of Labor—Occupational Safety and Health Administration (OSHA) and U.S. Department of Transportation (DOT).

## DEPARTMENT OF LABOR

The Department of Labor (DOL) is a cabinet-level department of the United States government. Among its responsibilities are It is responsible for enforcing safety and health regulations for employees as set forth in CFR Title 29—Labor.

## OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

The U.S. Occupational Safety and Health Administration (OSHA) is the lead federal agency responsible for protecting the safety and health of workers in the workplace. OSHA’s statutory authority is derived from the Williams-Steiger Occupational Safety and Health Act (OSHA) of 1970. This act ensures that safe practices and procedures are followed while on the job. Some of its regulations provide guidelines for:

- Accident prevention measures
- Reporting on-the-job accidents
- First aid and medical attention for on-the-job injuries
- Job related safety training
- Fire protection on the job
- Illumination of work areas
- Sanitation and general housekeeping at places of work

The OSH Act grants OSHA the authority to develop safety and health regulations and to conduct inspections to identify unsafe work practices, and it requires that corrective action be taken to protect worker health and safety. The law also allows OSHA to issue citations and pursue civil and criminal prosecution for noncompliance with its regulations.

OSHA regulations cover a wide variety of industries, processes, and environments, including facilities that manufacture, use, and store flammable and combustible liquids and gases. OSHA's liquefied petroleum gas regulations are found in 29 CFR 1910.110.

## OSHA HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE

OSHA Hazardous Waste Operations and Emergency Response (29 CFR 1910.120), also known as HAZWOPER, was issued under the authority of Title I of the Superfund Amendments and Reauthorization Act of 1986 (SARA). The regulation was written and is enforced by the Occupational Safety and Health Administration. The regulation applies to industry and public safety in those 23 states and 2 territories with their own OSHA-approved occupational safety and health plans. In the remaining 27 "non-OSHA" states, public sector personnel will be covered by a similar regulation enacted by the Environmental Protection Agency (40 CFR Part 311).

The regulation establishes important requirements for both industry and public safety organizations who respond to hazmat or hazardous waste emergencies. This includes firefighters, law enforcement and EMS personnel, hazmat responders, industrial Emergency Response Team (ERT) members and propane industry personnel who may function as a product or container specialist at a propane incident. Requirements cover the following areas:

- Hazmat Emergency Response Plan
- Emergency Response Procedures, including the establishment of an Incident Management System, the use of the buddy system with back-up personnel, and the establishment of a Safety Officer
- Specific training requirements covering instructors and both initial and refresher training
- Medical surveillance programs
- Post-emergency termination procedures

Of particular interest to hazmat managers and public safety and propane industry responders are the specific levels of competency and associated training requirements identified within OSHA 1910.120 (q)(6).

### OSHA 1910.120 LEVELS OF EMERGENCY RESPONDERS

**First Responder at the Awareness Level**—These are individuals who are likely to witness or discover a hazardous substance release and who have been trained to initiate an emergency response notification process. The primary focus of their hazmat responsibilities is to secure the incident site, recognize and identify the materials involved, and make the appropriate notifications. These individuals would take no further action to control or mitigate the release. First Responder—Awareness personnel shall have sufficient training or experience to objectively demonstrate the following competencies:

- a. An understanding of what hazardous materials are, and the risks associated with them in an incident.
- b. An understanding of the potential outcomes associated with a hazardous materials emergency.
- c. The ability to recognize the presence of hazardous materials in an emergency and, if possible, identify the materials involved.
- d. An understanding of the role of the First Responder—Awareness individual within the Employers Emergency Response Plan. This would include site safety, security, and control, and the use of the DOT Emergency Response Guidebook.
- e. The ability to realize the need for additional resources and to make the appropriate notifications to the communication center.

There is no minimum hourly training requirement for this level; the employee would have to have sufficient training to objectively demonstrate the required competencies.

**First Responder at the Operations Level**—Most fire department suppression and EMS personnel fall into this category. These are individuals who respond to releases or potential releases of hazardous substances as part of the initial response for the purpose of protecting nearby persons, property or the environment from the effects of the release. They are trained to respond in a defensive fashion without actually trying to stop the release. Their primary function is to contain the release from a safe distance, keep it from spreading, and protect exposures.

**First Responder**—Operations personnel shall have sufficient training or experience to objectively demonstrate the following competencies:

- a. Knowledge of basic hazard and risk assessment techniques
- b. Knowledge of how to select and use proper personal protective clothing and equipment available to the Operations-level responder
- c. An understanding of basic hazardous materials terms
- d. Knowledge of how to perform basic control, containment and/or confinement operations within the capabilities of the resources and personal protective equipment available
- e. Knowledge of how to implement basic decontamination measures
- f. An understanding of the relevant standard operating procedures and termination procedures

First responders at the operations level shall have received at least 8 hours of training or have had sufficient experience to objectively demonstrate competency in the previously mentioned areas, as well as the established skill and knowledge levels for the First Responder—Awareness level.

**Hazardous Materials Technician**—These are individuals who respond to releases or potential releases for the purposes of stopping the release. Unlike the operations level, they generally assume a more aggressive role in that they are often able to approach the point of a release in order to plug, patch, or otherwise stop the release of a hazardous substance.

Hazardous materials technicians are required to have received at least 24 hours of training equal to the First Responder—Operations level and have competency in the following established skill and knowledge levels:

- a. Capable of implementing the Employers Emergency Response Plan
- b. Able to classify, identify, and verify known and unknown materials by using field survey instruments and equipment (direct reading instruments)
- c. Able to function within an assigned role in the Incident Management System
- d. Able to select and use the proper specialized chemical personal protective clothing and equipment provided to the Hazardous Materials Technician
- e. Understand hazard and risk assessment techniques
- f. Able to perform advanced control, containment, and/or confinement operations within the capabilities of the resources and equipment available to the Hazardous Materials Technician
- g. Understand and implement decontamination procedures
- h. Understand basic chemical and toxicological terminology and behavior

Hazardous Materials Technicians may not necessarily be part of a hazardous materials response team. However, if they are part of a designated team as defined by OSHA, they must also meet the medical surveillance requirements within OSHA 1910.120.

**Hazardous Materials Specialists**—These are individuals who respond with and provide support to Hazardous Materials Technicians. While their duties parallel those of the Technician, they require a more detailed or specific knowledge of the various substances they may be called upon to contain. This individual would also act as the site liaison with Federal, state, local, and other governmental authorities in regard to site activities.

Similar to the Technician level, Hazardous Materials Specialists shall have received at least 24 hours of training equal to the technician level and have competency in the following established skill and knowledge levels:

- a. Capable of implementing the local Emergency Response Plan
- b. Able to classify, identify, and verify known and unknown materials by using advanced field survey instruments and equipment (direct reading instruments)
- c. Knowledge of the state emergency response plan
- d. Able to select and use the proper specialized chemical personal protective clothing and equipment provided to the Hazardous Materials Specialist
- e. Understand in-depth hazard and risk assessment techniques
- f. Able to perform advanced control, containment, and/or confinement operations within the capabilities of the resources and equipment available to the Hazardous Materials Specialist
- g. Able to determine and implement decontamination procedures
- h. Ability to develop a site safety and control plan



- i. Understand basic chemical, radiological, and toxicological terminology and behavior

Where the Hazardous Materials Technician possesses an intermediate level of expertise and is often viewed as a “utility person” within the hazmat response community, the Hazardous Materials Specialist possesses an advanced level of expertise. Within the fire service, the Specialist will often assume the role of the Safety Officer or Hazmat Group Supervisor, while an industrial Hazardous Materials Specialist may be “product specific.” Finally, the Specialist must meet the medical surveillance requirements outlined within OSHA 1910.120.

**On-Scene Incident Commander**—Incident Commanders, who will assume control of the incident scene beyond the First Responder Awareness level, shall receive at least 24 hours of training equal to the First Responder Operations level. In addition, the employer must certify that the incident commander has competency in the following areas:

- a. Know and be able to implement the local incident management system.
- b. Know how to implement the local Emergency Response Plan.
- c. Understand the hazards and risks associated with working in chemical protective clothing.
- d. Know of the state emergency response plan and of the Federal Regional Response Team.
- e. Know and understand the importance of decontamination procedures.

**Skilled Support Personnel**—These are personnel who are skilled in the operation of certain equipment, such as cranes and hoisting equipment, and who are needed temporarily to perform immediate emergency support work that cannot reasonably be performed in a timely fashion by emergency response personnel. It is assumed that these individuals will be exposed to the hazards of the emergency response scene.

Although these individuals are not subject to the HAZWOPER training requirements, they shall be given an initial briefing at the site prior to their participation in any emergency response effort. This briefing shall include elements such as instructions in using personal protective clothing and equipment, the chemical hazards involved, and the tasks to be performed. All other health and safety precautions provided to emergency responders and on-scene workers shall be used to assure the health and safety of these support personnel.

**Specialist Employees**—These are employees who, in the course of their regular job duties, work with and are trained in the hazards of specific hazardous substances, and who will be called upon to provide technical advice or assistance to the Incident Commander at a hazmat incident. This would include industry responders, chemists, and related professional or operations employees. These individuals shall receive training or demonstrate competency in the area of their specialization annually. Some designated propane industry responders may fall into this section of the law.

Individuals seeking further information on the application of OSHA standards to propane and hazardous materials response scenarios should consult the OSHA website at [www.osha.gov](http://www.osha.gov). Specific attention should be paid to (1) the



HAZWOPER Preamble; (2) OSHA interpretations of the HAZWOPER Standard; and (3) OSHA Directive Number CPL 2-2.59A—Inspection Procedures for the Hazardous Materials Operations and Emergency Response Standard, 29 CFR 1910.120 and 1926.65, Paragraph (q): Emergency Response to Hazardous Substance Releases (April 4, 1998).

## DEPARTMENT OF TRANSPORTATION

The Department of Transportation (DOT) is a cabinet-level department of the United States government. DOT establishes rules and regulations governing interstate transportation of materials and passengers, and under recent changes in federal law, intrastate transportation of hazardous materials such as propane and other LP-gases. The DOT Pipeline and Hazardous Materials Safety Administration (PHMSA) is the primary DOT agency with responsibility for the transportation of propane and other hazardous materials. Additional information on PHMSA can be found at [www.phmsa.dot.gov](http://www.phmsa.dot.gov).

DOT regulations of the Department of Transportation are covered by Title 49 of the Code of Federal Regulations (CFR), entitled Transportation (Parts 100–199, 301–398). Some of the regulations and design codes covered in Title 49 are:

- Regulations governing the transportation of propane across state lines by rail, aircraft, water vessel, public highway, or pipeline, both interstate and intrastate
- Regulations governing the proper care and handling of propane during container filling
- Design codes for the manufacture of portable, replaceable, and stationary propane cylinders
- Design codes for the manufacture of cargo tanks (bulk trucks and transports) and portable tanks (“skid tanks”)
- Design codes for the manufacture of railroad tank cars

Many of these specifications and regulations evolved from existing industry standards. ASME and NFPA are only two of the many organizations providing standards that have been adopted as DOT regulations.



**FIGURE 3-3** DOT regulations govern the design, manufacture and repair of containers used for the transportation of propane.

## OTHER FEDERAL REGULATORY AGENCIES

More recent CFR reporting requirements enforced by the Environmental Protection Act (EPA) are:

- 40 CFR 300, 355, 370, & 372—Superfund Amendments and Reauthorization Acts of 1986 (SARA) Title III—Community Right to Know. Some of the regulations covered concern hazard communication and emergency planning mandates.
- 40 CFR 300—Clean Air Act—Regulations governing vehicle emission. These regulations cover emission controls for mobile and stationary sources such as lift trucks and municipal fleets. The Act named propane as an alternative vehicle fuel.

## STATE AND LOCAL GOVERNMENT REGULATIONS

Each state and most local governments have a special set of fire prevention and operational safety codes that apply to propane operations. These codes may be based completely on nationally recognized standards such as ANSI Z223.1 (NFPA 54), NFPA 58, the International Fuel Gas Code® and DOT regulations.

Unlike federal regulations, state and local codes may be enforced by any one of many different types of agencies. Enforcement is usually accomplished through on-the-spot inspections by these agencies. Some of the agencies that may enforce regulations and conduct inspections are:

- *State Propane Commission or Agency*—Many states have created agencies that enforce regulations directed specifically at the propane industry: Texas, Louisiana, Alabama, California, and New Mexico are some of the states that currently have propane commissions or agencies.
- *State Fire Marshal's Office*—Many fire safety regulations for propane operations are enforced by the State Fire Marshal (for example, state enforcement of the LP-Gas Code). Additional information on the role of state fire marshal personnel can be obtained from the National Association of State Fire Marshals (NASFM) at [www.firemarshals.org](http://www.firemarshals.org).
- *State Department of Transportation*—Enforces regulations regarding transportation of propane within the state.
- *Public Safety Commission*—Monitors consumer safety in the area of propane operations.
- *Local Fire or Building Department*—Enforces fire prevention and building codes which are adopted at the local level.

## SUMMARY

Two of the most important types of standards that are developed and used by the propane industry are (1) manufacturing and equipment standards, and (2) fire prevention and operational safety standards.

LP-Gas standards must be constantly updated to meet the changing needs and technology of the industry. In order to accomplish this task, the propane industry relies on and supports many organizations whose sole purpose is to organize, develop and accredit voluntary consensus standards.

All of the national fire codes in the United States are developed through the voluntary consensus standards process, with the two key players being the National Fire Protection Association (NFPA) and Western Fire Chiefs Association. The National Fire Protection Association has over 70 individual voluntary consensus standards addressing hazardous materials. At least 8 of these deal specifically with flammable gas issues, with *NFPA 58—Liquefied Petroleum Gas Code* being the primary standard which addresses propane.

NFPA publishes three major consensus documents which are widely adopted by emergency response organizations who respond to hazardous materials emergencies. These include: *NFPA 471—Recommended Practice for Responding to Hazardous Material Incidents*, *NFPA 472—Standard for Professional Competence of Responders to Hazardous Material Incidents*, and *NFPA 473—Standard for Professional Competence of EMS Personnel Responding to Hazardous Material Incidents*. NFPA 472 is widely referenced and used throughout the emergency response community and specifies the minimum competencies for those who will respond to hazardous material incidents.

The U.S. Occupational Safety and Health Administration (OSHA) is the lead federal agency responsible for protecting the safety and health of workers in the workplace. The OSHA Hazardous Waste Operations and Emergency Response (29 CFR 1910.120) establishes important requirements for both industry and public safety organizations who respond to hazmat or hazardous waste emergencies. This includes firefighters, law enforcement and EMS personnel, hazmat responders, and industrial Emergency Response Team (ERT) members.





# NON-BULK AND BULK CONTAINER DESIGN AND CONSTRUCTION FEATURES



**OBJECTIVES**

1. Define the following terminology as it relates to propane containers:
  - Container
  - Non-bulk packaging
  - Bulk packaging
  - Fixed containers
2. Describe the following basic features of a propane container:
  - Basic storage container
  - Pressure regulators
  - Pressure relief devices
3. Describe the basic design and construction features for the following categories of propane containers:
  - DOT portable cylinders
  - DOT portable tanks
  - ASME mobile motor fuel tanks
  - ASME stationary tanks
4. Describe the following categories of DOT cylinders:
  - Portable service cylinder
  - Exchange service cylinder
  - Motor fuel cylinder
  - Stationary service cylinder
5. Describe the differences between a DOT-approved exchange cylinder and a cylinder exchange station.
6. Describe the differences between a DOT motor fuel cylinder and an ASME motor fuel tank.
7. List the basic cylinder markings found on DOT cylinders.
8. Describe the following basic design and construction features of a DOT portable tank:
  - Tank openings and valves
  - Mounting hardware
  - Data plate information
9. Identify facility and transportation markings and colors that can indicate the presence of propane, including the following:
  - Placards and labels
  - UN/NA identification numbers
  - NFPA 704 markings
  - Container markings

10. Describe the following applications of ASME motor fuel tanks:
  - Recreational vehicles
  - Lift trucks
  - Motor fuel tanks for road vehicles
11. Describe the basic design and construction features of ASME motor fuel tanks.

## ABBREVIATIONS AND ACRONYMS

|      |                                          |
|------|------------------------------------------|
| ABS  | Poly-Acrylonitrile Butadiene Styrene     |
| A.G. | Aboveground Tank                         |
| ASME | American Society of Mechanical Engineers |
| DOT  | U.S. Department of Transportation        |
| HDPE | High-Density Polyethylene                |
| ICC  | Interstate Commerce Commission           |
| MAWP | Maximum Allowable Working Pressure       |
| NFPA | National Fire Protection Association     |
| NPT  | National Pipe Thread                     |
| PERC | Propane Education and Research Council   |
| PET  | Polyethylene Terephthalate               |
| psig | Pounds per Square Inch Gauge             |
| U.G. | Underground Tank                         |
| w.c. | Water Capacity                           |

## BASIC CATEGORIES AND TYPES OF CONTAINERS

### DEFINITION OF CONTAINERS

The wide application and uses of propane in residential, commercial, industrial, and agricultural service require a variety of different propane containers to meet the needs of the consumer. Understanding the common design and construction features of propane containers and their unique features is important to emergency responders from both a safety and tactical perspective.

In this section, we will provide an overview of the different types of non-bulk and bulk containers, explain their use in both residential and commercial occupancies and in transportation, and provide an overview of each type of major propane container currently in use.

First, let's begin with some basic background information on containers, and then move onto specific types of cylinders and containers. *NFPA 472—Standard for Professional Competence of Responders to Hazardous Materials Incidents* defines a container as “Any vessel or receptacle that holds material, including storage vessels, pipelines, and packaging.” Within the emergency response community, containers are defined and divided into three broad categories:

**Non-bulk Packaging**—Includes containers such as bags, bottles, boxes, carboys, cylinders, drums, jerricans, multicell packages, and wooden barrels. Many propane cylinders and portable containers fall under the non-bulk container category since they are generally small to medium size containers. Containers with a gas capacity of 1,001 pounds (454 kg) or less, are considered to be non-bulk packaging. We will cover all of the general propane containers that fit under this category in this section of the text.

**Bulk Packaging**—Includes containers such as bulk bags, bulk boxes, cargo tanks, covered hopper cars, freight containers, gondolas, pneumatic hopper trailers, portable tanks and bins, protective overpacks for radioactive materials, tank cars, ton containers, and van trailers. Many propane containers fall under the bulk-packaging definition as “stationary tanks.” Containers with a gas capacity greater than 1,001 pounds (454 kg) are considered to be bulk packaging. Most fire departments and Hazardous Materials Response Teams may consider propane containers with water capacities greater than 2,000 gallons as bulk containers for emergency response purposes.

**Fixed Containers**—Includes piping systems, reactors, storage bins, and storage vessels. Larger stationary propane storage tanks such as those found at bulk plants and industrial facilities are examples.

It should be noted that although some regulations and codes define a container by placing size limitations on its capacity, NFPA 472 simply defines a container as anything designed to hold a hazardous material. While this method of categorization is familiar to the fire service and Hazardous Materials Response Teams, propane industry personnel are more accustomed to a system based upon design and use.

NFPA 58, the *LP-Gas Code*, defines a container as any vessel, including cylinders, tanks, portable tanks, and cargo tanks, used for the transportation or storing of LP-Gas.

## BASIC FEATURES OF CONTAINERS

Within the propane industry, most non-bulk and bulk containers that are not involved in bulk transportation (e.g., cargo tank trucks, railroad tank cars, intermodal containers) can be broken into four broad categories:

- DOT cylinders
- DOT portable tanks
- ASME mobile/motor fuel tanks
- ASME stationary tanks

We will review the differences between each of these four categories in this section. However, it should be noted that despite their differences in size and construction features, every propane system used to distribute propane gas to fuel-burning equipment and appliances has three common components. These include the propane container, a pressure regulator, and a pressure relief device.

## CONTAINER

The container is designed to store liquid propane safely under pressure. It may consist of cylinders, tanks, or a series of cylinders or tanks that are manifolded together.

American Society of Mechanical Engineers (ASME) tanks are some of the most common types of propane containers used in residential and commercial service. All ASME tanks, regardless of purpose, are built according to the *ASME Boiler and Pressure Vessel Code*. Because all ASME tanks are built to meet the same code, they have numerous design and construction similarities:

- Capacities are calculated by the maximum amount of water that they can hold. This maximum amount is called the water capacity (w.c.) of the tank and is expressed in gallons (gallons w.c.) or in pounds (pound w.c.).
- All ASME tanks are built from steel, and the method of manufacture must comply with ASME codes. The tanks are normally made by welding a “head” to each end of a barrel, also known as a shell. All tanks have fittings and various types of valves.
- A metal data plate must be attached to every ASME tank in order to comply with the ASME code. See Figure 4-1. The data plate serves as the ID card for the tank and is the primary way used to confirm that the tank meets ASME requirements. Every propane tank data plate must have the following information stamped on it:
  - o Manufacturer’s name and address
  - o Type of intended service (under or above ground, etc.)
  - o Water capacity of the tank in pounds or U.S. gallons
  - o Design or maximum allowable working pressure (MAWP) in psig
  - o The wording: “This container shall not contain a product having a vapor pressure in excess of \_\_ psig at 100°F
  - o Outside surface area in square feet
  - o Year of manufacture
  - o Shell thickness and head thickness
  - o Overall length (OL), outside diameter (OD), head design (HD)
  - o Manufacturer’s serial number
  - o ASME Code Symbol

Every ASME tank must have this data plate attached and legible or the data plate information must be clearly stamped on the container.

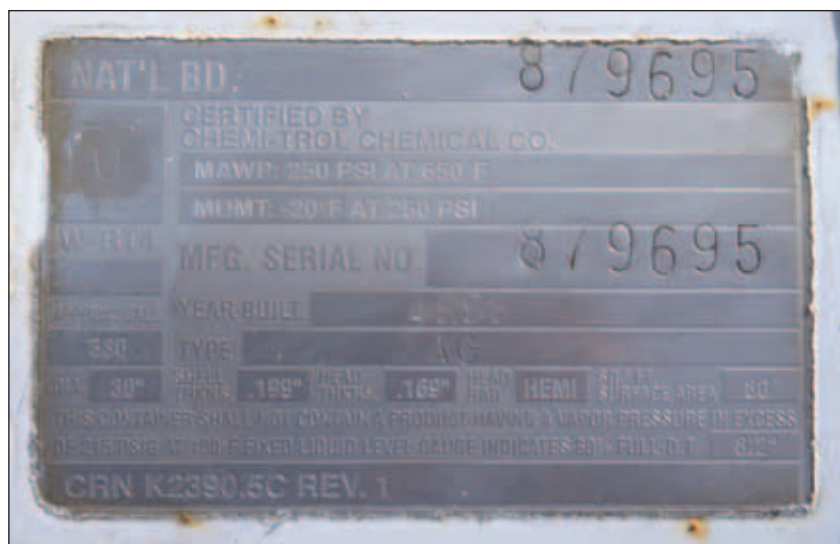


FIGURE 4-1 ASME data plate.

## PRESSURE REGULATORS

Pressure regulators are not actually part of the propane container, but are attached when the container is placed in service. There may also be regulators attached to piping at the building or structure that the container is supplying. Pressure regulators are designed to control propane vapor pressure. Propane containers are subjected to temperature changes as the outside air temperature fluctuates. These temperature changes effect the temperature of the liquid and therefore, the internal vapor pressure of the container. For example, as the day becomes warmer, the container's contents heat up and the internal propane gas vapor pressure increases correspondingly. Pressure regulators reduce the higher gas vapor pressure inside the storage container to a lower and more constant pressure, which is necessary to operate gas appliances, like heaters, and stoves, safely and efficiently.

Regulation of pressure is usually controlled in two or more "stages." See Figures 4-2A and B. The first stage decreases container pressure to the supply line pressure (usually 10 psi), and then a second-stage regulator decreases the pressure to the building distribution line pressure (1/2 psi or approximately 11 inches water column or less). Some smaller systems will accomplish both stages of pressure regulation in a single assembly at the container by linking a small first-stage regulator to a small second-stage regulator.

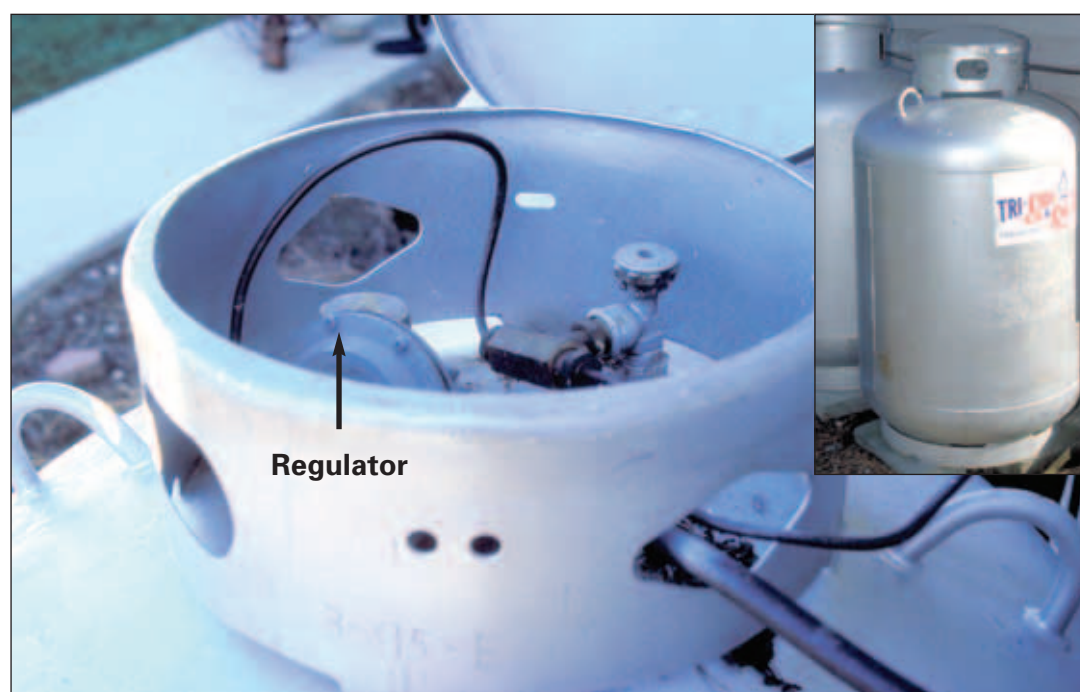


**FIGURE 4-2A** Single-stage regulator system.

NFPA 58 has required the use of two-stage regulator systems for most fixed installations in buildings since 1995. However, some older propane gas systems can be found with a single-stage regulator that reduces container pressure to the lower pressure required by appliances in one step. In single-stage systems, this lower pressure will range from approximately 10 inches to 13 inches water column due to the changes in container pressure from winter to summer.

Marketers are also starting to use a three-stage regulator system. The first stage decreases container pressure down to the supply line pressure (usually 10 psi), and the second-stage regulator decreases the pressure down to 2 psi. The third-stage reg-



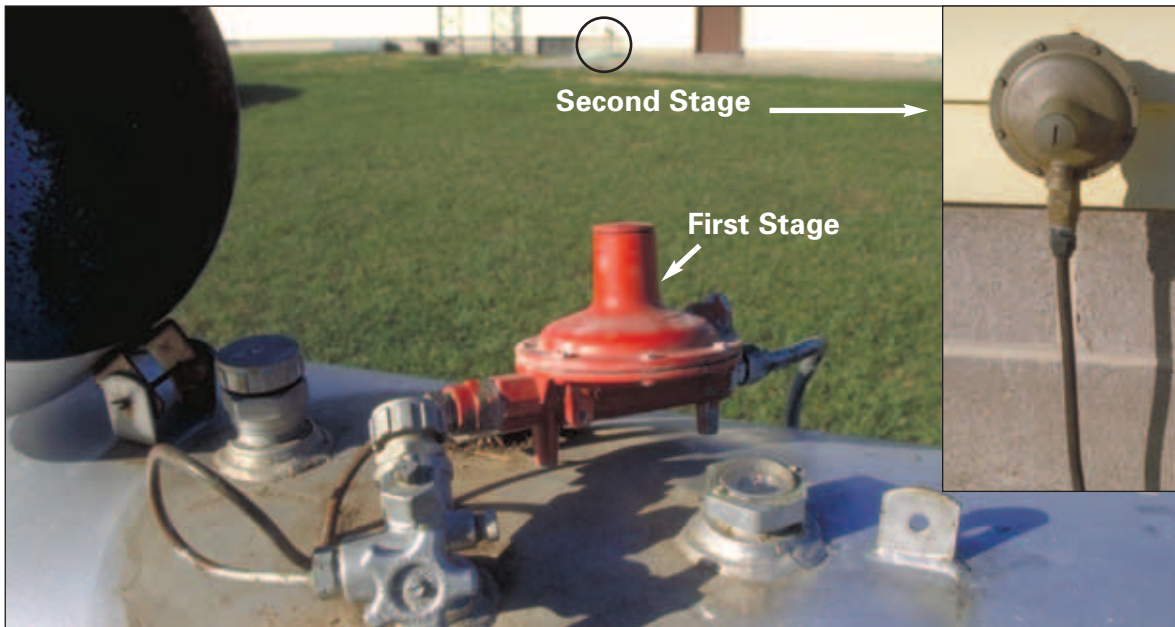


**FIGURE 4-2B** Two-stage regulator system.

ulator is located close to the appliance and decreases the pressure to the building distribution line pressure (1/2 psi or approximately 11 inches water column or less).

Emergency responders and fire inspectors should understand the role played by pressure regulators in residential and commercial propane vapor systems. For pressure regulators to be effective they must be:

- Selected to match the total gas requirements of the system;
- Installed to protect them from the effects of freezing rain, sleet, and snow; and
- Set by trained propane personnel using proper techniques and accurate instruments, to deliver the proper gas flow at the proper pressure for the total system; and
- Inspected and calibrated periodically, rechecked, and replaced as required.

Regulators are typically protected by installation under a protective dome and cover with regulator vents pointed down, as shown in Figure 4-2A.

### PRESSURE RELIEF DEVICES

Propane containers are equipped with pressure relief valves to relieve excess pressure during emergency conditions such as a fire, or when the container is in danger of failing due to overpressure. Pressure relief valves are preset to relieve internal pressure to the atmosphere. They are usually set to open between 250 psig and 375 psig, depending on whether the container is an ASME tank or a DOT cylinder.



**FIGURE 4-3** Simple residential and commercial propane installation.



## DOT PORTABLE CYLINDERS

### BASIC FEATURES OF CYLINDERS

Cylinders are used in hundreds of different applications. All propane cylinders built today are manufactured according to U.S. Department of Transportation (DOT) specifications. Before 1967, these specifications were under the control of the Interstate Commerce Commission (ICC).

Cylinders are marked with the maximum amount of water that can be stored in the cylinder. The amount is usually expressed in pounds of water. However, cylinders are typically referred to by the maximum amount of propane that can be stored in them. For example, a 100 lb. propane cylinder is a cylinder that can safely store 100 pounds of propane. This cylinder would typically be marked with a water capacity (w.c.) of 239 lb.

### DOT CYLINDER STRUCTURE

Regardless of the intended service, nearly every DOT cylinder is built by one of these three methods: (1) seamless construction, (2) two-piece construction, and (3) three-piece construction.

**Seamless Cylinders**—DOT and ICC cylinders are made from either aluminum or some type of alloyed steel. Seamless containers are not commonly found or used today.

**Two-Piece Cylinders**—Two-piece cylinders are built from two sections of metal that are joined together by welding or brazing. Two-piece cylinders typically have one seam that surrounds the center of the cylinder (called the waist seam). See Figure 4-4.

**Three-Piece Cylinder**—These cylinders are made from three sections of metal that are joined together by welding or brazing. The cylinder usually has three seams. One vertical seam forms the center section while the two waist seams join the top and bottom heads to the center section. See Figure 4-5.

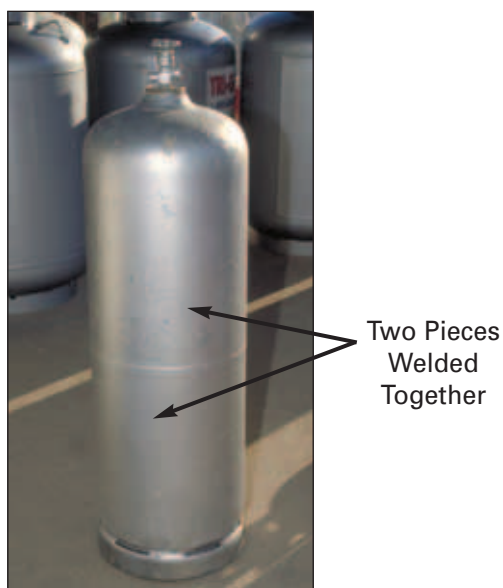


**FIGURE 4-4** Two pieces of metal. Note seams.

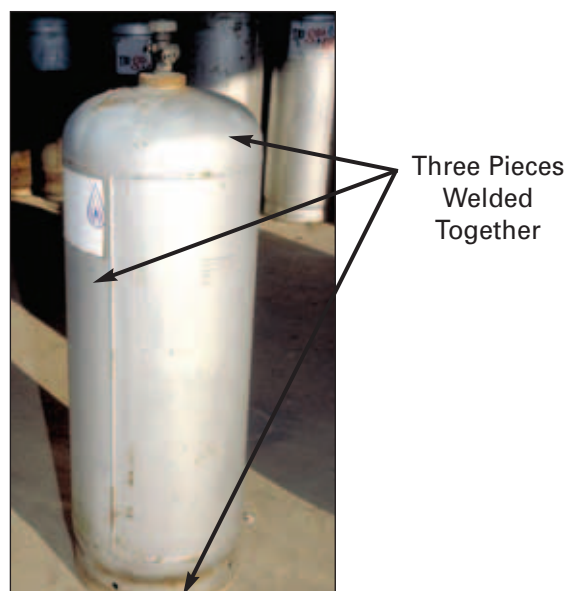


**FIGURE 4-5** Three pieces of metal. Note seams.

## TYPES OF DOT CYLINDERS

DOT cylinders can be divided into four basic types based on their intended service. These include cylinders used in:

- Portable service
- Exchange service
- Motor fuel service
- Stationary service

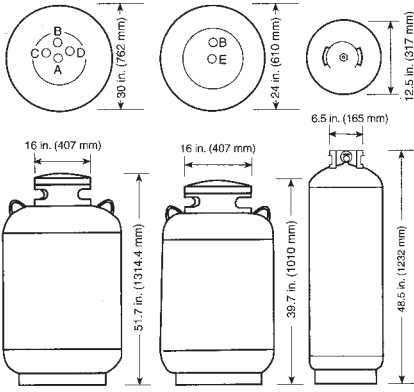
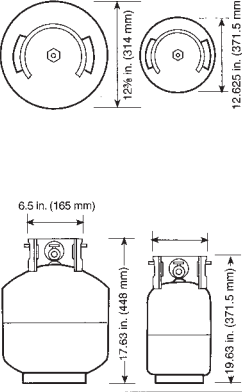
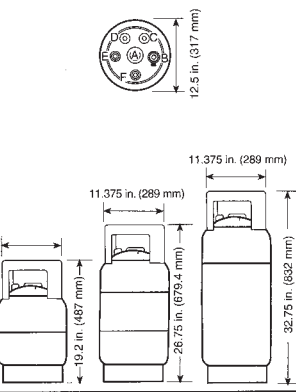
| Industrial/Commercial                                                                                     |  |  | Consumer                                                                           |  | Industrial Truck/Fork Lift                                                           |  |  |
|-----------------------------------------------------------------------------------------------------------|--|--|------------------------------------------------------------------------------------|--|--------------------------------------------------------------------------------------|--|--|
| Description/Size Openings                                                                                 |  |  |                                                                                    |  | Description                                                                          |  |  |
| A. Safety relief valve 1 in.<br>B. NPT float gauge 1 in.<br>C. Fill valve .75 in.                         |  |  |                                                                                    |  | A. Universal float gauge<br>B. Liquid service valve<br>C. Safety relief valve        |  |  |
| D. Vapor service valve .75 in.<br>E. Multi-valve .75 in.                                                  |  |  |                                                                                    |  | D. Fixed liquid level<br>E. Vapor service (plugged)<br>F. Liquid fill port (plugged) |  |  |
|                         |  |  |  |  |   |  |  |
| <b>420 lb</b><br>LP-Gas cap. 100 gal<br>Tare wt. 289 lb/131 kg<br>Water cap. 1000 lb/454 kg<br>DOT-4BW240 |  |  | <b>20 lb</b><br>5 gal<br>18 lb/8.2 kg<br>47.7 lb/21.6 kg<br>DOT-4BA240             |  | <b>20 lb</b><br>5 gal<br>26.5 lb/12 kg<br>47.7 lb/21.6 kg<br>DOT-4BA240              |  |  |
| <b>200 lb</b><br>47 gal<br>150 lb/71 kg<br>474 lb/215 kg<br>DOT-4BW240                                    |  |  | <b>6 lb</b><br>1.5 gal<br>9.2 lb/4.1 kg<br>15.5 lb/7 kg<br>DOT-4BA260              |  | <b>33-1/2 lb</b><br>8 gal<br>34.5 lb/15.5 kg<br>80 lb/36.3 kg<br>DOT-4BW240          |  |  |
| <b>100 lb</b><br>23 gal<br>72 lb/32.6 kg<br>240 lb/108 kg<br>DOT-4BW240                                   |  |  |                                                                                    |  | <b>43-1/2 lb</b><br>10 gal<br>40 lb/18 kg<br>103.6 lb/47 kg<br>DOT-4BW240            |  |  |

**FIGURE 4-6** Dimensions and capacities of typical DOT cylinders. Courtesy of Worthington Cylinder Corp.

## PORTABLE SERVICE CYLINDERS

Portable cylinders are used in more applications than any other DOT or ICC cylinder. The propane industry estimates that there are more than 80 million 20 lb. cylinders in circulation. Consequently, they are the primary source of propane emergencies for emergency responders because there are so many of them in circulation. Typical portable cylinder applications include small propane hand torches, barbecue grills, agricultural weed burners, plumber's melting pots, and recreational vehicles.

Most DOT cylinders are purchased by the customer as an individual stand-alone cylinder or as part of a propane gas appliance (e.g., a barbecue grill comes with a cylinder). When the cylinder is empty, it is usually taken by the user to a propane marketer or filling station to be refilled. Since the cylinder must be moved from point A to point B by some mode of over-the-road transportation, it must meet DOT requirements.



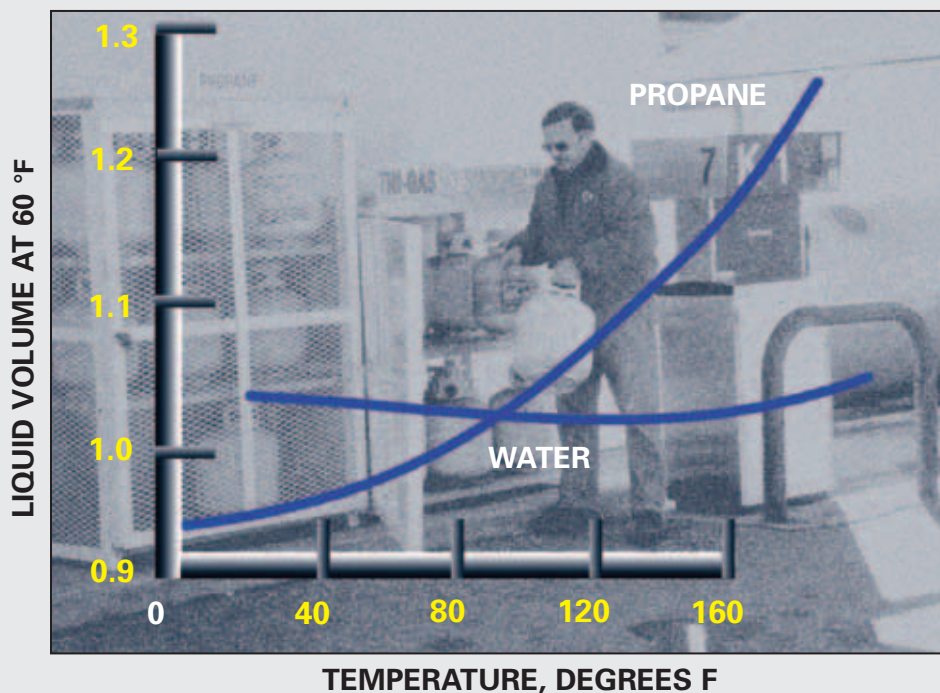
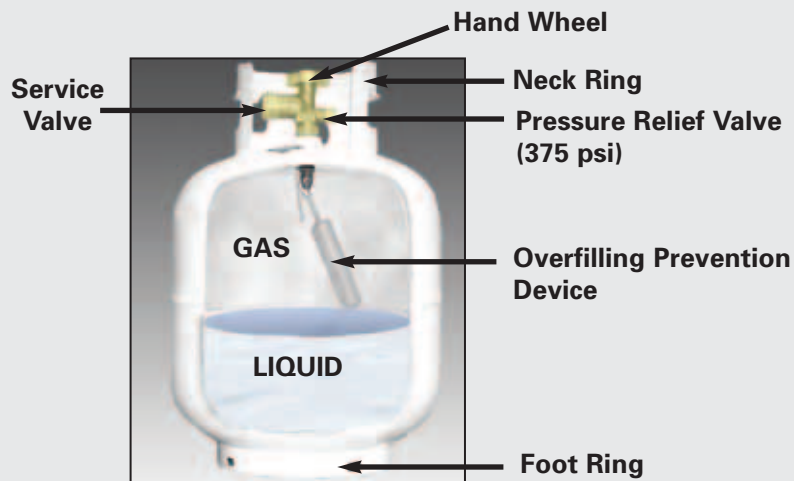
**FIGURE 4-7** 20 pound DOT portable cylinder.

Water capacities of small portable cylinders range from 2.2 lb. to 95 lb. The 20 lb., 30 lb. and 40 lb. portable cylinders are often used to supply appliances in motor homes and campers. The 20 lb. portable cylinder holds approximately 5 gallons of propane. With different valves, these same cylinders are also used for small industrial applications. The .93 lb. (commonly called one pound non-refillable) cylinder is used for torches, gas lanterns, camp stoves, etc.

All portable cylinders must have some type of openings for valves and fittings. These openings are located in the service end of the cylinder. Threaded fittings or appurtenances are usually welded to the opening. The number of openings is generally determined by the intended service of the cylinder.

Portable cylinders use a neck ring to protect the cylinder's brass valve from damage. See Figure 4-7. The neck ring is a wide metal band that is welded to, and partially surrounds, the cylinder neck in the service end of the cylinder. The neck ring often incorporates a hand hold to move the cylinder.

## DOT PROPANE SERVICE CYLINDERS AND EMERGENCY RESPONSE ISSUES



### PROPANE CYLINDER VALVES AND OVERFILLING INCIDENTS

All propane cylinders have valves to control the flow of their contents. To control that flow, valves are attached to the service end of the cylinder. Propane cylinder valves are closed in the clockwise direction and are opened counter-clockwise. In many leak situations, it may simply be a case where the cylinder valve is not completely closed.

Portable and exchange service cylinders may be intended for either vapor or liquid service. They are commonly equipped with a combination valve and pressure relief valve (PRV). On cylinders equipped for liquid service, the service connection is equipped with a special threaded outlet. The service valve is connected to a liquid withdrawal tube that extends to a point near the bottom of the cylinder. These valves are equipped with an excess flow valve that reduces



the flow of liquid propane if the valve is accidentally opened or if there is a severe break in the connected line to a regulator or appliance. Recognize that there will still be a small amount of propane that will continue to flow out any break when an excess flow valve is actuated.

## OVERFILL PREVENTION DEVICES (OPD'S)

Overfilling of cylinders can result in the release of liquid propane through the pressure relief valve. An overfilled propane cylinder that is heated can lead to expansion of the liquid propane in the cylinder. If the liquid expands to the point where the cylinder is completely filled, the internal pressure will be relieved through the pressure relief valve.

In response to this potential overfill scenario, *NFPA 58—The LP-Gas Code*, requires that all 4 to 40 pound cylinders in vapor service after April 1, 2002 be equipped with an overfill prevention device (OPD) and a fixed maximum liquid level gauge. These devices are typically integrated into the design of the cylinder valve assembly. While there are some exceptions to the OPD requirement for situations where a larger flow of gas is required (e.g., some floor maintenance machines, horizontal cylinders manufactured before October 1, 1998, etc.), emergency responders will find most cylinders equipped with the OPD device. Exempted cylinders must be labeled with their use.

Propane cylinders are typically filled by weight or by volume. The fixed maximum level gauge has been used for many years to determine that the cylinder is properly filled by the volumetric method. The OPD is a secondary safety device that prevents overfilling.

The operation of the OPD is simple—as the liquid level within the cylinder rises, a small float mechanically connected to the cylinder valve also rises until reaching the 80% fill point as established by the fixed level gauge. At this point, the cylinder valve will no longer allow propane to flow into the cylinder.

To make identification easy, OPD-equipped cylinder valves have a unique hand wheel—a modified triangle. In addition, an OPD marking will be molded into both the hand wheel and the valve body. Correctly identifying OPD valves is especially important when the cylinder is refilled and due for re-qualification inspections.

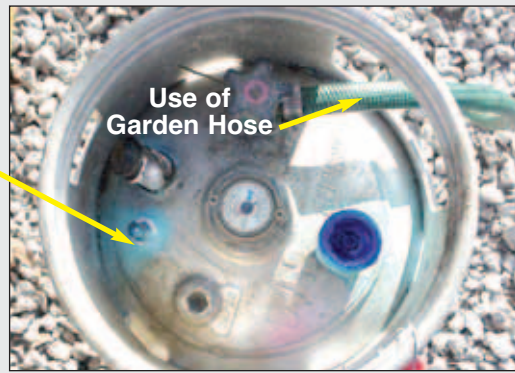
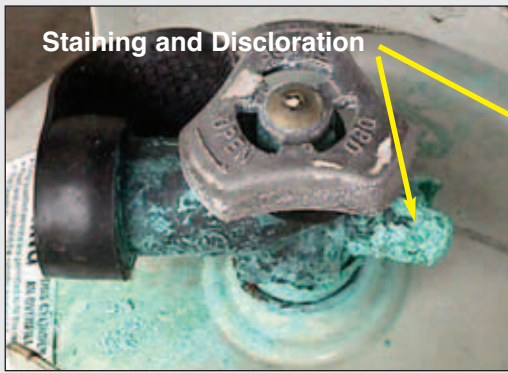


## PROPANE CYLINDERS AND METHAMPHETAMINE LABS

Portable propane cylinders are being increasingly used for the production of methamphetamine at clandestine drug labs. The propane cylinders are used for the storage and use of anhydrous ammonia, which is a feedstock chemical in the meth production process. As a result, numerous propane cylinders that have stored anhydrous ammonia are being found at illicit meth labs, cylinder exchange facilities and refilling locations. These cylinders pose a potential explosive risk and must be handled in a safe manner.

The brass valve in a propane cylinder will be damaged if it comes in contact with anhydrous ammonia. This deterioration will lead to cracking of the valve body or its components, and can ultimately result in a violent expulsion of the valve from the cylinder. A blue-green stain on any brass portion of a service valve is evidence that it may have been in contact with anhydrous ammonia. Other clues can include the pungent odor of ammonia on or near the cylinder.





These cylinders should be isolated and access to the container restricted until either hazardous materials and/or law enforcement personnel can be contacted. Due to the unknown integrity of the cylinder valve, the risks of cylinder movement should be carefully evaluated. If the cylinder must be moved, the hazards due to valve expulsion can be reduced by pointing the valve end of the container away from personnel and towards a safe area.

Emergency responders have also encountered propane cylinders that have been modified and have a compartment built inside of the container. The compartment is typically used for the transportation of illicit materials, such as drugs. In addition, some quantity of propane will also be stored in the container. See the photos.



## COMPOSITE PROPANE CYLINDERS

New technologies are bringing the use of composite cylinders for propane storage and transportation to the marketplace. Among the proposed uses for these cylinders is to fuel cabinet heaters. Although currently prohibited by NFPA 58—The LP-Gas Code, indoor cabinet heaters are in widespread use throughout the world and it is expected that they may ultimately be allowed domestically. At the time this publication went to press, composite cylinders were allowed for transportation in the United States under a special permit from DOT. They are permitted by NFPA 58 for outdoor use only, however changes to the LP Gas Code were proposed in 2007 that might allow their use indoors in conjunction with cabinet heaters. For more information and the current status of this issue go to [www.propanesafety.com](http://www.propanesafety.com). Composite cylinders can be found in the following designs:

- One piece design in which a liner, composite layer and outer casing are pieced together, and;
- Two-piece design in which two halves of a cylinder are formed by wrapping fiberglass fibers around a mandrel, saturating the fibers with a resin materials to create each half of the cylinder. The two halves are then bonded together to create the cylinder. This cylinder also has a protective outer casing.

Construction materials include poly(acrylonitrile butadiene styrene [ABS]), high-density polyethylene (HDPE), and polyethylene terephthalate (PET).

To determine the viability of using composite propane cylinders in the United States and the potential for using them indoors with cabinet heaters, the Propane Education & Research Council (PERC) has funded a research project with the Battelle Memorial Institute to conduct fire testing of the cylinders. These tests have focused upon the following three questions:

1. What is the cylinder heat release rate when a cylinder is impinged upon by fire?
2. What are the effects of a burning cabinet heater and composite cylinder upon a room?
3. What are the effects of a burning room on a cabinet heater and composite cylinder?

As of this date, composite cylinder fire test performance has been encouraging and is continuing. Fire testing has revealed that cylinder design (one-piece versus two-piece) may affect the performance of the cylinder in a fire. Composite cylinders become permeable in fire situations and allow propane to escape through the shell; therefore, the pressure relief valve typically will not activate. Tests have also shown that the escaping propane vapor would burn with a low velocity flame, unlike the high velocity flame jets such as through a pressure relief valve, until the fuel is exhausted. The released gas would be consumed in the fire. This behavior also significantly reduces the possibility of a BLEVE scenario with composite cylinders.



**One-Piece Cylinder**



**Two-Piece Cylinder**

## DISPOSAL OF PROPANE CYLINDERS

The transition from the older type of propane cylinder valves to the current cylinders manufactured with an overfill protection device has resulted in emergency responders being faced with numerous incidents and questions pertaining to the disposal of old propane cylinders. In addition, natural disasters such as Hurricane Katrina and major floods typically result in propane cylinders being scattered throughout a large geographic area.

The following guidance is designed to assist emergency responders in dealing with this issue:

- Check with your local propane marketers for information on local or regional programs regarding the exchange and/or disposal of propane cylinders. Some areas have programs for the recycling of propane cylinders.
- Many jurisdictions have programs for the disposal of household chemical wastes, including propane cylinders.
- Do not put a propane cylinder into a dumpster or other disposal container. In addition, never dispose of any pressurized cylinder as a household waste. This could create an explosion hazard.
- Avoid cutting the tank with a torch or cutting wheel. A cylinder may still contain propane and create a potential fire and explosion hazard.
- U.S. DOT regulations provide specific regulations on the precautions, methods and documentation requirements on preparing DOT cylinders for scrap.

## EXCHANGE SERVICE CYLINDERS

Exchange service cylinders are quite popular in some parts of the country. While still employed by some companies, they are rapidly giving way to stationary or multivalve cylinders. They are similar to the portable service cylinders, except the propane marketer takes a full cylinder to the customer's site and exchanges the empty cylinder for a full one. Since these cylinders must be transported over the road either partially or completely full, they must also meet DOT requirements. See Figure 4-8.

The 60 lb. and 100 lb. cylinders are most often used in exchange service. In rare cases, a 150 lb. cylinder may also be used. However, because of the weight of 150 lb. cylinders, most propane marketers only use exchange cylinders with a maximum capacity of 100 lb.

DOT portable exchange cylinders in the 40 lb., 60 lb., and 100 lb. size rarely have more than one fitting welded in the service end of the cylinder. The fitting is threaded to a "female NPT." The fitting is raised above the surface of the cylinder. One valve is installed in the fitting, and this valve is a combination service and pressure relief valve.

Most cylinders used in exchange service do not have a protective collar. Instead, exchange cylinders have a special protective cap installed over the service valve. The steel cap is installed when the cylinder is transported to the customer site. When the cylinder is installed, the cap is removed. Usually, the delivery person removes the cap from the filled cylinder and installs it on the empty cylinder being exchanged. These caps are extremely important since they protect the cylinder valve and the neck fitting from damage.

In recent years, there has been a trend in the retail community, such as convenience stores, gas stations, and hardware stores, to allow customers to exchange empty propane cylinders with full ones by using "Cylinder Exchange Facilities" which are located at the store. This is a potential source of confusion in terminology for emergency responders and fire inspectors, since an approved DOT Exchange Service Cylinder is NOT the same thing as a Cylinder Exchange. As described previously, a DOT Exchange Service Cylinder is a class of cylinder that meets specific DOT-approved design criteria and is delivered to the customer by a propane marketer. In contrast, a Cylinder Exchange Facility is a place at a retail store where customers can bring their empty 20 lb. cylinders and trade them in for full ones. See Figure 4-9.



**FIGURE 4-8** DOT portable exchange cylinder. These cylinders are filled by a propane dealer and transported to the customer's site.



**FIGURE 4-9** Small "Cylinder Exchange" cylinders should not be confused with DOT exchange cylinders.



## STATIONARY SERVICE CYLINDERS

Cylinders in stationary service have hundreds of commercial and industrial applications. Stationary cylinders are normally installed empty at the customer's location, then filled from a propane delivery vehicle "bobtail truck." The most common cylinders used include the 200 lb. and 420 lb. cylinder. Remember that this is pounds w.c.; a 420 lb. cylinder will contain approximately 100 gallons of liquid propane. See Figure 4-10.

Stationary cylinders are normally designed to be installed vertically or with the service end up. However, some 200 lb., 300 lb., and 420 lb. cylinders are designed to be installed horizontally. These special cylinders have feet welded to each end of the cylinder.

Stationary cylinders have as many as three threaded or flanged openings in the service end of the cylinder. The opening sizes are:

- 3/4-inch NPT—combination service valve with fill valve and pressure relief valve. In some cylinders, a separate 3/4-inch or 1 1/4-inch opening may be used for an independent fill valve.
- 1/4-inch female NPT—for fixed maximum liquid level gauge.
- 1 5/16-inch special flange—for direct reading liquid level gauge.

Stationary cylinders use a protective collar similar to those used on motor fuel cylinders. The neck ring incorporates a hinged lid, called a dome. This assembly is similar to ASME stationary tank domes. The lid can be closed and locked to prevent tampering with the valves. In addition, the dome protects the valves and service regulator from weather damage.



**FIGURE 4-10** Stationary cylinder  
Note: Cylinders are brought to site empty, then filled from a bobtail.

## MOTOR FUEL SERVICE CYLINDERS

Motor fuel service cylinders are typically used as portable fuel containers for forklifts, and for heavy duty building maintenance equipment such as aisle sweepers and floor polishers.

DOT motor fuel service cylinders used to power equipment such as forklifts are different from ASME motor fuel tanks used to power cars and trucks in two ways:

1. DOT motor fuel cylinders are small portable containers that can be easily removed from the equipment and changed out for a full cylinder or refilled on site. For example, when a cylinder is empty on a forklift, it can be easily exchanged for a full tank.

The most common sizes of motor fuel cylinders range from 14 lb. and 20 lb. cylinders on smaller equipment like floor polishers to the 33.5 lb. and 43.5 lb. cylinders normally found on forklifts. In most cases these cylinders are filled at the propane marketer's facility and delivered to the customer, although some industrial facilities operate their own fill stations.

## DOT MOTOR FUEL CYLINDERS

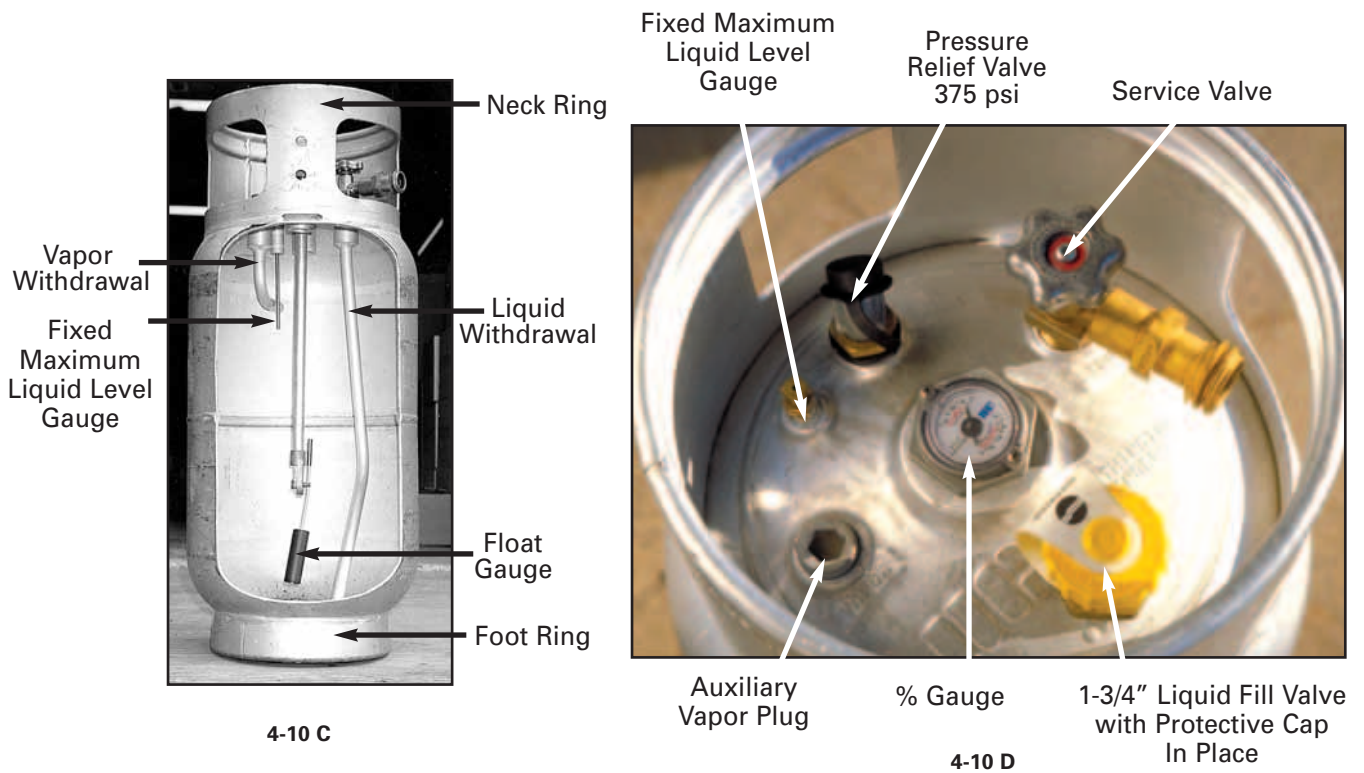
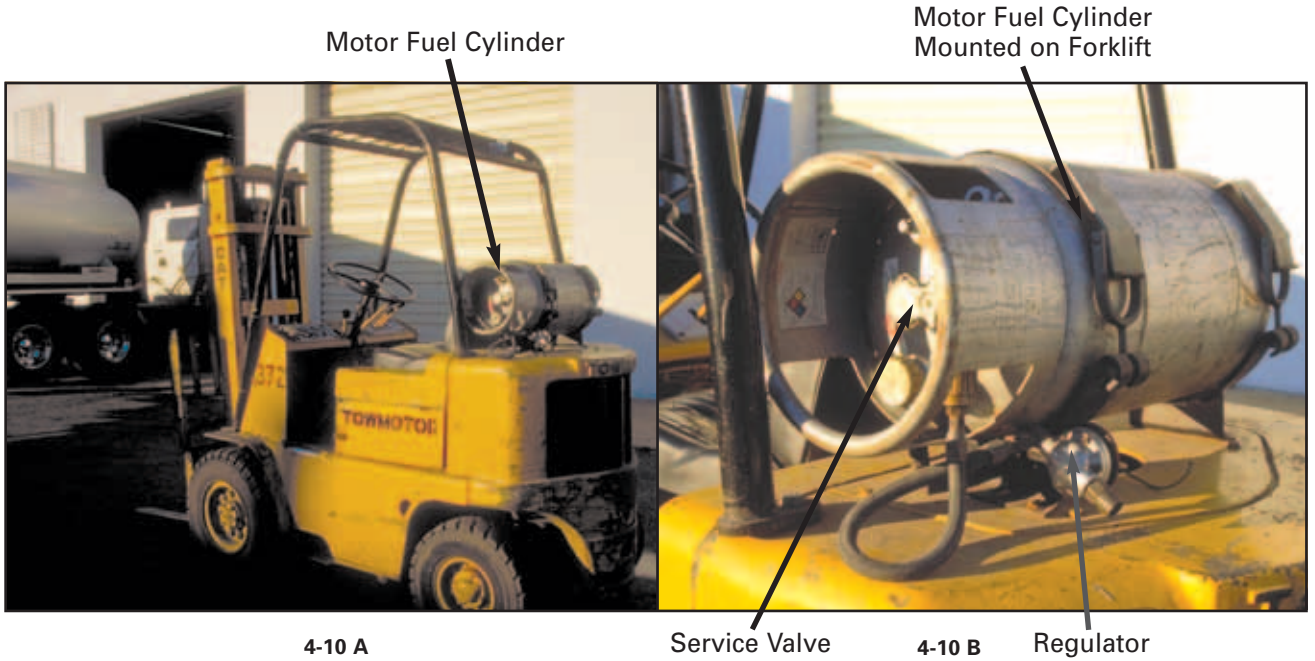


FIGURE4-11 A, B, C, D DOT motor fuel cylinders.



2. ASME motor fuel tanks are permanently mounted on the car or truck just like a motor vehicle's gasoline or diesel tank. The vehicle must be driven to a propane filling station to fill the tank.

There are two important points about fittings on motor fuel cylinders that emergency responders should know. First, each service valve opening is marked for either vapor or liquid service. These markings indicate that the opening has a dip tube attached which runs to the liquid or vapor space of the cylinder. Typically, motor fuel cylinders are configured to supply liquid rather than vapor. Second, all of the fittings may not be used. In this case, the unused fittings must have a male plug installed in the opening.

Motor fuel service cylinders can have as many as five openings in the service end of the cylinder, as illustrated in Figure 4-11. The fittings can be threaded or flanged.

The neck ring, as illustrated in Figure 4-11D, is common on motor fuel cylinders. This neck ring completely surrounds the service end of the cylinder. An opening is provided in the neck ring for vapor and/or liquid service lines, as well as for the discharge of the pressure relief valve.

Many exchange cylinders have a metal plate attached to the bottom of the foot ring. This plate is called a false bottom. Because exchange cylinders are sometimes placed directly on the ground, the false bottom provides additional protection against corrosion.

## CYLINDER MARKINGS

The DOT and ICC require that cylinder information (e.g., design or manufacturing code) be permanently marked on the cylinder. This information is stamped on the outside of the neck ring or on the cylinder body itself. In some cases, the information is stamped on a metal plate and the plate is attached to the cylinder. See Figure 4-12.

Like the ASME data plate, the DOT or ICC marking is the ID card for the cylinder. This information can easily be used to distinguish between different types of cylinders. In addition, the information can be used in selecting valves and determining when the cylinder needs requalification. Some DOT cylinders are also dual certified as ASME cylinders. This is more economical for propane marketers who wish to reduce the cost associated with periodic requalification.

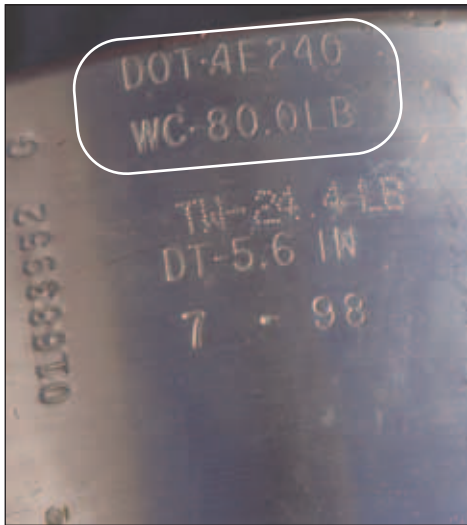
## DESIGN OR MANUFACTURING CODE

Cylinders of any type of service can be built under several design codes. DOT or ICC design code markings normally consist of two basic parts: the design code and the service pressure.

There are two important things to remember about these design codes. First, cylinders manufactured before April, 1967 are indicated by the letters ICC before the specification code. After April, 1967, all cylinders are marked with the letters DOT. Whether the design code is preceded by DOT or ICC, it is the same code.

Second, the service pressure indicated on the cylinder is the normal working pressure of the cylinder. This pressure is sometimes confused with the pressure rating for pressure relief valves. Pressure relief valves for most DOT or ICC cylinders have a pressure rating of 375 psig, which is higher than ASME requirements. ASME containers are not usually subjected to shock from impact as are containers in transportation. Shock caused by a low impact can momentarily cause high static pressures.

## CYLINDER MARKINGS



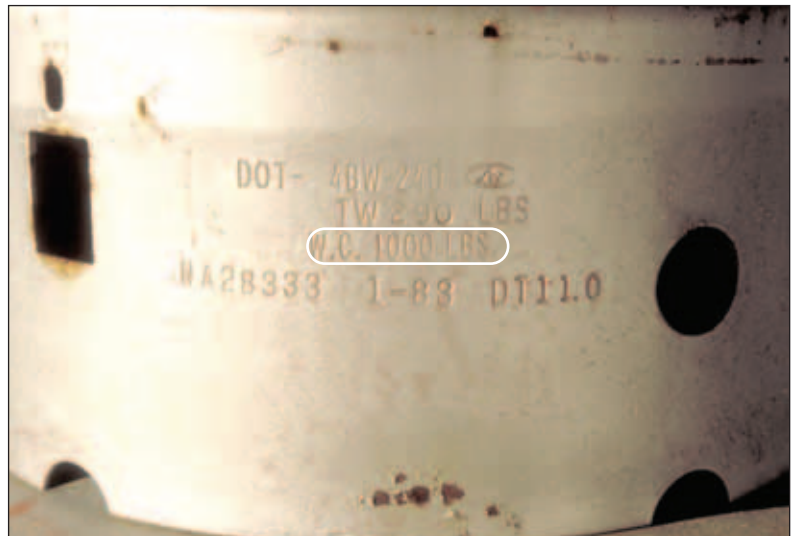
Stamp on cylinder designates it as DOT with 80 pound water capacity



Label indicating hazard class and UN number. Note phone number for propane dealer.



Note large readable toll free telephone number



Stamped marking indicates 1,000 pound water capacity.

FIGURE 4-12 Cylinder Markings.

### WATER CAPACITY OF THE CYLINDER

The propane capacity is never marked on a DOT or ICC cylinder. Instead the water capacity (in pounds) is used to establish the cylinder capacity. **Don't confuse the water capacity of the cylinder with the propane capacity.** The water capacity, in pounds, is the weight of water needed to fill the cylinder completely. The maximum propane capacity in pounds is 42% in weight of the water capacity.

## TARE WEIGHT OF THE CYLINDER

The tare weight is the weight of the cylinder when it is empty. The tare weight includes the weight of the cylinder valves. On exchange cylinders, the tare weight does not include the weight of the protective cap.

The tare weight is used when a cylinder is filled by weight. The tare weight should always be checked before a cylinder is filled by weight, since even cylinders with the same water capacity can have different tare weights.

## RETEST DATE

Although every DOT cylinder is pressure tested before being sold, it should be visually inspected prior to each filling. In addition, each DOT cylinder transported in commerce is required to be requalified for continued use when 12 years have elapsed from the original date of manufacture. Requalification of a cylinder may be done in one of three ways:

- External visual inspection, which requalifies the cylinder for 5 additional years.
- Modified hydrotest or proof of pressure test, which requalifies the cylinder for 7 additional years.
- Volumetric hydrostatic test, which requalifies the cylinder for 12 additional years.

When the cylinder is tested, the cylinder requalifier business must place their Requalifier Identification Number (RIN) on the cylinder, followed by a series of numbers indicating the date of requalification. The first numbers indicate the month of the test and the last two numbers indicate the year. In addition to the RIN and test date, an "E" is added to and precedes the date stamp when the external visual inspection method (5 years) is used. Likewise, when the modified hydrotest or proof of pressure test is used (7 years), an "S" is added to and precedes the date stamp. There is no additional marking for the volumetric hydrostatic test (12 years).

## DOT PORTABLE TANKS

DOT portable tanks are normally used for temporary service at construction sites or for emergency service at a customer's site. DOT portable tanks are built with water capacities of more than 1,000 pounds and can be as large as 34,500 pounds. Because of their large size, they are primarily used to store bulk quantities of propane.

DOT portable tanks are built in the same manner as most ASME tanks. The tank is essentially a barrel with a



**FIGURE 4-13** Cylinder with RIN (A132) and external inspection date (10-05).

head welded to each end. All DOT tanks have openings and fittings. Valves are installed for filling and withdrawing propane, measuring the amount of propane in the tank, and relieving the excess vapor pressure that may build up in the tank. Every DOT tank includes special hardware so that the tank can be installed at a customer site or mounted on a vehicle for transporting propane.

## BASIC FEATURES OF DOT PORTABLE TANKS

Unlike other propane containers, DOT tanks are not universal tanks. This means that every type of DOT tank is designed and built for a specific application and each tank has its own special features.

DOT portable tanks are built according to both ASME and DOT codes. Because of the dual code, many service fire inspectors and tank installers often confuse DOT portable tanks with ASME tanks. There are three primary differences between ASME and DOT tanks:

- Tank openings for valves
- Mounting and lifting hardware
- Data plate information

### TANK OPENINGS FOR VALVES

Tank openings vary in number and size depending on the intended service of the tank. Like ASME tanks, DOT tanks have from two to seven openings. The fittings in the openings are commonly threaded. The threaded openings may be female NPT and usually range in size from 1/4" to 2" NPT. The tank openings are located in the top center of the tank barrel or head. Unlike ASME tanks, the fittings on DOT portable tanks are usually protected by a valve ring and/or by being recessed inside the profile of the head or shell and by a heavier dome.

### MOUNTING AND LIFTING HARDWARE

ASME tanks commonly use small steel feet for mounting. These steel feet are welded directly to the bottom of the tank. On DOT portable tanks, the tank mountings are actually steel skids. In addition, the skids are never welded to the bottom of the tank; instead, they are welded to support pads, which are welded directly to the tank. The skids are used to fasten the portable DOT tank to the flat bed of a truck or trailer. ASME tanks are equipped with lifting lugs; however, they are not designed to lift the weight of the tank plus the weight of the propane. Consequently, these tanks should only be lifted by the lifting lugs when empty. See Figure 4-14.

DOT portable tanks also have lifting lugs similar to those installed on ASME tanks. Although they appear to be the same, the lugs on a DOT portable tank are considerably different. The lugs are designed to lift the weight of the tank plus the weight of the propane inside of the tank. The lugs are welded to support pads which are welded to the tank. The support pads distribute the weight when the tank is lifted. The skids and lifting lugs are both an important part of the DOT portable tank. Check the skids, lugs, and support plates for damage before working with a DOT portable tank. Corrosion or cracked welds are extremely dangerous.



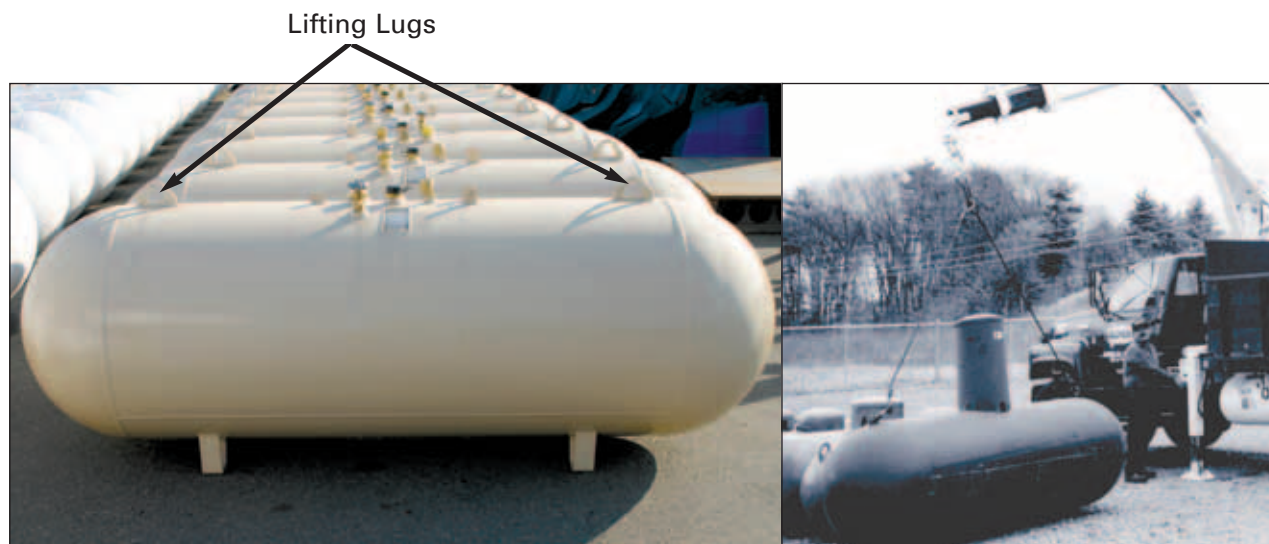


**FIGURE 4-14** ASME tank with Lifting Lug. Note: Tanks should only be lifted empty.

### DATA PLATE INFORMATION

Since DOT portable tanks are built according to both ASME and DOT codes, each tank may have two data plates. The additional DOT data plate, as illustrated in Figure 4-15, has different information than the ASME data plate. Also, the DOT data plate is commonly welded to one of the tank heads. The DOT data plate is the “ID card” for the tank.

The DOT plate will contain the following information:

- Water Capacity and Tare Weight**—Unlike the ASME data plate, the DOT plate lists the water capacity of the tank in pounds. The tare weight of the tank is listed in the event the tank is filled by weight. Because the water capacity is listed in both pounds as well as gallons, emergency responders may be confused over the exact water capacity of the tank.
- Design Pressure**—The design pressure stamped on the DOT plate is the same as the maximum allowable working pressure (MAWP) on the ASME data plate. The pressure rating is 250 psig on both data plates. Check both the DOT and ASME data plates to ensure that both read 250 psig before placing a DOT portable tank into service.
- Design Specific Gravity**—The DOT data plate lists the specific gravity of the product that can be safely stored in the tank. The design-specific gravity for a propane tank is 0.510. The design specific gravity is used to find the weight of the tank when it is filled and to determine the weight limit for the tank.
- Test Dates**—Like the ASME tank, the DOT data plate lists the original test date of the tank. The DOT plate also includes a space for a retest date. Like all

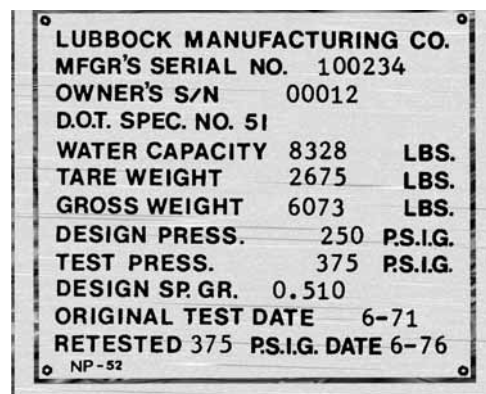


**FIGURE 4-15** DOT /ICC portable tank data plates.



DOT containers, the DOT portable tank must be inspected and retested periodically. The exact retest dates for all DOT containers are covered in *NFPA 58—The LP-Gas Code*, or 49 CFR Part 180.

## ASME MOBILE/MOTOR FUEL TANKS

Mobile / motor fuel tanks for propane service meeting ASME requirements are commonly found on different types of vehicles and can be classified according to their usage. A motor fuel tank is used to provide propane fuel to actually power a vehicle on a roadway. In contrast, a mobile fuel tank provides fuel for other than motor fuel usage, such as a propane tank on a RV vehicle that supplies fuel for cooking appliances. A mobile fuel tank will have a regulator installed, while a motor fuel tank will not be equipped with a regulator.

Three types of applications are discussed in this section: recreational vehicles, lift truck tanks, and motor fuel tanks for road vehicles.

### RECREATIONAL VEHICLES

Recreational vehicle tanks are used to supply gas to appliances on recreational vehicles. The tank is often located behind an access door in the side of the vehicle body and is commonly bolted to the side of the chassis. See Figure 4-16.



**FIGURE 4-16** Mobile RV tanks should not be confused with the vehicles fuel tank.

RV tanks are sometimes confused with the propane motor fuel tank for the vehicle. To avoid this confusion, check the working pressure stamped on the data plate.

### LIFT TRUCK TANKS

One of the most common applications of ASME motor fuel tanks is on lift trucks. See Figure 4-17. These tanks are usually strapped or bolted to the lift truck directly above the engine compartment. A quick-release latch is often used to secure these tanks. Lift truck ASME tanks must have a working pressure of 312.5 psig.

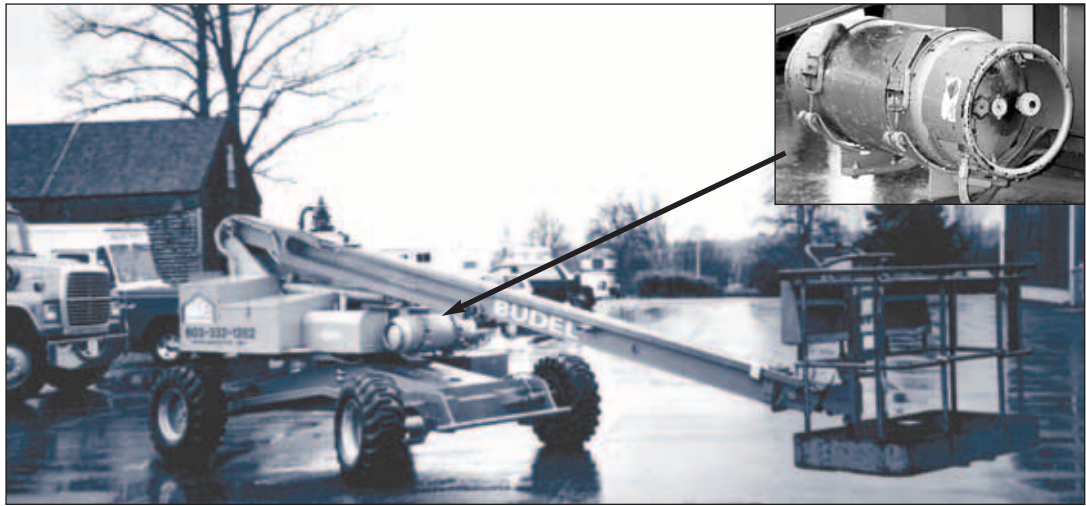


**FIGURE 4-17** Lift truck tanks are usually strapped or bolted to the lift truck directly above the engine compartment.



**FIGURE 4-18** Motor fuel tank configurations.

### MOTOR FUEL TANKS FOR ROAD VEHICLES

ASME motor fuel tanks for road vehicles are designed to be installed in cars, vans, pickup trucks, and buses. See Figure 4-18. These tanks are built in a variety of shapes and sizes to accommodate different vehicle designs and space requirements. All road vehicle motor fuel tanks for new vehicles must have a 250 psi minimum working pressure and a maximum working pressure of 312.5 psig.

Pressure relief valves must be vented to the outside of the vehicle. All fittings must be vented to the outside of the vehicle if the tank is installed within a confined space within the vehicle, such as in the trunk or in a camper shell.

In some vans and cars, the installation may consist of three tanks that are manifolded or piped together. Only the outside tank has fittings for valves. This installation is normally used in vans, where space is limited and the tanks must be small. In this case the tank manifold is mounted underneath the van body and replaces the

## CAPACITIES OF ASME MOBILE FUEL TANKS

| Type of Vehicle          | Maximum Allowable Work Press. (Psig) | Water Capacity Per Tank (Gallons) | Total Water Capacity (Gallons) |
|--------------------------|--------------------------------------|-----------------------------------|--------------------------------|
| Motor Homes/Campers (RV) | 312.5                                |                                   | 200                            |
| Fork Lift Trucks         | 312.5                                | 4.0                               | 4.0                            |
| Fork Lift Trucks         | 312.5                                | 8.5–14.0                          | 8.5–14.0                       |
| Fork Lift Trucks         | 312.5                                | 20.0–24.0                         | 20.0–24.0                      |
| Buses, School            | 312.5                                |                                   | 200                            |
| Buses, Vans              | 312.5                                | 35.0–55.0                         | 200                            |
| Buses, Vans              | 312.5                                | 55.0–110.0                        | 200                            |
| Pickup Trucks & Trucks   | 250                                  | 25.0–30.0                         | 300                            |
| Pickup Trucks & Trucks   | 250                                  | 10.0–15.0                         | 300                            |
| Automobiles              | 312.5                                | 35.0–65.0                         | 300                            |

**NOTE:** The sizes listed are common capacities. Nonstandard or custom-built tanks may vary in water capacity.

TABLE 4-1

original gasoline tank. Don't confuse this type of tank with the RV tank. Always check the data plate for the maximum allowable working pressure.

The capacities and applications of mobile ASME tanks are listed in Table 4-1.

## MOBILE/MOTOR FUEL TANK CONSTRUCTION FEATURES

ASME motor fuel tanks are designed to be installed in a variety of ways, such as in a car trunk or in a truck cargo bed. The data plate on an ASME motor fuel tank will show the outside surface area of the tank in square feet. Because of the limited capacity of tanks used in mobile service, the outside surface area of most mobile tanks is 50 square feet or less.

Tanks used in mobile applications have three basic features:

- Valve fittings
- Valve protection
- Mounting hardware

### VALVE FITTINGS

The number, size, and location of valve fittings in mobile tanks will vary. There are some general rules that apply only to mobile tanks.

- Most valve fittings are threaded. Also, the sizes of the openings are often limited to 1/4-inch, 3/4-inch, and 1-inch female NPT.



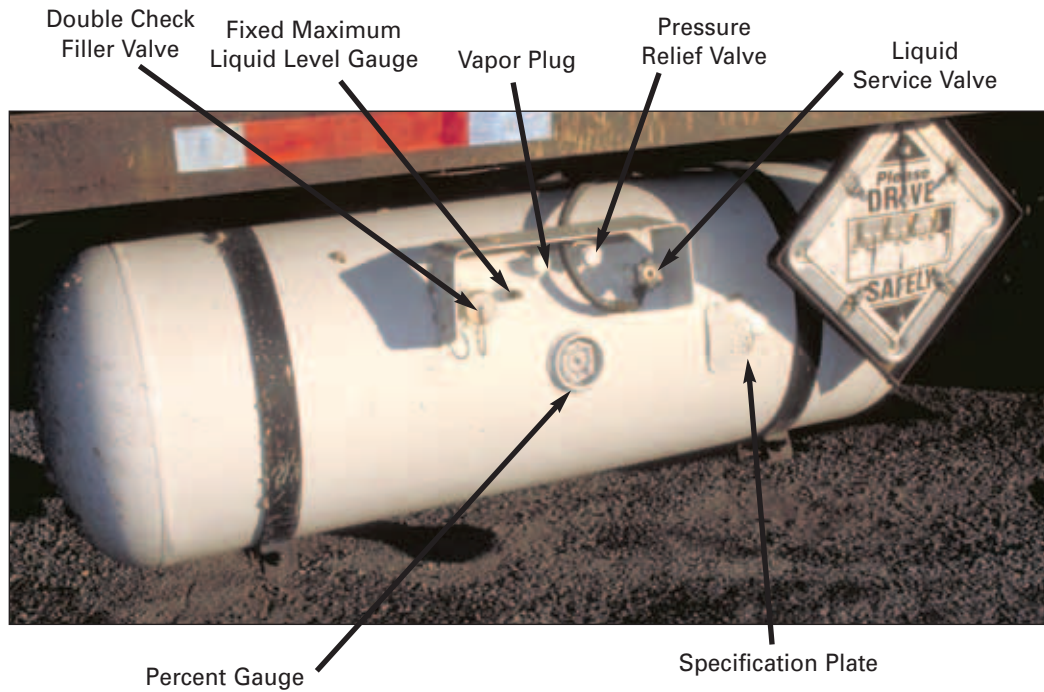


**FIGURE 4-19** Key features of motor fuel tanks.

- Mobile tanks usually have a maximum of 5 threaded openings.

The number and sizes of fittings on a particular tank may be different from those shown in Figure 4-19.

#### VALVE PROTECTION

Mobile tanks have special hardware to protect tank valves. Typically, mobile tanks are equipped with a protective ring that consists of a metal plate that partially surrounds the fittings and valves in the tank. See Figure 4-18. This protective ring may be welded directly to the tank or it may be bolted to brackets that are welded to the tank.

#### MOUNTING HARDWARE

ASME tanks used in mobile service must be securely attached to the vehicle. All tank manufacturers install special hardware for mounting the tank to the vehicle. The location of the mounting hardware varies according to the type of vehicle on which the tank is being installed. Steel strips or brackets are usually drilled so that they can be bolted to the vehicle.

#### DATA PLATE MARKINGS

The data plate on a mobile tank is similar to those used on most ASME tanks. However, certain features on the data plate are different.

- The data plate is usually located next to the protective ring. In some cases, the data plate may be located in the center of the barrel above or below the valve.
- Mobile tanks can be designed with one of two design working pressures as indicated on the tanks data plate. These include:

1. Tanks designed with a design working pressure of 312.5 psig. These are used on lift trucks, recreational vehicles, buses, taxis, and motor fuel tanks installed in enclosed spaces on road vehicles.
2. Tanks with a design working pressure of 250 psig. These tanks may be used on all other vehicles where leakage or relief valve discharge will not be directed toward or into passenger spaces, or onto the tank container, the exhaust system, or any other part of the vehicle.

In addition to data plate markings, over-the-road general purpose vehicles powered by propane are usually identified with a diamond shaped label, although this type of marking is not universal. The label is located on an exterior surface on the lower right rear of the vehicle. The diamond shaped marking consists of a border and the letters "PROPANE" of silver or white reflective luminous material on a black background.

## ASME STATIONARY TANKS

Stationary ASME tanks are fundamentally different from mobile ASME tanks in that they are not designed to be moved when they are legally full of propane liquid. As a result, both federal regulations and many state and local codes require that ASME stationary tanks with water capacities of 125 gallons or more must not contain more than 5% of their water capacity in propane liquid when transported.

### COMMON WATER CAPACITIES OF STATIONARY ASME TANKS

| Type of Service                    | Water Capacity<br>(In Gallons) | LP-Gas Capacity<br>In Gallons* |
|------------------------------------|--------------------------------|--------------------------------|
| Residential                        | 100                            | 80                             |
| Residential                        | 125                            | 100                            |
| Residential                        | 150                            | 120                            |
| Residential                        | 250                            | 200                            |
| Residential                        | 325                            | 260                            |
| Residential                        | 500                            | 400                            |
| Residential                        | 1,000                          | 800                            |
| Industrial/Agricultural/Commercial | 1,000–5,000                    | 800–4,500                      |
| Service Stations                   | 1,000–6,500                    | 800–5,850                      |
| Bulk Plant or Standby Storage      | 12,000–18,000                  | 10,800–16,200                  |
| Bulk Plant or Standby Storage      | 20,000–30,000                  | 18,000–27,000                  |
| Bulk Plant or Standby Storage      | 20,000–60,000                  | 27,000–54,000                  |
| Bulk Plant or Standby Storage      | 60,000–120,000                 | 48,000–96,000                  |

\*Based on Propane Specific Gravity of .504 @ 60°F.

**NOTE:** Underground tanks may be filled to slightly higher capacities because they are not subjected to the same higher ambient temperatures of aboveground tanks.

TABLE 4-2



Capacities of ASME stationary tanks vary considerably. Residential tanks range from 250 to 1,000 gallons. Tanks in service at industrial and distribution facilities can range from 1,000 to 120,000 gallons, with the most common sizes being 12,000, 18,000, 30,000, 60,000, and 120,000 gallons. See Table 4-2 lists common water capacities for most stationary ASME tanks.

ASME stationary tanks are used in many different applications. There are four basic types of ASME stationary tanks:

- Domestic and commercial storage
- Industrial and agricultural storage
- Fill station storage for filling recreational vehicle motor fuel tanks or DOT cylinders
- Bulk plant or standby fuel plant storage

#### DOMESTIC AND COMMERCIAL STORAGE

Domestic and commercial tanks normally provide propane storage for home or business heating, water heating, or cooking appliances. As a result, most domestic and commercial tanks rarely have water capacities greater than 1,000 gallons. However, commercial facilities may have multiple 1,000 gallon ASME tanks manifolded together in tank farms.

#### INDUSTRIAL AND AGRICULTURAL STORAGE

In most cases, industrial and agricultural appliances use more fuel each day than domestic appliances. Most propane companies install larger storage tanks for industrial and agricultural customers to limit the frequency of gas deliveries, or to increase vaporization capacity. As a result, ASME tanks used in these applications have water capacities that range from 1,000 gallons to 5,000 gallons. In some cases, larger bulk storage containers ranging from 18,000 to 60,000 gallons are found.

#### FILLING STATION STORAGE

Propane filling stations that service recreational vehicle tanks, motor fuel tanks, and DOT cylinders may fill 50 to 100 containers each day. As a result, the service station must use a tank with a much higher water capacity than a domestic tank. Common service station tanks have water capacities ranging from 500 gallons to 5,000 gallons. In some cases, larger bulk storage containers ranging from 18,000 to 60,000 gallons are found. Recent installations have featured vertical ASME tanks of 500 to 1,000 w.c. to conserve space.

#### STANDBY FUEL TANKS

Stationary tanks are used for propane stored as standby fuel (secondary fuel for industry) and for propane marketer bulk plants. In both cases, large quantities of propane must be stored. Common water capacities of these tanks range from 18,000 gallons to as high as 120,000 gallons or multiple tanks of 30,000 to 60,000 gallons.

### STRUCTURE OF ASME STATIONARY TANKS

ASME stationary installations have five distinguishing features. These include the tank shape, the valve fittings, protection for valves, the tank coatings, and the mounting hardware. See Figure 4-20.

## ASME STATIONARY ABOVEGROUND TANK

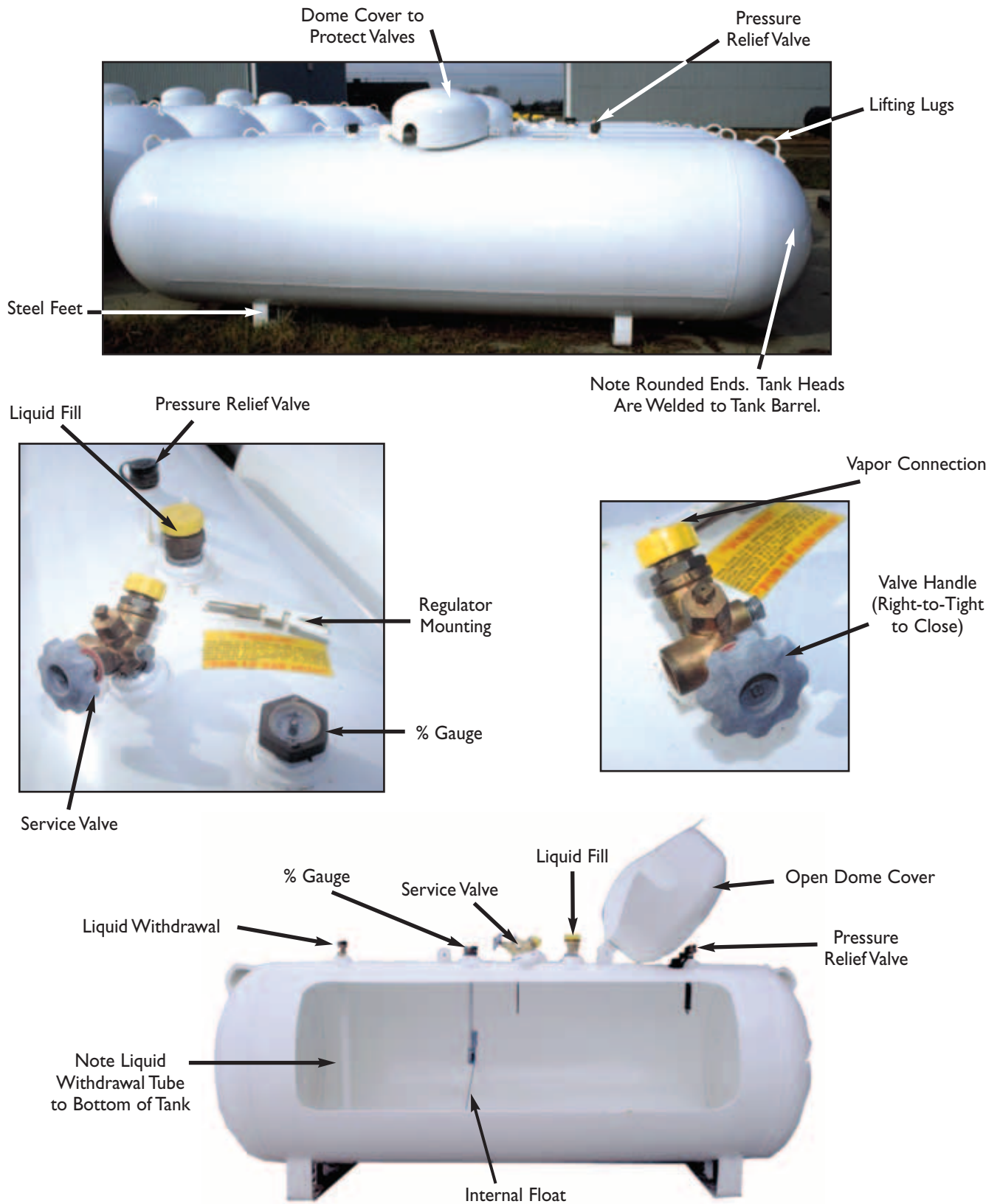


FIGURE 4-20 ASME stationary tank features.

## TANK SHAPE

Like the majority of mobile ASME tanks, most stationary ASME tanks are built by welding a head to each end of a barrel. The ends of the tank are rounded. Most are horizontal in configuration.

## VALVE FITTINGS

Fittings for valves in stationary tanks vary in size and in number. Each tank is manufactured with the number of fittings required for the intended service.

Fittings on aboveground tanks under 2,000 gallons w.c. are normally threaded. Threaded openings for both liquid and vapor service are commonly 1/4 inch to 2-1/2 inch female NPT. The openings are normally located on the top of the tank. However, some tank openings may be located in the bottom of the tank.

Unlike aboveground tanks, most underground tanks under 2,000 gallons w.c. have one opening in the top of the tank. See Figures 4-21 and 4-22. The opening has a pipe attached to it called the riser. The top of the riser is threaded to a 2-1/2 inch male NPT. Usually, a large combination valve is installed on the top of the riser. The combination valve contains a filler valve, vapor equalizing valve, service valve, pressure relief valve, fixed maximum liquid level gauge, and an optional pressure gauge. A liquid withdrawal valve is usually in a separate location away from the combination valve and riser. Potential scenarios with underground tanks include damage to the riser caused by vehicles or snowplows in improperly protected installations.

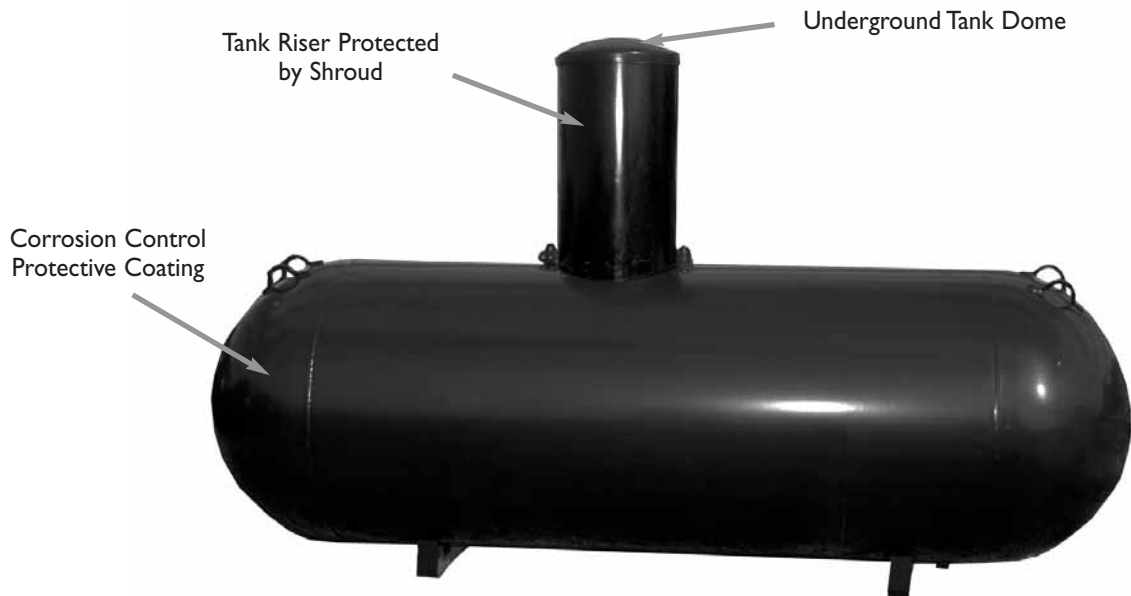


FIGURE 4-21 Basic features of underground storage tanks.

## PROTECTION FOR VALVES

Most small aboveground tanks (under 2,000 gallons w.c.) use a dome or cover to protect container valves or fittings. The dome is attached to a hinge, which is welded to the top of the tank and completely surrounds the valve openings.

On underground tanks, a coated steel or composite plastic shroud is used to protect the “riser” as well as the combination valve on the top of the riser. The riser

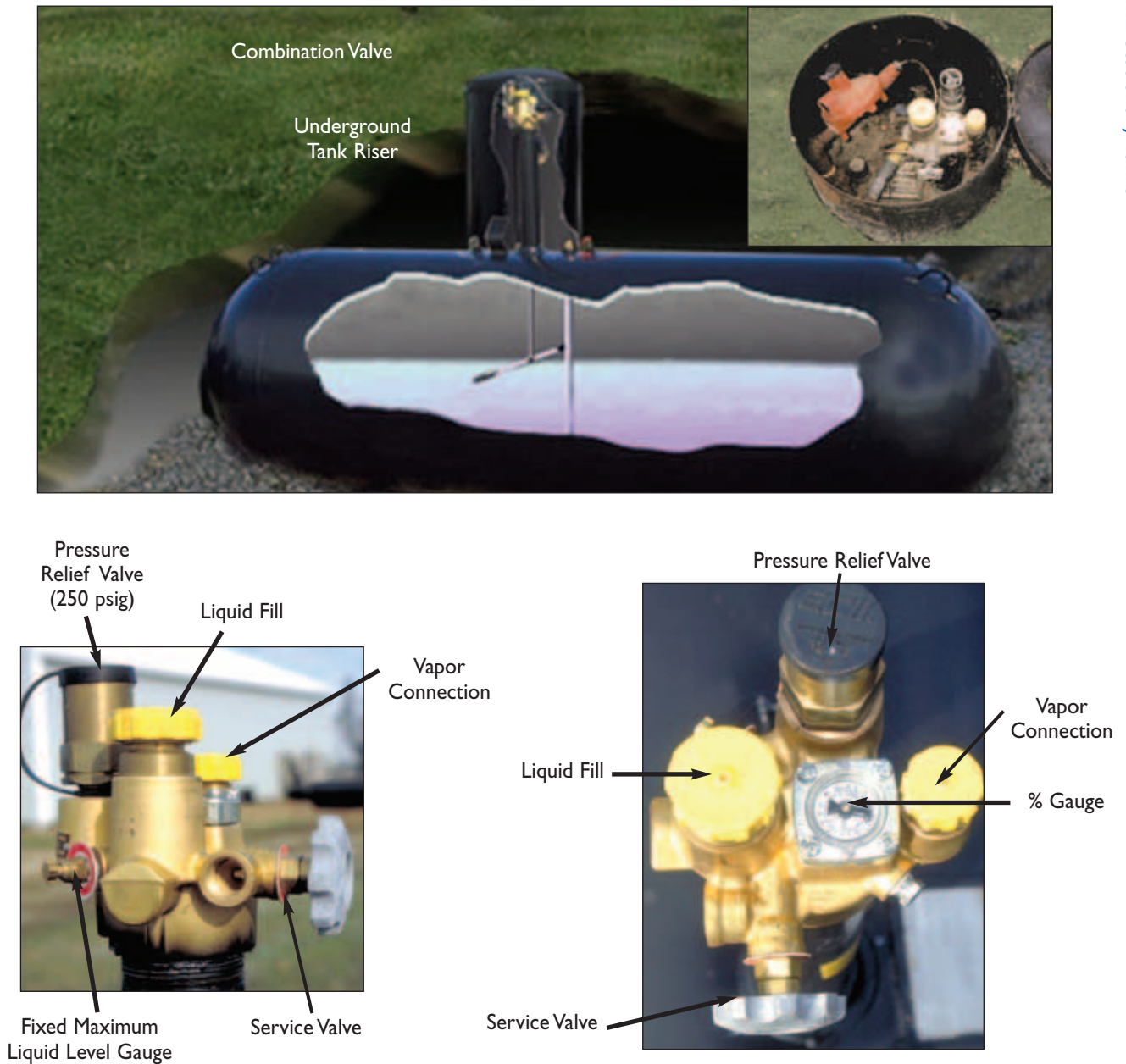


**FIGURE 4-22** Basic features of underground storage tanks.

length on a typical AG/UG domestic tank is 14 inch while the riser length on a typical UG domestic is 28 inch. A shroud is an 18 inch to 32 inch tube with a hinged lid that surrounds the riser. This is a key identification feature for emergency responders.

### TANK COATINGS

The body of an aboveground tank is normally coated with a noncorrosive primer after it is built. The primer prevents corrosion or rusting until the tank is painted.



Underground tanks are usually coated with some type of mastic (petroleum or coal tar). Although the mastic does not require any type of finish coat, care must be exercised to find and repair any damaged areas of the mastic coating prior to backfilling the soil around the tank. Also, mastic is usually not effective protection for underground tanks without cathodic protection and electrical isolation, and may even accelerate corrosion failure if incorrectly applied.

### MOUNTING HARDWARE

Optional tank mountings are often found on aboveground and underground tanks with water capacities under 4,000 gallons. The mountings are usually angle iron or steel feet that are welded to the bottom of the tank. The mountings are used to support the tank on a masonry block or concrete foundation.

Tanks above 4,000 gallon w.c. use concrete or steel saddles. The saddles are made in the shape of the bottom of the tank. The tank is usually set directly on or is welded to the saddle. Regardless of the size, ASME stationary tanks may or may not be bolted to the foundation.

### DATA PLATE MARKINGS

The requirements for marking stationary tanks are the same as for mobile tanks. However, there is no “rule of thumb” for the location of the data plate. The data plate can be welded to the heads, shell, top, or bottom of the tank.

ASME tanks have been designed for different maximum allowable working pressures (MAWP). Originally, separate ASME tanks were made for propane and butane. The major difference between the two tanks is the maximum allowable working pressure. The design working pressure for butane is only 50% of the design working pressure of propane tanks. The only way to distinguish between the two tanks is to check the working pressure stamped on the data plate: 250 psig for propane or butane, and 125 psig for butane only. See Figure 4-23.

In addition, the data plate on stationary ASME tanks can also indicate three types of service for the tank. Note that the service type code of the container in the lower

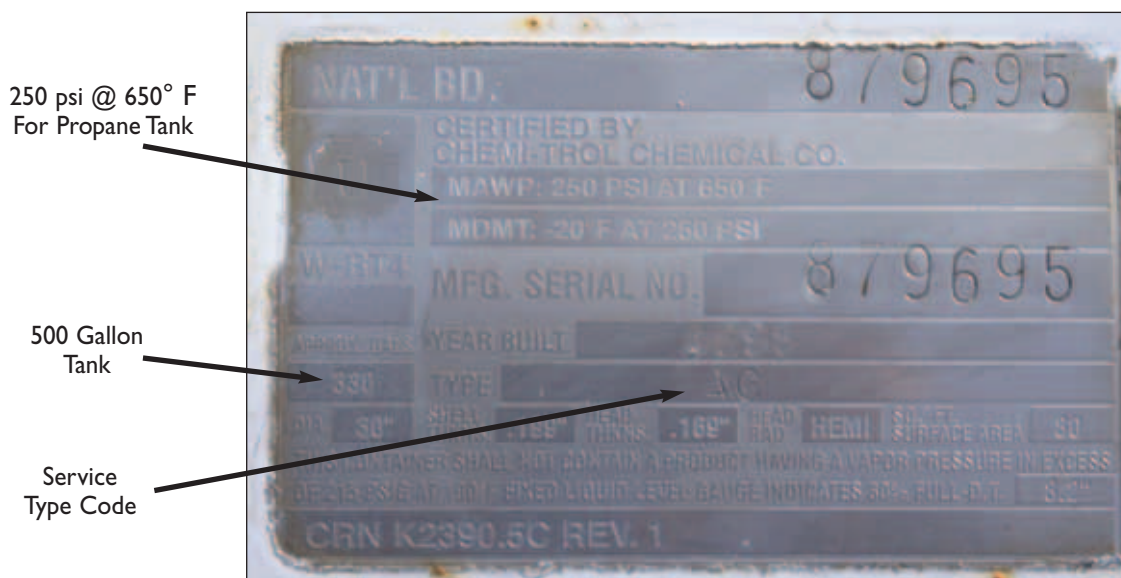


**FIGURE 4-23** Data plate for ASME stationary tank.



lefthand corner of the data plate is stamped UG. The UG indicates that the tank is designed for underground use only. The service type codes are as follows:

| ASME SERVICE TYPE CODES |                            |
|-------------------------|----------------------------|
| Service Type Code       | Service Type               |
| UG                      | Underground only           |
| AG                      | Aboveground only           |
| AG/UG                   | Aboveground or Underground |

**NOTE:** Always check the data plate before selecting a tank for an installation.

TABLE 4-3

SUMMARY

The wide application and uses of propane in residential, commercial, industrial, and agricultural service requires a variety of different propane containers to meet the needs of the consumer. Understanding the common design and construction features of propane containers and their unique features is important to emergency responders from both a safety and tactical perspective.

Propane containers can be divided into three broad categories:

1. Non-bulk Packaging—containers such as cylinders;
2. Bulk Packaging—containers such as portable tanks, tank trucks, and rail cars; and
3. Fixed Containers—including stationary propane storage tanks such as those found at bulk plants.

Within the propane industry, most non-bulk and bulk containers which are not involved in bulk transportation (e.g., cargo tank trucks, railroad tank cars, inter-modal containers) can be broken into four broad categories:

1. DOT cylinders;
2. DOT portable tanks;
3. ASME mobile/motor fuel tanks; and
4. ASME stationary tanks.





# BULK TRANSPORTATION DESIGN AND CONSTRUCTION FEATURES

**OBJECTIVES**

1. Describe the basic design and construction features of the MC-331 cargo tank truck used to transport propane. [NFPA 472-6.2.3.1(A)(1)]
2. Describe the differences in design and construction between a propane bobtail delivery vehicle and a bulk transport cargo tank truck.
3. Explain the design, construction, and operation of each of the following safety devices that may be found on an MC-331 cargo tank truck: [NFPA 472-12.2.1(7)].
  - Internal safety valve
  - Excess flow valve
  - Emergency remote shut-off device
  - Fusible links, nuts, and plugs
  - Pressure relief valves
4. Describe the basic design and construction features of a propane railroad tank car (DOT-105, DOT-112, DOT-114). [NFPA 472-6.2.3.1(A)(6)]
5. Explain the design and purpose of each of the following components found on a propane railroad tank car: [NFPA 472-11.2.1(3)]
  - Head shields
  - Shelf couplers
  - Thermal protection
6. Describe the design, construction, and operation of each of the following valves and fittings found on a propane railroad tank car: [NFPA 472-11.2.1(8)]
  - Liquid valves
  - Vapor valves
  - Excess flow valve
  - Pressure relief valve
  - Gauging device
  - Thermometer well
  - Sampling tube
7. Describe the basic design and construction features of the IMO Type 5 / DOT Spec 51 propane tank container used for transporting propane. [NFPA 472-6.2.3.1(A)(3)]

**ABBREVIATIONS AND ACRONYMS**

|      |                                          |
|------|------------------------------------------|
| AAR  | Association of American Railroads        |
| ASME | American Society of Mechanical Engineers |
| DOT  | U.S. Department of Transportation        |
| IMO  | International Maritime Organization      |
| MC   | Motor Carrier                            |

|      |                              |
|------|------------------------------|
| NPT  | National Pipe Thread         |
| NQT  | Non-Quench Tempered          |
| PRV  | Pressure Relief Valve        |
| psig | Pounds per Square Inch Gauge |
| PTO  | Power Take-Off               |
| QT   | Quenched and Tempered        |
| TC   | Transport Canada             |

## BOBTAILS AND CARGO TANK TRUCKS

This section will provide an overview of the primary methods of transporting propane in bulk transportation vehicles and containers. We will specifically discuss the cargo tank truck, the railroad tank car, and intermodal containers.

Bulk propane vehicles are an integral element in the propane transportation and distribution system. Key elements of this system are (1) the bulk transport cargo tank truck, which primarily moves propane from production, storage, and distribution facilities to propane marketers, and (2) the bobtail delivery vehicle used by marketers to transport and deliver propane to the end user. Although there may be differences in the truck or trailer chassis to which the propane tank is attached (e.g., truck chassis, semi-trailer, etc.), there are virtually no differences in the fundamental design, construction, and safety features of the cargo tank itself.

Cargo tank truck specifications are established and enforced by the U.S. Department of Transportation (DOT). Like DOT portable tanks, propane cargo tank trucks are built to strict design specifications and codes established by both the American Society of Mechanical Engineers (ASME) and DOT. Since 1967 propane cargo tanks have been constructed to the MC-331 cargo tank specification. However, propane cargo tanks constructed to the MC-330 specification (prior to 1967) are still in-service. Tank valves and fittings on these containers must meet the MC-331 specification requirements. In addition, a limited number of “nonspec” bobtails that were built for strictly intrastate commerce may also be found; their design and construction features are essentially the same as the MC-331 design.

It should be noted that other hazardous materials may be found in the MC-331 cargo tank truck, including anhydrous ammonia, butane and butadiene. Hazardous materials, such as chlorine, carbon dioxide, and nitrous oxide, may be found in MC-331 cargo tanks, although there are also special DOT container requirements for these materials. A limited number of high vapor pressure flammable liquids (e.g., mercaptans) may be transported in a two-compartment MC-331 cargo tank.

## GENERAL FEATURES

Propane tank trucks are constructed of steel metal sheets that are formed into a cylindrical shape, then welded along the seams. When the hemispherical or elliptical ends/tank heads are attached to the container or “barrel,” the tank becomes a structural unit. As a result, the tank’s structural integrity is considerable and doesn’t depend on the chassis or trailer for support. In an emergency, greater attention must be directed toward the barrel and its attachments rather than the “framing or chassis” to which it is attached. See Figure 5-1.





FIGURE 5-1 Bobtail single tank delivery vehicle.

Propane cargo tanks are normally 8 feet in diameter, and a bolted manway is usually found in the rear head of the tank. The size, capacity, and arrangement of fittings will vary based upon the cargo tank's application and use. Common vehicle types include the following:

- **Bobtail Single-Tank Delivery Vehicle**—The “workhorse” of the propane marketing business, it is used to transport and deliver fuel to customers who use propane containers that are filled onsite. Capacities can range from 750 to 6,500 gallons. See Figure 5-1 and Figure 5-2.



FIGURE 5-2 MC-331 single-tank vehicle.

- **Bobtail Twin-Tank Delivery Vehicle**—Although rarely found, some bobtail delivery vehicles may consist of two 4-foot-diameter tanks mounted side-by-side instead of the single larger-diameter tank. The capacity of each tank can range from 750 to 1,500 gallons. These tanks were originally designed to transport propane in tank #1 and butane in tank #2.



**FIGURE 5-3** Transport cargo tank truck.

- **Semi-Trailer Unit**—The bulk cargo tank trailer is one of the prime methods for delivering propane to bulk plants and marketing facilities. Tank capacities range from 9,000 to 14,500 gallons, although cargo tanks as large as 17,000 gallons may be found in some states (e.g., Michigan). Tandem cargo tank trucks or “pups” may also be found in certain parts of the United States. Federal and state vehicle weight limits—rather than volume restrictions—are the primary criteria for determining vehicle loads and capacities. See Figures 5-3 and 5-4.



**FIGURE 5-4** MC-331 propane “pup” trailers.

Although there are differences in size between the smaller bobtail propane delivery vehicles and the larger bulk transport semi-trailers, there is little difference in the cargo tank’s basic design, construction, and safety features.

MC-331 cargo tanks have a minimum design pressure of 100 psig and a maximum design pressure of 500 psig.

All MC-331 cargo tanks will have several different valves and attachments. These will be discussed in detail later in this section and include the following:

- Pressure relief valves
- Temperature, pressure and liquid level gauges
- Liquid and vapor transfer lines and valves
- Remote emergency valve controls

Most propane cargo tanks are uninsulated and are required to have the upper two-thirds of the tank painted a heat reflective color. However, insulated MC-331 cargo tanks may be encountered in limited instances; insulated tank trucks will have an aluminum, stainless steel, or other bright non-tarnishing outer metal jacket.

### TANK SHELL

Propane tanks are constructed from top quality seamless and/or welded steel. During manufacture, the steel is tempered or hardened through different heat treatment or quenching processes. The two processes are known as quenched and tempered (QT) and non-quench tempering (NQT). Understanding these points can become a critical consideration if a propane cargo tank is involved in a severe rollover incident.

To facilitate this identification process, MC-331 cargo tanks will be marked with either the letters QT or NQT. These markings will be located above or next to the DOT specification plate. In addition, the proper name of the commodity (e.g., PROPANE) must be marked on both the sides and ends of the cargo tank. See Figure 5-5.

Emergency responders should understand the following basic principles regarding QT and NQT tanks:

- QT tank metals are heated to a high temperature, then rapidly cooled. This produces a metal that is quite hard and strong, but also can be somewhat brittle. The brittleness of a metal can become an issue if the cargo tank is subjected to extensive mechanical stress, such as when the tank is involved in a serious rollover or strikes a concrete abutment.
- NQT tank metals are heated to specified temperature for a specified period of time, then slowly cooled through the use of some type of heated media (e.g., melted salt). This produces a metal that is hardened, but not as hard as QT metal. In addition, NQT metals are not as brittle as QT metals.

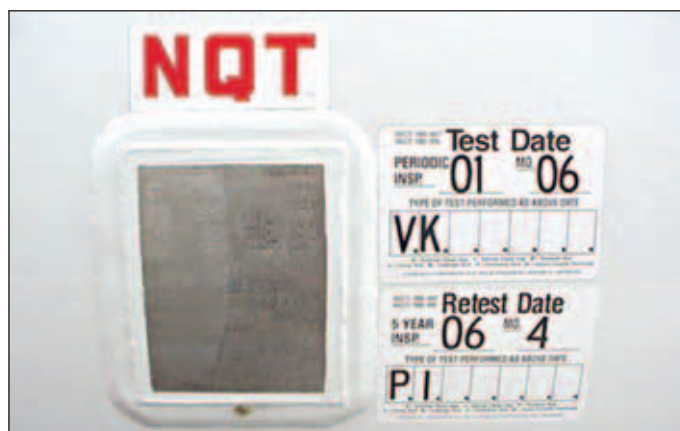


**FIGURE 5-5** MC-331 Cargo tanks will be identified as either QT or NQT tanks.



## TANK OPENINGS

With the exception of gauging devices and pressure relief valves, all openings on an MC-331 cargo tank must be closed with a plug, cap, or bolted flange. These openings are either threaded or flanged. Outlets must be marked to designate whether they communicate with liquid or vapor when the cargo tank is full.

- **Threaded Openings**—Threaded openings are normally used for vapor fill valves, pressure relief valves, equalizing valves, and gauges. The thread sizes of the openings will vary from tank to tank, and may be as small as 1/4-inch NPT or as large as 3-inch NPT.
- **Flanged Openings**—Flanged openings will vary in size according to their application. For example, flanged openings for liquid withdrawal valves are usually 3-inch or 4-inch and are found on virtually all bobtails and cargo tank trucks. On cargo tanks over 3,500 gallon water capacity, flanged openings may be as large as 15 inches. These large openings are inspection manholes or manways used for the periodic inspection of the tank interior and do not contain a valve. A steel plate is normally bolted over the flanged opening. Remember—the tank interior is a confined space and any tank entries for tank inspections or repairs must be in accordance with *OSHA 1910.146—Permit-Required Confined Spaces for General Industry*.

Although tank openings may be located anywhere on the tank, some general rules apply:

- Inspection manholes are normally located in the upper section of the rear head and are occasionally found on the front head.
- Openings for transferring propane liquid and vapor are usually located in the bottom of the tank, either in the underside of the shell and/or in the bottom half of the rear head.
- Openings for the pressure relief valves are located in the top of the tank.

## TANK BAFFLES

Tank baffles are circular, rectangular, or cross-shaped steel plates that are mounted inside the cargo tank. Some have holes drilled or punched out of each plate. Baffles are welded or bolted to clips inside the tank shell before the heads are welded to each end of the barrel. The baffles limit the movement of liquid when the bulk propane delivery vehicle is in motion. They are most effective at decreasing the sloshing of liquid in forward and backward movement, but are less effective in limiting side-to-side motion or preventing vehicle rollover. Only good vehicle maintenance and safe driving practices minimize the danger of liquid load surges. See Figure 5-6.

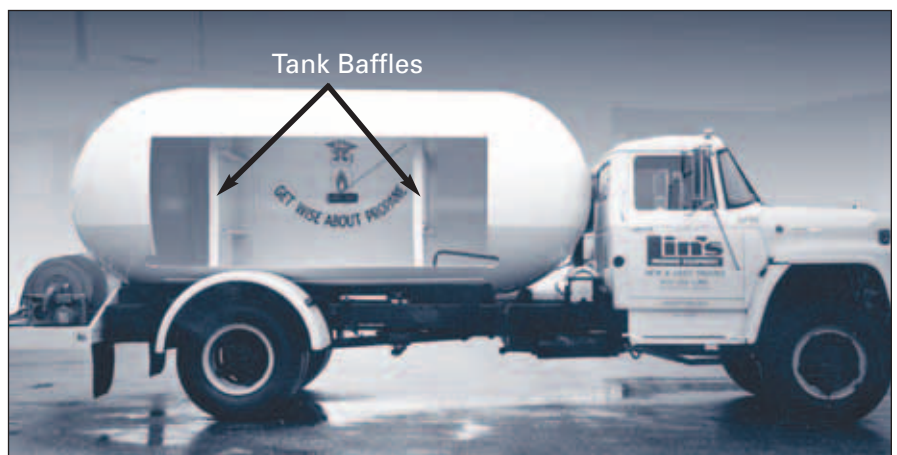


**FIGURE 5-6** Tank truck baffles. Note: Cutaway view of bobtail training vehicle.

## SPECIFICATION PLATE AND MARKINGS

MC-331 cargo tanks in propane service are built according to both DOT and ASME codes and will have design markings for both codes. These markings can be stamped on the tank specification plate or on separate data plates.

Under federal law, cargo tanks constructed to DOT specifications must have a certification plate mounted on the cargo tank. On tank and trailer units, the certification plate will be mounted on the left front of the tank, although units constructed before 1985 may have it on the right front of the tank. See Figure 5-7.

The DOT specification plate will include the following information:

- Name of the manufacturer and the manufacturer's serial number.
- DOT specification number. Propane cargo tanks are built under one DOT specification code—MC-331. However, cargo tanks built to the older MC-330 design code are still in use. Remember that all propane cargo tanks are built under both DOT and ASME codes, and that there are many additional requirements for DOT cargo tanks.
- Water capacity of the tank in pounds. Cargo tanks are rated according to the water capacity in gallons—one gallon of water weighs 8.35 pounds.
- Original date of manufacture.
- Design pressure and test pressure.
- Materials of construction.

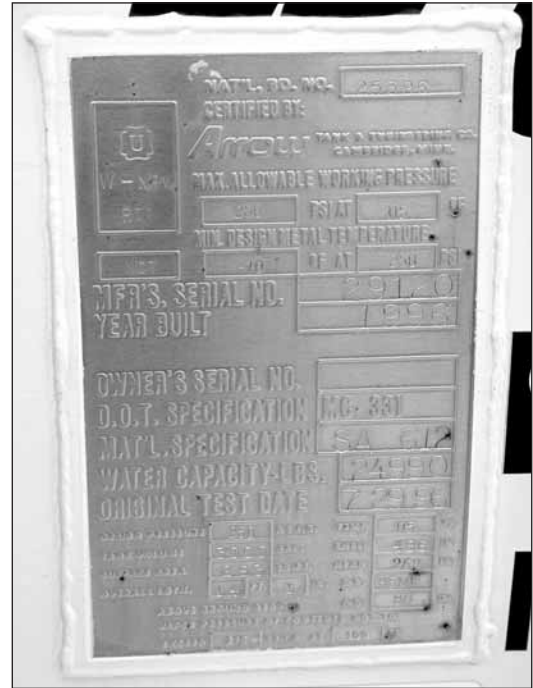


**FIGURE 5-7** Bobtail single tank delivery vehicle.

## SAFETY FEATURES

Propane cargo tank trucks will have a number of safeguards, ranging from pressure relief valves and excess flow valves, to an emergency remote shut-off. These are outlined next.

**Internal Safety Valves**—Each tank will usually be equipped with a cable or air actuated internal safety valve. However, the Flowmatic® valve is a pressure differential actuated valve and uses neither a cable nor air actuation to open. Since a propane cargo tank will contain both liquid and vapor propane, both a liquid and vapor valve will be found. This spring-actuated valve is normally closed and will require either cable activation or air pressure to a pneumatic actuator to remain open. In an emergency, the internal safety valve can be closed by manually actuating the remote emergency valve control or by heat actuating a fusible device and releasing tension on the cables or pressure on the air system.



The liquid internal safety valve is normally a 4 inch valve, while the vapor valve is typically a 2 inch valve. Many older vapor valves are 1-1/4 inch. Some propane cargo tanks may contain an additional exterior liquid loading fitting, which is connected to an internal “*spray fill*” at the top of the tank. Loading the liquid product through this spray fill helps to condense vapors in the tank back into liquid. Propane tanks with this feature may have two liquid connections—one designed for unloading and the other designed for loading.

The vapor valve will be connected to an eduction tube that extends into the vapor space of the container. It is important to recognize that if a propane cargo tank is overturned, the valves will now be reversed. That is—the liquid valve will now be in the “high” position and will function as the vapor valve, and vice-versa. If the cargo tank is resting on its side, both valves may be in the liquid or vapor space, depending upon the attitude/position of the cargo tank and the amount of product being transported. To assist with identification, some propane companies color-code these valves and their associated piping. Color-code schemes include orange (liquid) and yellow (vapor), and dark blue (liquid) and light blue (vapor). Color-coding is not universal.

DOT regulations require that the internal safety valve be protected against mechanical stress and accident damage. As a result, the plug-type valve actually sits inside the cargo tank. Within four inches of the tank shell is a “shear cut” section of piping, which is designed to break under mechanical stress, such as when an auto goes under the cargo tank. This shear cut reduces the thickness of the piping by approximately 20%. If a collision causes stress at that point, the piping should fail at the shear point while the internal valve remains intact within the tank shell, thereby minimizing the release of liquid propane.

**Excess Flow Valves**—Excess flow valves are designed to close automatically when the flow of liquid or vapor reaches the volume specified in the design of the valve or when the flow pressure exceeds a preset value, such as when an unloading hose is ruptured or cut. They are required on the liquid internal safety valve, as well as on discharge piping or hoses if they are reduced in size, thereby making the primary excess flow valve on the liquid internal safety valve ineffective. Excess flow valves are mounted within a tank nozzle or flange so that any external damage to the cargo tank will not tear out the internal safety valve or the excess flow device.

Excess flow valves are also commonly found in bulk plants. It should be noted that there may be certain conditions where these devices may not function properly. Examples include extremely low ambient temperature and low product pressure conditions, and where there is an incomplete break of the valve or line and the quantity being released is below the pre-specified limits of the excess flow device.

**Emergency Valve Controls**—MC-331 cargo tanks with a water capacity greater than 3,500 gallons (e.g., semi-trailers) must have two remote means of automatically closing the internal safety valve. Under DOT requirements, the emergency remote control(s) must operate by mechanical and thermal means and be installed diagonally opposite of each other. Emergency valve controls are typically located at the left front and the right rear of the cargo tank. See Figure 5-8.

MC-331 cargo tanks with a water capacity less than 3,500 gallons (e.g., bobtail delivery vehicles) must be provided with at least one means of automatically

closing the internal safety valve. Emergency valve controls on the smaller bob-tail units are normally found at the left front of the cargo tank, away from the loading/unloading connection area.

#### LOCATION OF EMERGENCY CONTROLS ON MC-331 CARGO TANKS



**FIGURE 5-8** Location of Emergency Controls on MC-331

**Off-Truck Remote Shut-off Device**—DOT regulations require that MC-330/331 cargo tank trucks with a capacity less than 3,500 gallons have the capability to remotely shut-off the vehicle engine and auxiliary power equipment during unloading operations. The vehicle operator possesses a control device that uses radio frequency (RF) technology to remotely isolate propane transfer operations and shutdown the vehicle engine should an emergency occur during unloading operation.

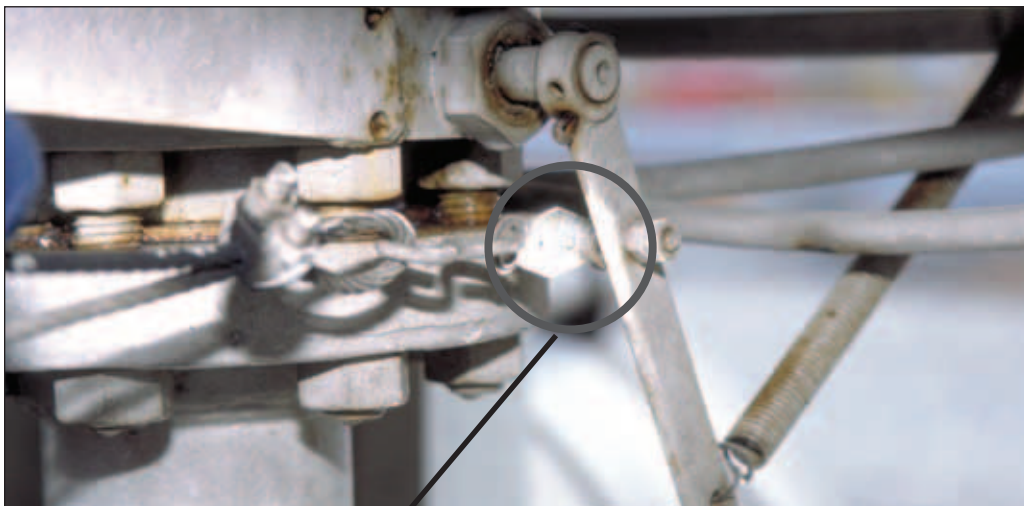
Key points of the off-truck remote shut-off device include:

- Must function at a distance of 150 feet from the vehicle.
- Must not be capable of reopening the internal valve after emergency activation. The vehicle operator must physically enter the vehicle to reset the RF device and system.
- Must be tested daily.
- There is currently a five-year retrofit period through 2007 for bobtails currently in-service. All new vehicles are equipped with this technology.



**FIGURE 5-9** OFF-truck remote shut-off device.

**Fusible Links, Nuts, and Plugs**—Fusible links and nuts are found on cable-actuated systems, while fusible plugs and plastic air lines are used on air-actuated systems. In the event of a fire around the vehicle during propane transfer operations, the fusible device will melt, releasing cable tension or air pressure. Both fusible links and nuts are required to actuate at temperatures not greater than 250°F (121°C). See Figure 5-10.



Fusible Link Melts at Temp  
< 250° F (121° C)

**FIGURE 5-10** Fusible link on tank truck.



**Pressure Relief Valves (PRVs)**—These are spring-loaded valves that communicate with the vapor space and discharge upward so as to prevent any impingement of the escaping gas upon the cargo tank shell. A rain cap prevents water from entering the valve seat area; if the tank does not have a rain cap, some carriers will apply light-weight grease into the well to prevent water and debris build-up.

Bobtail units will typically have one PRV, while bulk transport cargo tank trucks will typically have at least two PRVs. The PRV must be set to discharge at a pressure no higher than 100% of the tank design, and all PRVs must have the total capacity to prevent a maximum pressure in the cargo tank above 120% of the design pressure. See Figure 5-11.

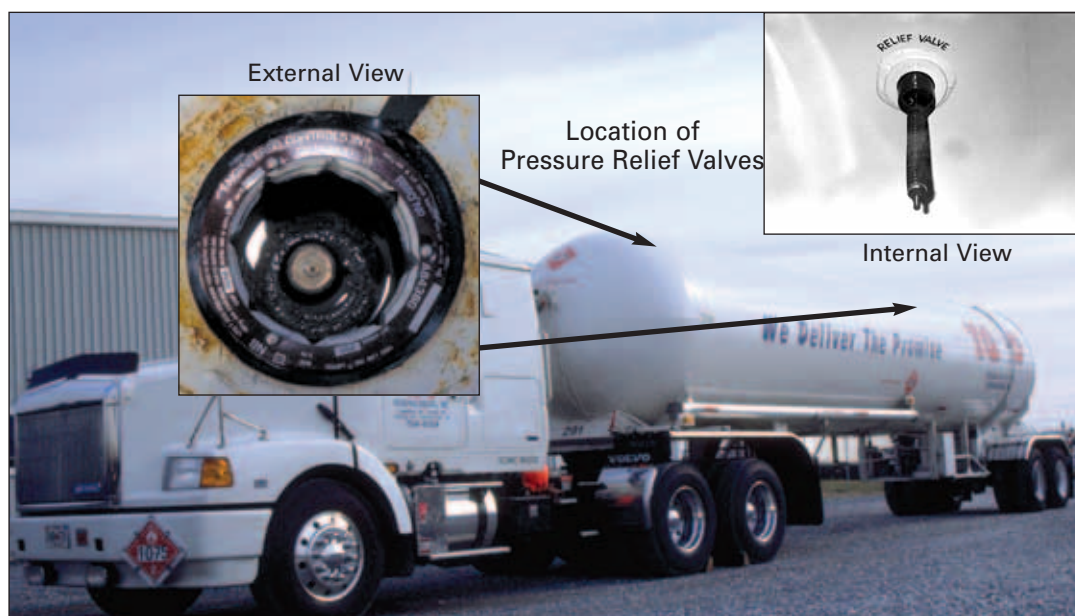


**FIGURE 5-11** Pressure relief valves on cargo tanks are set at 250 psi.

**Overturn and Accident Protection**—All piping, fittings and pressure relief valves must be protected against damage that could be caused as a result of a collision, jackknifing, or overturn scenario. Transport trailers have a roll cage surrounding the valves, fittings and pump from damage during a rollover or from a vehicle going underneath the transport. See Figure 5-14. Pressure relief valves must be protected in a manner that in the event of an overturn on a hard surface, the opening will not be covered and the relief valve discharge will not be restricted.

## TANK ACCESSORIES

**Measuring Devices**—Propane cargo tank trucks will be equipped with measuring devices to determine the amount of product within the container. Two types may be found:

- *Rotary Gauge*—A common measuring device, it is usually found at the rear of the tank on bobtails and on the right side of MC-331 bulk trailers. The gauge is operated by opening a small bleed orifice when the tube is in the

vapor space of the tank. Moving the pointer on the dial causes the end of the tube to move until it contacts the liquid propane. (The pointer should be rotated in both directions to determine that the internal tube is not bent.) At that point, the discharge from the bleed orifice will turn from vapor to liquid. Reading where the pointer is located on the rotary gauge dial will provide the user with the volume percentage of liquid propane in the tank. An experienced product or container specialist may be able to use this device at a rollover incident to estimate the quantity of propane involved. See Figure 5-12.



**Rotary Gauge**



**Magnetel Gauge**

**FIGURE 5-12** Rotary and magnetel gauges.

- *Fixed Maximum Liquid Level Gauge*—These are fixed gauges that identify the specific quantity within the cargo tank. One to four fixed gauges may be found. If the cargo tank is overturned and the liquid product level is below this gauge, responders will be unable to determine the amount of liquid product within the tank. See Figure 5-12.

Other types of measuring devices that can be found on a propane cargo tank truck are:

- *Pressure Gauge*—Indicates the internal pressure of the container. It can also be used to estimate the temperature of a product when used with temperature/pressure curves. See Figure 5-13.
- *Temperature Gauge*—Indicates the temperature of the product within the container. The temperature sensor is enclosed in the thermo well and is not in direct contact with the product. When used with temperature/pressure curves, temperature readings can assist in determining whether the product is expanding and increasing the internal tank pressure. It should be noted that in a rollover incident, the temperature sensor may end up in the vapor space, thereby limiting its effectiveness. See Figure 5-13.

**Transfer Pumps**—Both bobtails and transport cargo tank trucks are equipped with power-take off (PTO) driven pumps for the transfer of product.



Some PTO-driven pumps on transport cargo tanks may also have a recovery valve on the pump that can be used to transfer product from a fixed storage tank or another cargo tank truck. The use of PTO-driven pumps for rollover scenarios is further discussed in Section 9.

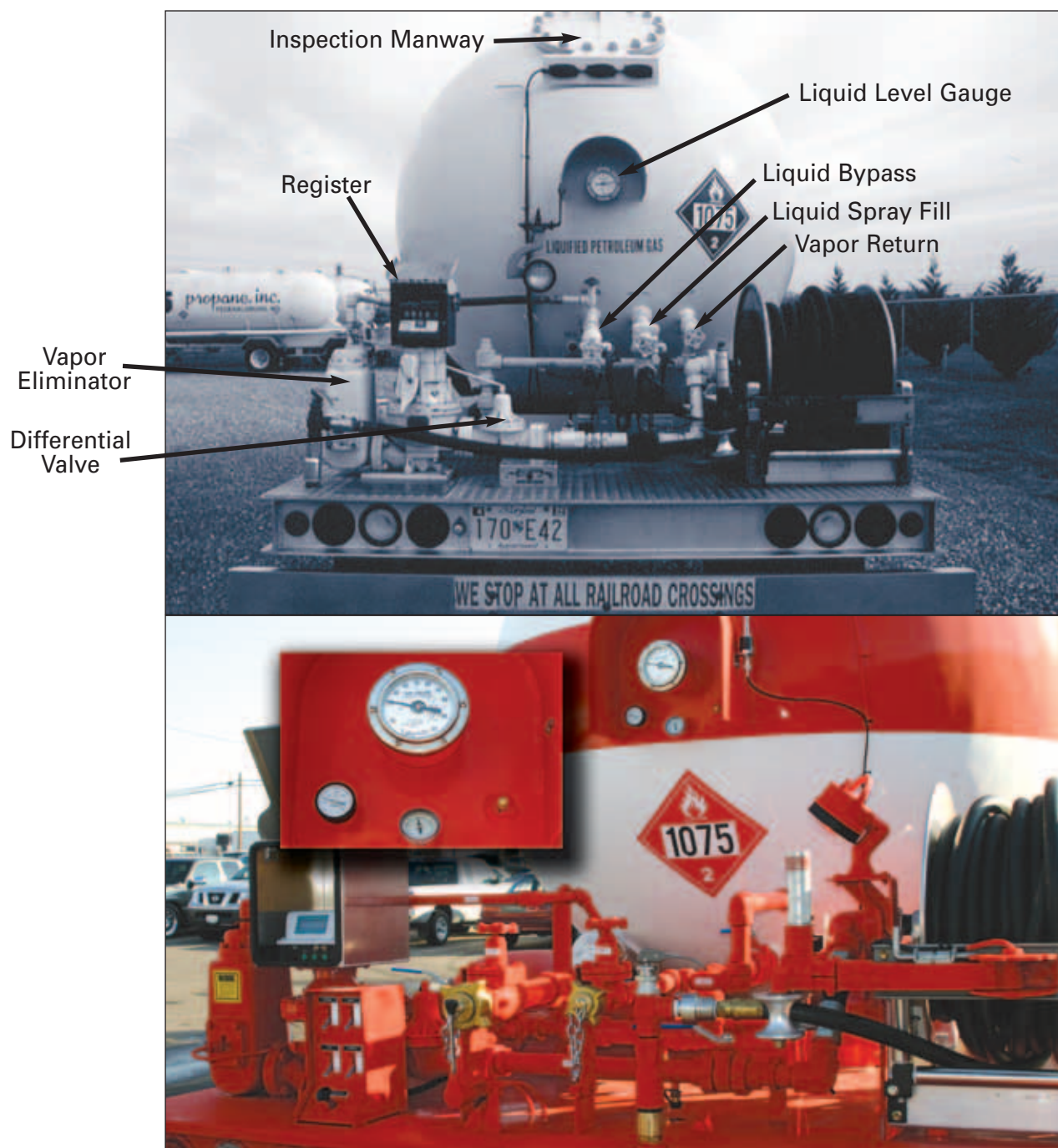


**FIGURE 5-13** Bobtail cargo tank loading platform and key features.

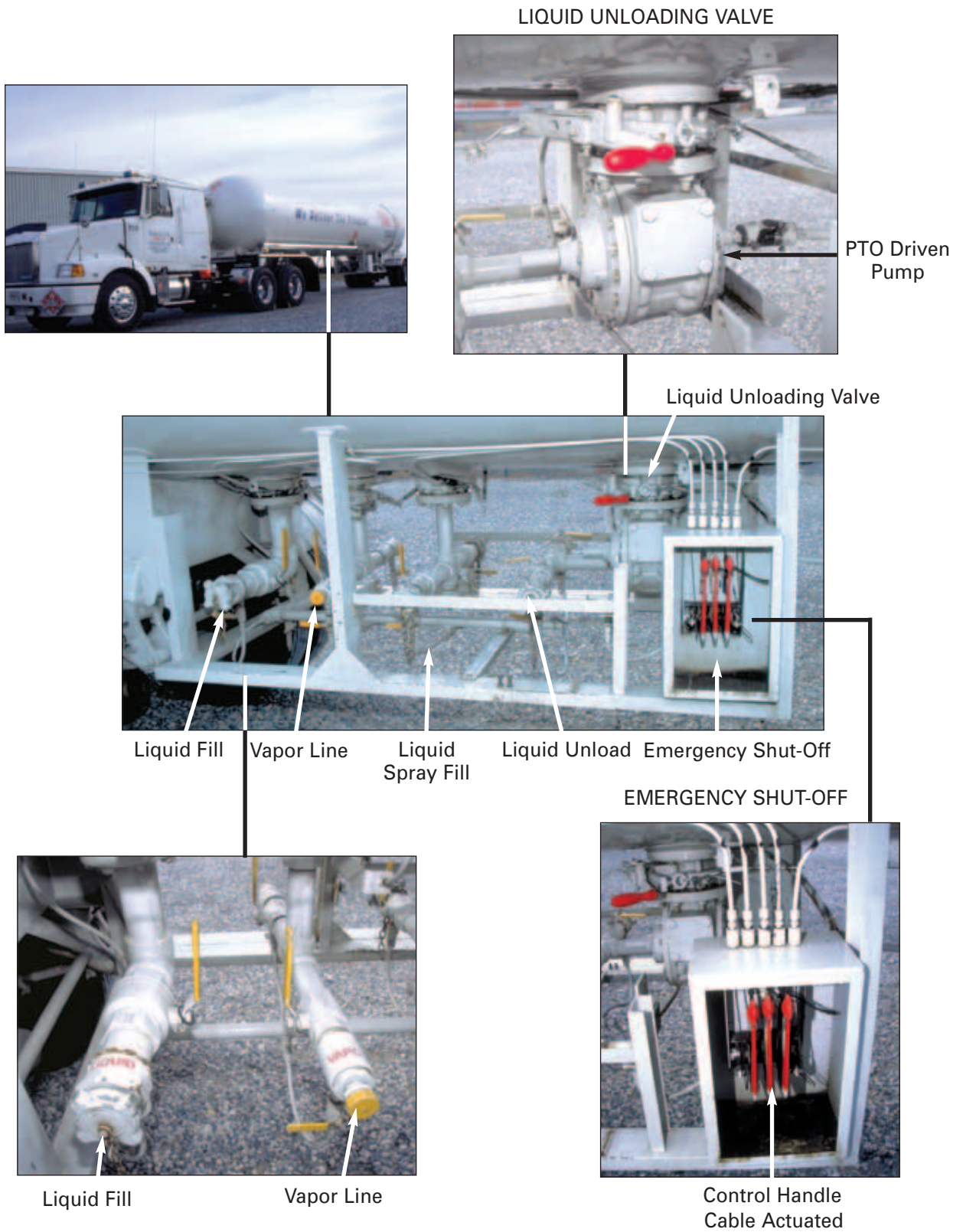


FIGURE 5-14 MC-331 transport loading valves and internal shut-off valve.

## INSPECTIONS AND TESTS

MC-331 cargo tanks must be visually inspected and leak tested by a registered DOT-approved inspector on an annual basis. A separate mechanical inspection of the truck chassis is also required annually. The month, year, and cargo tank inspection codes are displayed near the data plate as follows (see Figure 5-15):

- V—External Visual Inspection of the cargo tank for any defects or missing items
- K—Leakage Test checking all valves, accessories and openings for product leakage.

DOT regulations also require that cargo tanks be retested and inspected every five years; retest dates are typically located on or near the specification plate. The date of the original pressure test will be stamped on the DOT tank specification plate. DOT regulations specify that any MC-330 or MC-331 cargo tank that has been out of service for one year or more must undergo a complete visual inspection and pressure test before being placed back into service. Five-year inspection codes are as follows:

- I—Internal Visual Inspection, where the cargo tank is purged and inspectors physically inspect the tank interior for cracks or other damage.
- P—Pressure or Hydrostatic Test, where pressure relief valves (PRV) are removed, the tank filled with water, and then tested to 1-1/2 times their normal working pressure to ensure that they are still in proper condition.



FIGURE 5-15 Cargo tank inspection markings.

## DOT RAILROAD TANK CARS

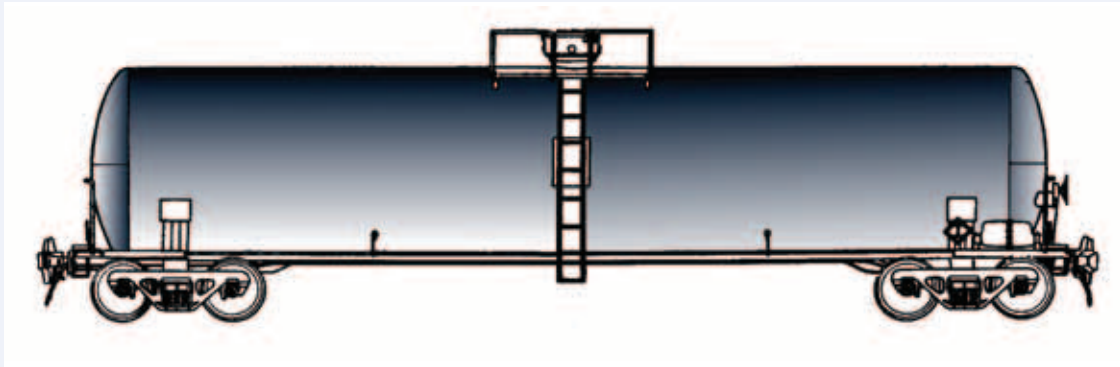
The DOT railroad tank car is simply a large bulk storage tank on a rail car chassis. They are primarily used to deliver large quantities of propane from refineries and gas plants to bulk plants where they are off-loaded into bulk storage tanks. Small railroad tank cars have water capacities between 11,000 and 12,000 gallons, while the modern jumbo railroad tank cars have water capacities as high as 34,500 gallons.

Unlike cargo tank trucks, railroad tank cars are rarely owned by propane producers or marketers. As a result, propane marketers rarely get involved in the inspection



tion, service or repair of a propane tank car or its valves. However, propane marketers are required to visually inspect the tank, tank valves, and tank markings to ensure that the tank car is safe to unload. As a result, many bulk plant operators have a working knowledge of propane tank cars and special rules and regulations that must be followed when working with them. At an incident involving a propane tank car, it may be necessary to have both a propane product specialist and railroad tank car specialist present.

### PRESSURIZED RAILROAD TANK CARS



- Cylindrical tank with rounded ends.
- Fittings and valves enclosed in dome.
- Off-white paint indicates sprayed-on thermal insulation.
- Black paint usually will indicate a jacketed tank car.
- Tank pressures range from 100 to 600 psi.
- Capacities of 4,000 to 45,000 gallons.



**PROPANE  
CAR CLASSES**  
DOT 105  
DOT 112  
DOT 114

**FIGURE 5-16** Pressurized railroad tank cars.



FIGURE 5-17 Railroad tank car identification markings.

## GENERAL FEATURES

Before we discuss the types of tank cars used for transporting propane and their design and construction features, it may be helpful first to review the type and meaning of the information the tank car specification markings will provide. See Figure 5-17.

Railroad tank car specifications are established and enforced by the U.S. Department of Transportation (DOT). The specification marking indicates the standards to which a tank car was built. These markings will be printed on both sides of the tank car (right end as one faces the side of the tank) and provide the following information:

- Authorizing agency (i.e., DOT, AAR, TC)
- Class designation
- Separator / delimiter character (significant in certain tank cars)
- Tank test pressure (psi)
- Type of material used in tank construction
- Type of weld used
- Other car features (e.g., fittings, materials, lining)



## TANK SHELL

Railroad tank cars used for transporting propane are built under several different specifications—DOT 105, DOT 112, and DOT 114. Although there are some differences regarding the size and design pressure of the three DOT tank car specifications, there are also a number of common design and construction features. These include the following:

- Tank shell is constructed of fusion-welded, carbon steel. The tank shell can range from 9/16-inch to 3/4-inch steel.
- Tank test pressures can vary from 300 psig (DOT 105) and 340 psig (DOT 112 and 114) to 400 psig (DOT 114).
- Water capacities can vary—DOT 105 ranges from 11,000 to 34,500 gallons, while the DOT 112 and DOT 114 can range from 26,000 to 34,500 gallons.
- Designed for only top loading and unloading.
- Provided with manway nozzles.
- Bottom outlets, washouts, connections, etc. are prohibited.

In the 1960s and 1970s, a number of significant train derailments occurred which resulted in the catastrophic failure of both flammable and toxic pressurized tank cars, including LPG, propane and butane, chlorine, and vinyl chloride. Investigations showed several common factors in the behavior of tank cars during these derailment scenarios, including the following:

- Railroad car couplers would disengage and puncture an adjoining pressurized tank car.
- Most tank car punctures occurred in the head of the car.
- Pressurized tank cars subjected to flame impingement on the vapor side of the container were likely to fail catastrophically.

As a result of these incidents, industry and government groups joined efforts that eventually resulted in a number of improvements in the basic design and construction of pressurized tank cars. Today, these design and construction features are found in virtually all pressurized tank cars that transport flammable or toxic liquefied gases:

1. **Head Shields**—These are heavy 1/2-inch steel plates mounted on the tank head. Depending upon the tank car, they may be mounted on the outside of the tank and be visible, or they may be integrated within the outer jacket of the tank car and not be visible. The head shield is designed to absorb the impact of a train derailment and prevent a car coupler or any other object from puncturing the head of the propane tank car. See Figure 5-18A.
2. **Shelf Couplers**—Conventional rail car couplers ride up and down freely and can disengage in a derailment and puncture an adjacent tank car. Shelf couplers reduce the potential for coupler disengagement and head punctures by forging a heavy steel plate, or shelf, above and below the coupler itself. These shelves prevent other railcar couplers from riding over or under the tank car coupler and impacting the tank itself. As a result, tank cars tend to remain coupled when involved in a derailment scenario. All tank cars used to transport hazardous materials are required to be equipped with double shelf couplers. See Figure 5-18B.



FIGURE 5-18A

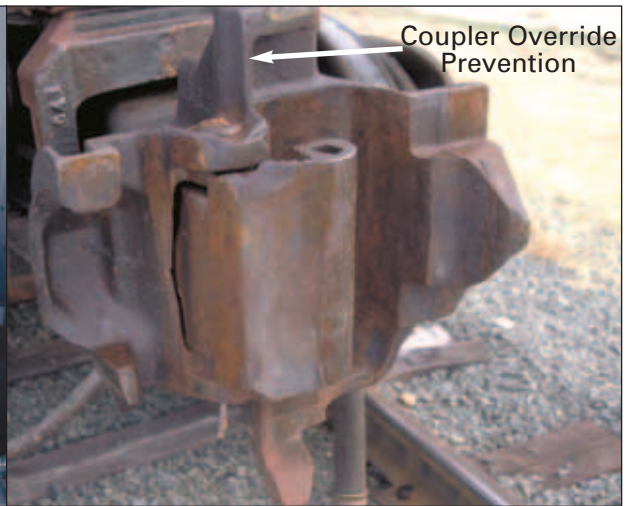


FIGURE 5-18B

DOT railroad tank car head shields and shelf couplers have eliminated many catastrophic railroad accidents.

3. **Thermal Protection**—All DOT tank cars used for propane transportation are provided with thermal protection to minimize the tank shell's exposure to flame impingement and fire. Thermal protection is designed to keep tank metal temperatures below 800°F (37.8°C) for 100 minutes if the exposure is from a pool fire or 30 minutes if the exposure is from a torch fire.

Thermal protection can be provided in two ways—jacketed protection or sprayed-on insulation. Jacketed thermal protection is the most common and consists of mineral wool or fiberglass insulation that is installed and kept in place by an outer metal jacket. This outer jacket is 1/8-inch steel, and is designed to only hold the insulation and thermal protection in place. Sprayed-on thermal protection is applied on the outside of a nonjacketed tank car. This insulation is designed to expand when exposed to high temperatures.

### TANK CAR FITTINGS

Propane tank cars are provided with several valves and fittings that provide for loading and unloading, overpressure protection, and gauging. These can be found on the top of the tank car and are attached to a manway cover plate. The manway allows access to the interior of the tank car and is a permanent cover plate that is bolted onto the tank car shell. All tank car valves and fittings will be found on this manway cover. (See Scan Sheet 5-A, page 103.)

Valves and fittings are covered by a protective housing, commonly referred to as a dome cover. The dome cover is designed to protect the valves and fittings from mechanical damage in the event of a derailment. It is also a distinctive feature that allows emergency responders to distinguish pressure from nonpressure tank cars. While some non-pressure tank car may have their top valves and fittings enclosed in a dome, ALL pressure cars used for propane will have their top fittings inside the dome.

### LOADING AND UNLOADING VALVES

Propane tank cars are equipped with two liquid valves and one vapor valve. The liquid valves consist of angle valves, which are mounted on the manway cover plate, and an eduction tube beneath the cover plate, which extends to the bottom of

the tank car. The vapor valve consists of the vapor valve, which is mounted on the manway cover plate and a short pipe or nipple, which is mounted under the cover plate and extends a few inches into the vapor space.

Liquid and vapor valves are either plug or ball-type angle valves and have a plug in the valve orifice. Liquid and vapor valves can be distinguished by their placement within the dome cover. Liquid valves will be in-line with the ends of the tank car (remember Liquid—Length), while the vapor valve points toward the side of the tank. In a derailment scenario where a propane tank car is overturned, these valves and eduction tubes may be in the liquid or vapor space, depending upon the attitude and position of the tank and the amount of lading.

## EXCESS FLOW VALVES

Excess flow valves are designed to stop product flow if a liquid or vapor valve is sheared off during a derailment or if a hose or other fitting fails during loading or unloading. They are mounted inside of the tank under the liquid and vapor valves. These valves operate by either gravity or pressure differential.

## PRESSURE RELIEF VALVE (PRV)

The PRV is a spring-loaded valve that normally opens into the vapor space and discharges upward so as to prevent any impingement of the escaping gas upon the tank shell. There is an opening on the dome cover directly above the PRV that allows the vapors to be released. As with liquid and vapor valves, if the tank car is on its side or inverted, the PRV will now be in the liquid space rather than the vapor space. Tank car PRVs are set to actuate at 75% of the tank test pressure (e.g., PRV on a DOT-114-J340W tank car will actuate at 255 psi).

## GAUGING DEVICE

The gauging device is used to determine the amount of lading in a tank car. It is typically an “open-type” device (e.g., slip tube) which releases liquid when the device reaches the liquid level. Care must be taken when using the slip tube gauging device, as the rod may shoot up quickly when opened and create a physical hazard. “Closed-type” gauging devices, which use a float with a magnet on a measuring rod or a dial indicator, may be found.

In order to determine accurately the amount of lading within the tank car, both the liquid level and the content’s temperature must be referenced against the out-gage table for the car.

## THERMOMETER WELL

This is a closed tube normally filled with alcohol or antifreeze (e.g., ethylene glycol) that extends into the tank. A thermometer is placed into the well and the temperature of the lading is determined. When used with temperature/pressure curves, temperature readings can assist in determining whether the product is expanding and increasing the internal tank pressure. If the thermometer well tube breaks inside the tank, leaks may occur either around the well cap or where the well extends into the manway cover plate.

## SAMPLE TUBE/LINE

Sample lines are mounted on the manway cover plate and can be used to obtain a sample of the lading without opening the tank. The sample line may also be protect-

ed with an excess flow valve mounted on the end of the tube inside of the tank. Sample lines may develop leaks at the handle or around the plug and may break in the event of an accident. Note: Some shippers remove and plug sample lines because they are easy to damage. Samples are then taken from the gauging device or a liquid valve.

## TANK CAR MARKINGS

There are a number of markings on propane tank cars that can be used to gain knowledge about both the tank and its contents. This information may be extremely useful in evaluating the condition of the container. These markings include the following:

- **Commodity Stencil**—Under DOT regulations, tank cars transporting Division 2.1 material (flammable gas) must have the name of the commodity marked on both sides of the tank car in 4-inch (102 mm) minimum letters. Other divisions require similar markings (e.g., anhydrous ammonia, ammonia solutions).
- **Reporting Marks and Number**—All railroad cars are identified through a unique set of initials and a number (e.g., GATX 12345). These are known as the railcar reporting marks and are unique to that railcar. The reporting marks are stenciled on both sides (left end as one faces the side of the tank car) and both ends of the car. Newer railcars may also have the reporting marks stenciled on the top of the railcar to aid in the identification process if the car is derailed and is lying on its side. The reporting markings can be used to obtain information about the contents of the car from the railroad, the shipper or CHEMTREC. See Figures 5-20 and 5-21.
- **Capacity Stencil**—The capacity stencil shows the volume of a tank car in gallons (and sometimes liters), as well as in pounds (and sometimes kilograms). Weight markings are found on both sides of the car under the reporting marks. For certain tank cars (e.g., DOT-105, DOT-112, and DOT-114) the water capacity/water weight of the tank car is stenciled on both ends of the car and may also be found near the center of the car. See Figure 5-21.



FIGURE 5-19 Propane tank car being off-loaded at a terminal unloading rack.

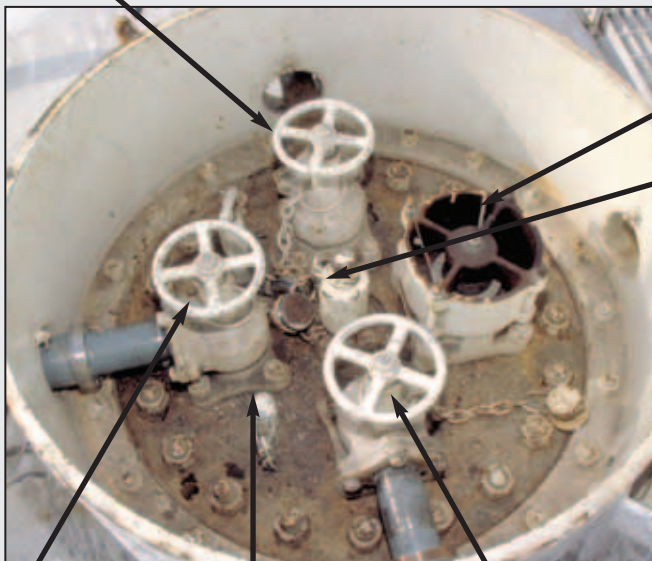


## DOT 112 RAILROAD TANK CAR FITTINGS

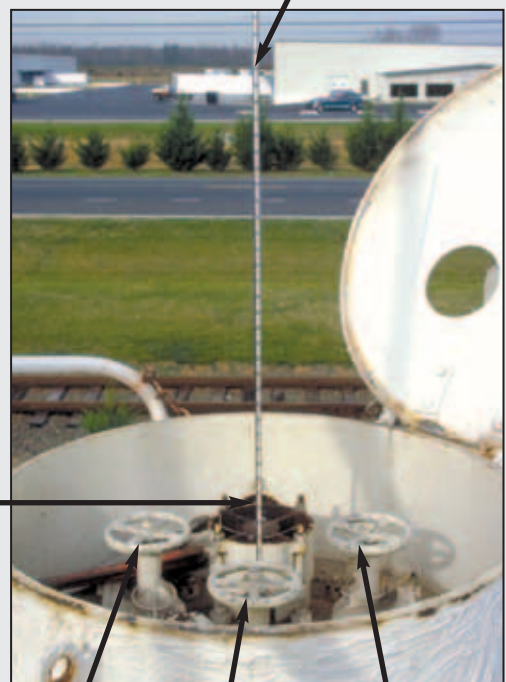
DOT 112 RAIL CAR CONNECTED TO LOADING RACK



Liquid Valve Front of Car



**CAUTION:** Note Height of Gauging Rod; Do Not Stand Over Gauging Rods





## DOT SPECIFICATION MARKINGS FOR RAILROAD TANK CARS

- **Specification Plate.** Tank cars ordered after 2003 will have a plate on the A-end right bolster and the B-end left bolster (i.e., structural cross-member which cradles the tank) that provides information about the tank car's characteristics. Although not designed as an emergency response tool, the plate will provide the following information:

|                                       |                                   |            |
|---------------------------------------|-----------------------------------|------------|
| Car Builder's Name                    | Tank Shell Material/Head Material | Date Built |
| Builder's Serial Number               | Insulation Materials              |            |
| Certificate of Construction/Exemption | Insulation Thickness              |            |
| Tank Specification                    | Underframe/Stub Sill Type         |            |

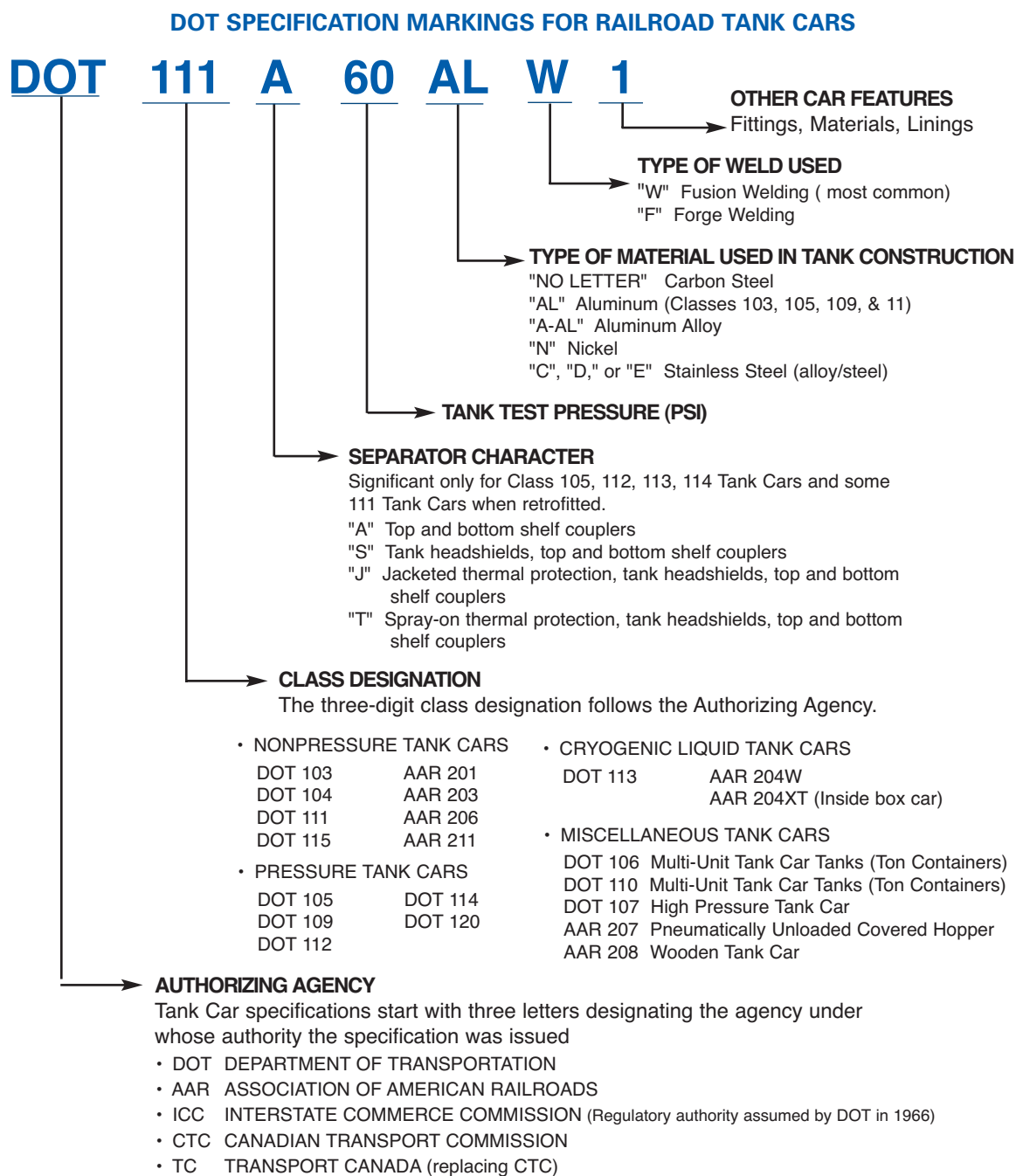
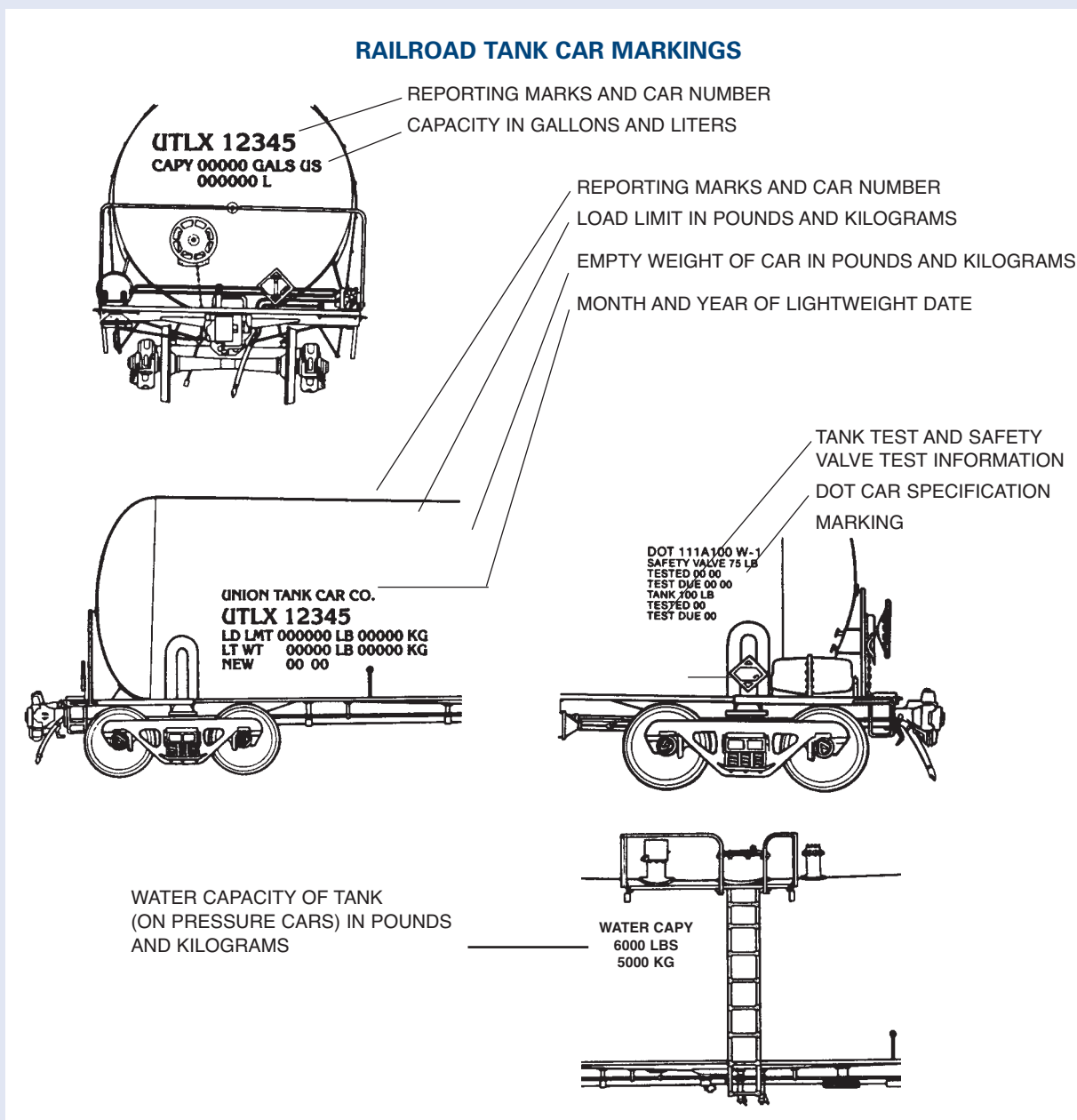


FIGURE 5-20 DOT specification markings for railroad tank cars.

## RAILROAD TANK CAR MARKINGS

- **Capacity Stencil.** Shows the volume of a tank car in gallons (and sometimes liters), as well as in pounds (and sometimes kilograms). These markings are found on the sides of the car under the reporting marks. For certain tank cars (e.g., DOT-105, DOT-109, DOT-112, DOT-114 and DOT-111A100W4), the water capacity / water weight of the tank car is stenciled near the center of the car. The term load limit may also be used for capacity.



- **Specification Marking.** The specification marking indicates the standards to which a tank car was built. These markings will be on both sides of the tank car (right end as one faces the tank) and provide the following information:

Approving Authority  
Class Number  
Separator / Delimiter Character  
(significant in certain tank cars)

Tank test pressure  
Type of material used in construction  
Type of weld used  
Fittings/material/lining

FIGURE 5-21 Railroad tank car markings.

## INTERMODAL CONTAINERS

This section will discuss the different types of intermodal containers which may carry propane. It is based on material from the text: *Hazardous Materials Emergencies Involving Intermodal Containers: Guidelines and Procedures* by Gregory G. Noll, Michael S. Hildebrand, and Michael L. Donahue (Fire Protection Publications, Oklahoma State University, 1995, 800-654-4055).

Intermodal containers are designed as a transport container that can be physically moved on one or more mode of transportation (e.g., from ship to trucks to rail cars). These containers are not only intermodal, but are also constructed to standard international designs.

Intermodal containers are designed, constructed, and handled in accordance with a number of codes, regulations, and standards. Within the United States, the most notable include the International Maritime Organization (IMO) and the U.S. Department of Transportation (DOT).



FIGURE 5-22 IMO type 5 / DOT Spec 51 intermodal container.

## PRESSURE TANK CONTAINERS

Intermodal pressure tank containers, commonly known within the United States as DOT Spec. 51 Portable Tanks or International (IMO) Type 5 containers, are a less common method of transporting propane than tank trucks or rail cars. However, their usage is rapidly expanding in international commerce, and they are commonly used in remote locations where railroad or cargo tank truck shipments are not readily available.

DOT Spec. 51 containers are pressurized containers designed to handle internal pressures ranging from 100 to 500 psig. They must be designed for product lading in excess of 1,000 pounds water capacity and have a minimum shell thickness of .1875 inches. See Figure 5-22.

DOT specifications for the design and construction of Spec. 51 containers can be referenced in 49 CFR 178.245 and 178.245.7. Spec. 51 containers are required by DOT to be designed and built to the ASME Code and bear an ASME "11" stamp. These tanks must also be 100% x-rayed to provide for high joint efficiency per ASME requirements.

Spec. 51 containers used to transport propane will be in the range of 4,500 to 5,500 gallons. However, it is not uncommon to find Spec. 51 tanks having other capacities, depending on customer and shipper requirements. For example, one iso-tank manufacturer has designed an IMO Type 5 container for butadiene, butylene, and butane service. The portable container is a 40 foot beam constructed unit with 10,610 gallons (40,160 liters) capacity.

## DATA PLATES

Each Spec. 51 tank container must have a name plate affixed to either head of the portable tank by soldering, welding, or brazing around the entire perimeter of the plate. The following information is required:

- Manufacturer's name
- Serial number
- Manufacturer's serial number
- U.S. DOT specification number (e.g., Spec. 51)
- Water capacity (pounds)
- Tare weight (pounds)
- Design pressure (psig)
- Design specific gravity
- Original test date
- Tank retested at \_\_\_\_ psig on \_\_\_\_.

## TANK CONTAINER FITTINGS

The following fittings can be found on Spec. 51 tank containers to make them both safe and functional. These fittings may be on the top, the end, or the bottom. Generally, the fittings are enclosed with a cover or recessed to protect them from mechanical damage.

**Loading/Unloading Valves**—Liquid and vapor valves are used for both filling and emptying the tank. The liquid valve extends into the lading by means of an eduction pipe, which may also be fitted with an excess flow check valve. Vapor valves, which also may have an excess flow check valve, are used to remove vapors from the tank or to pressurize the tank for unloading.

All tank outlets must be marked to designate vapor or liquid discharge potential when the tank is filled to the maximum level permitted. They may be either threaded or flanged valves. However, unlike cargo tank and railroad tank cars, valve threads may be British Standard Pipe (BSP) or metric threads. See Figure 5-23.

**Gauging Devices**—Gauging devices may be installed to measure how much liquid is in the tank. Various types are found, including rotary gauge and open and closed gauging devices, as found on some propane railroad tank cars.

Open-type gauging devices measure tank outage (i.e., vapor space) by releasing liquid when the liquid level reaches the bottom of a tube. Closed-type gauging devices measure outage with a float and a magnet on a measuring rod or dial indicator.

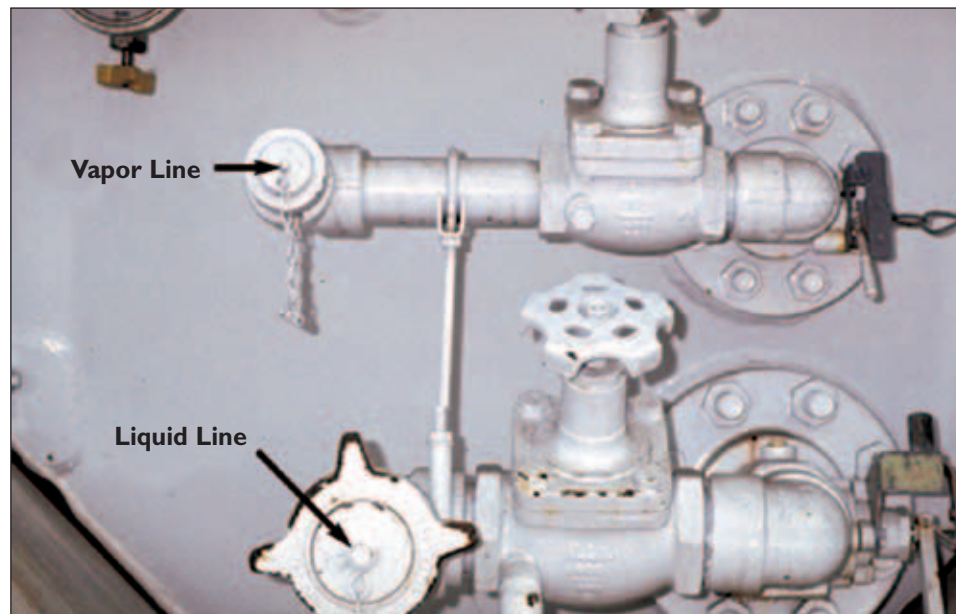


**FIGURE 5-23** IMO Type / DOT Spec 51 container—liquid and vapor valves are found inside of a cabinet located on the tank end.

**Sample Lines**—These are used to sampling the lading without opening the tank. Sample lines can develop leaks at the handle or around the plugs.

**Temperature Gauge**—Indicates the temperature of the product within the container. The temperature sensor is enclosed in a thermo well and is not in direct contact with the product. It can also be used to estimate the internal pressure when used with temperature/pressure curves.

## TANK CONTAINER SAFETY DEVICES

The following safety devices can be found on the Spec. 51 tank containers:

**Pressure Relief Devices**—Pressure relief devices are mounted on top of the container to protect the tank from over-pressure under abnormal conditions, such as fire impingement. These devices may be found inside of an unhinged compartment, which protects them from the elements. Remember that a Spec. 51 container can fail violently if impinged upon by fire, even if the pressure relief devices have actuated. See Figure 5-24.

**Excess Flow Valves**—As noted previously, excess flow valves may be found on both liquid and vapor piping. Mounted inside of the tank under the liquid and vapor valves, excess flow valves will stop the product flow if a valve is sheared off. Excess flow valves are operated by gravity or pressure differential. It is important to remember that excess flow valves will not function unless the flow rate is enough to cause activation of the valve. Sometimes a small break in a hose is not sufficient to seat the valve, and because of the large expansion ratio of propane, a dangerous release of propane can still occur.



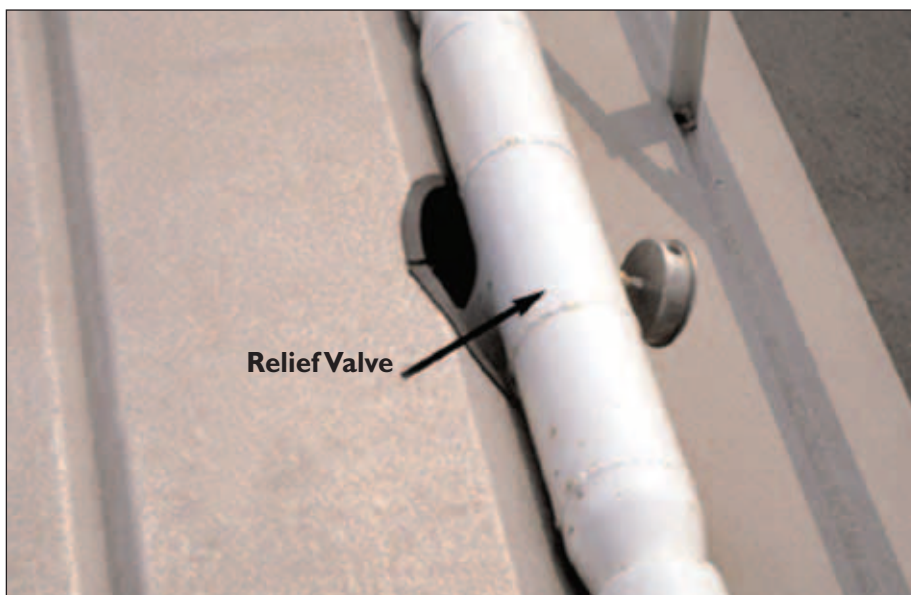


**FIGURE 5-24** Pressure relief device on a IMO Type 5 / DOT Spec 51 container.

## INSPECTIONS AND MAINTENANCE

Under DOT regulations (49 CFR 173.32c(d)), a pre-trip inspection of the intermodal tank is required. This is primarily an external visual inspection to spot mechanical damage, deterioration, or equipment malfunction and to check for current test inspection dates. In addition, some companies also perform interchange inspections when the carrier changes (e.g., when the intermodal tank container is delivered via truck at a plant site prior to the plant taking responsibility for the container).

### TANK AND VALVE TESTING

Tank and valve test inspections are based upon both DOT and IMO Dangerous Goods regulations. Intermodal tank containers must be hydrostatic tested every five years, with the test witnessed by a certified approval agency (e.g., American Bureau of Shipping, Marine Container Equipment Certification Corporation). At least every 2-1/2 years (30 months), the tank must be visually inspected and the spring-loaded pressure relief valve removed from the tank and tested.

Upon successful completion of these tests, the tank data plate must then be marked with the month and year of the test. Tank containers marked as complying with Association of American Railroads (AAR-600) requirements must be marked and stenciled with the test due dates. The next due date for periodic testing will be shown on the data plate.

## SUMMARY

Bulk propane vehicles are an integral element in the propane transportation and distribution system. Key elements of this system are (1) the bulk transport cargo tank truck, which primarily moves propane from both production, storage, and distribution facilities to propane marketers, and (2) the bobtail delivery vehicle used by marketers to transport and deliver propane to the end user.

Cargo tank truck specifications are established and enforced by the U.S. Department of Transportation (DOT). Like DOT portable tanks, propane cargo tank trucks are built to strict design specifications and codes established by both the American Society of Mechanical Engineers (ASME) and DOT.

The Bobtail Single-Tank Delivery Vehicle is the “workhorse” of the propane marketing business. It is used to transport and deliver fuel to customers who use propane containers that are filled onsite. Capacities can range from 750 to 6,500 gallons. The semi-trailer bulk transport cargo tank is one of the prime methods for delivering propane to bulk plants and marketing facilities. Tank capacities range from 9,000 to 14,500 gallons, although cargo tanks can be as large as 17,000 gallons. Although there are differences in size between the smaller bobtail propane delivery vehicles and the larger bulk transport semi-trailers, there is little difference in the cargo tank’s basic design, construction, and safety features.

The DOT railroad tank car is simply a large bulk storage tank on a rail car chassis. Tank cars are primarily used to deliver large quantities of propane from refineries and gas plants to bulk plants, where they are off-loaded into bulk storage tanks. Small railroad tank cars have water capacities between 11,000 and 12,000 gallons, while the modern jumbo railroad tank cars have water capacities as high as 34,500 gallons.

Intermodal containers are designed as a transport container that can be physically moved on one or more mode of transportation (e.g., from ship to trucks to rail cars). The DOT Spec. 51 / International (IMO) Type 5 portable containers are pressurized containers designed to handle internal pressures ranging from 100 to 500 psig with 4,500 to 5,500 gallons capacity.



## BULK PLANTS AND BULK STORAGE TANKS

OBJECTIVES

1. List and describe the operational objectives of a propane bulk plant.
2. List and describe the three primary operational areas of a propane bulk plant.
3. Describe the design, construction, and operation of each of the following valves and fittings found on a bulk propane storage tank [NFPA 472-C.2.1.3]:
  - Liquid valves
  - Vapor valves
  - Excess flow valves
  - Pressure relief valve
  - Gauging devices
4. Identify the impact of the following fire and safety features on the behavior of propane during an incident at a bulk plant, when present. [NFPA 472-C.2.2.1]
  - Tank spacing
  - Transfer and product movement capabilities
  - Monitoring and detection systems
  - Fire protection systems
5. Describe the key elements of a Product Release Prevention and Incident Preparedness Review for a bulk plant, as outlined in NFPA 58-6.23 (2004).
6. Describe the operation of the following two types of bulk transport unloading stations found at a bulk plant.
  - Truck Unloading Stations
  - Rail Unloading Stations
7. Describe the purpose and operation of a cylinder filling station.
8. List two additional hazardous materials and related operations that may be found at a propane bulk plant.

ABBREVIATIONS AND ACRONYMS

|      |                                          |
|------|------------------------------------------|
| AHJ  | Authority Having Jurisdiction            |
| ASME | American Society of Mechanical Engineers |
| DOT  | U.S. Department of Transportation        |
| EFV  | Excess Flow Valve                        |
| FSA  | Fire Safety Analysis                     |
| NFPA | National Fire Protection Association     |
| NPGA | National Propane Gas Association         |
| PERC | Propane Education and Research Council   |
| PRV  | Pressure Relief Valve                    |

## BASIC FEATURES OF BULK STORAGE FACILITIES

The terms bulk plant, bulk storage facility, and bulk terminal are often used interchangeably and have different meanings to different people. According to the *LP-Gas Code (NFPA 58)*, a Bulk Plant is defined as a facility where the primary function is to store LP-Gas prior to further distribution. LP-Gas may be received by cargo tank truck, railroad tank car or pipeline, and then distributed to the end user by portable container delivery, by cargo tank truck, or through gas piping. Bulk Plants have bulk LP-Gas storage of at least 2,000 gallons (7.6 m<sup>3</sup>) water capacity or more and have container filling and/or truck loading facilities on the premises. In simple terms, a bulk plant is primarily a propane warehouse and distribution facility.

LP-Gas marketers generally keep enough propane on-site to meet the changing needs of customers. To do this, the bulk plant must have the basic equipment and facilities to meet three essential operational objectives.

1. The bulk plant must be able to receive large quantities of propane from the wholesaler. Propane may be delivered to the bulk plant in cargo tank transport vehicles, in railroad tank cars, or by pipeline. In either case, the bulk plant must have the proper equipment to unload these bulk transport containers safely
2. The bulk plant must be able to store a large inventory of propane. This requires large storage tanks. Small marketers may only need one 30,000 gallon tank of propane. In contrast, propane marketers serving large areas or a large number of customers may store as much as 100,000 gallons or more of propane.
3. Propane stored at the bulk plant must have a delivery system to supply propane to customers. Some marketers may only have an exchange cylinder service for delivering propane to its customers. Other marketers may also deliver bulk propane to their customers in small bulk propane delivery vehicles called “bob-tails”. See Figure 6-1.

The design and layout of each bulk plant is different to meet the owner’s and customer’s needs. However, there are several common features and equipment found in almost every bulk plant that are necessary for effective and safe operation of the facility. The typical bulk plant operation consists of three distinct groups of equipment or operational areas within the plant: 1) bulk storage tanks, 2) unloading stations, and 3) filling stations. At some bulk plants, unloading and filling stations may be combined. See Figure 6-2.

## BULK STORAGE TANKS

Bulk storage tanks used in propane bulk plants are constructed to American Society of Mechanical Engineers (ASME) standards. These tanks that are built to the same ASME codes that apply to customer tanks. However, the water capacity (w.c.) of individual bulk tanks is much greater than most customer tanks. The horizontal tanks range in size from 6,000 to 60,000 gallons but may be as large as 120,000 gallons. See Figure 6-3.





**FIGURE 6-1** MC-331 bobtail cargo tank truck being filled at a bulk plant.

Several tanks of various sizes may be installed at a bulk plant. For example, a large bulk plant may use four 30,000 gallon tanks. However, a small propane marketer may have only one or two 18,000 gallon tanks.

### TANK INSTALLATIONS

Bulk storage tanks must be installed on a firm foundation. These foundations are often called saddles or piers. The fire-resistant saddles are designed to fit the shape of the bottom of the tank and are typically made from reinforced concrete, steel, or a combination of the two. Each storage tank must be a specific distance away from other tanks, important buildings, flammable liquid storage and the property lines of the bulk plant. Exact separation distances are determined by local, state, and national regulations that are usually based on the requirements of NFPA 58.

### TANK VALVES AND ACCESSORIES

Bulk storage tanks will have a number of safeguards that are outlined below.

**Internal Valves**—For convenience and accessibility, most valves for unloading and filling a bulk storage tank are located in the bottom of the barrel. In this case,

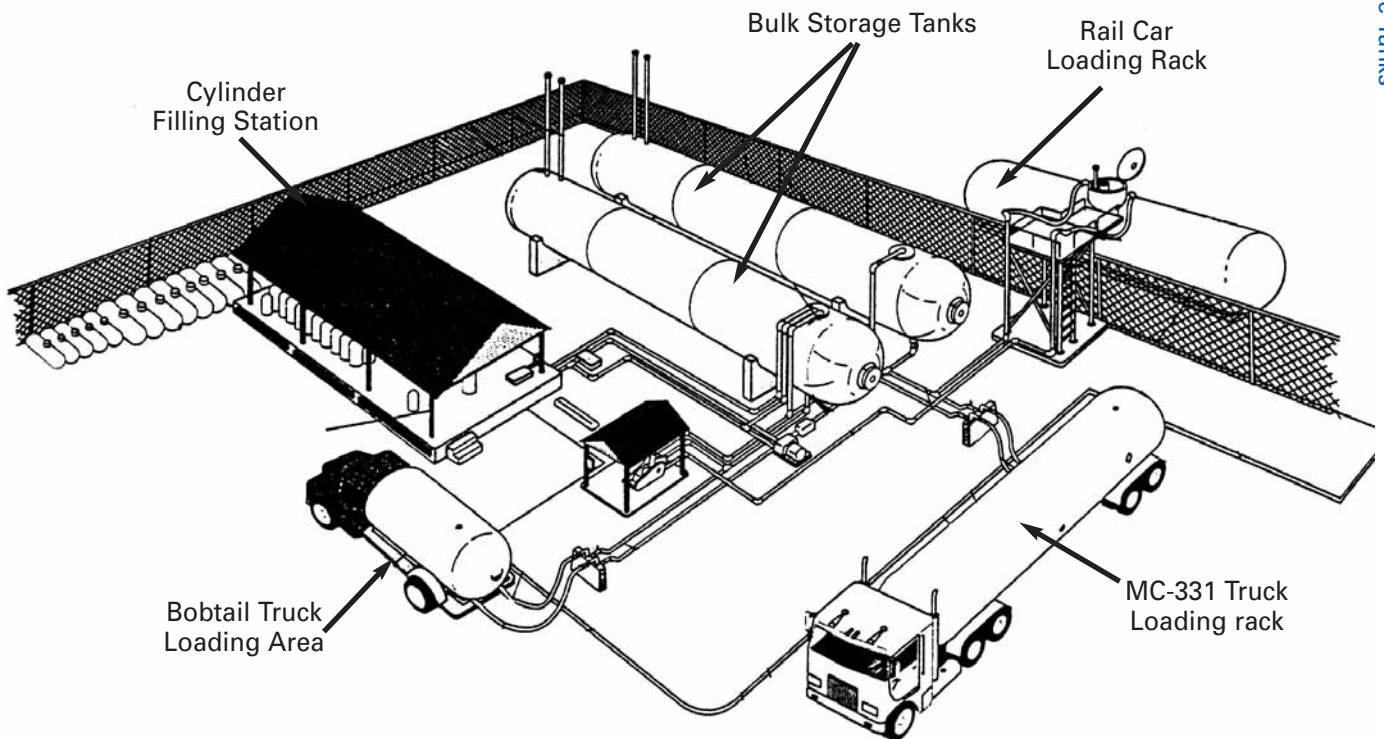


FIGURE 6-2

## ASME BULK STORAGE TANKS

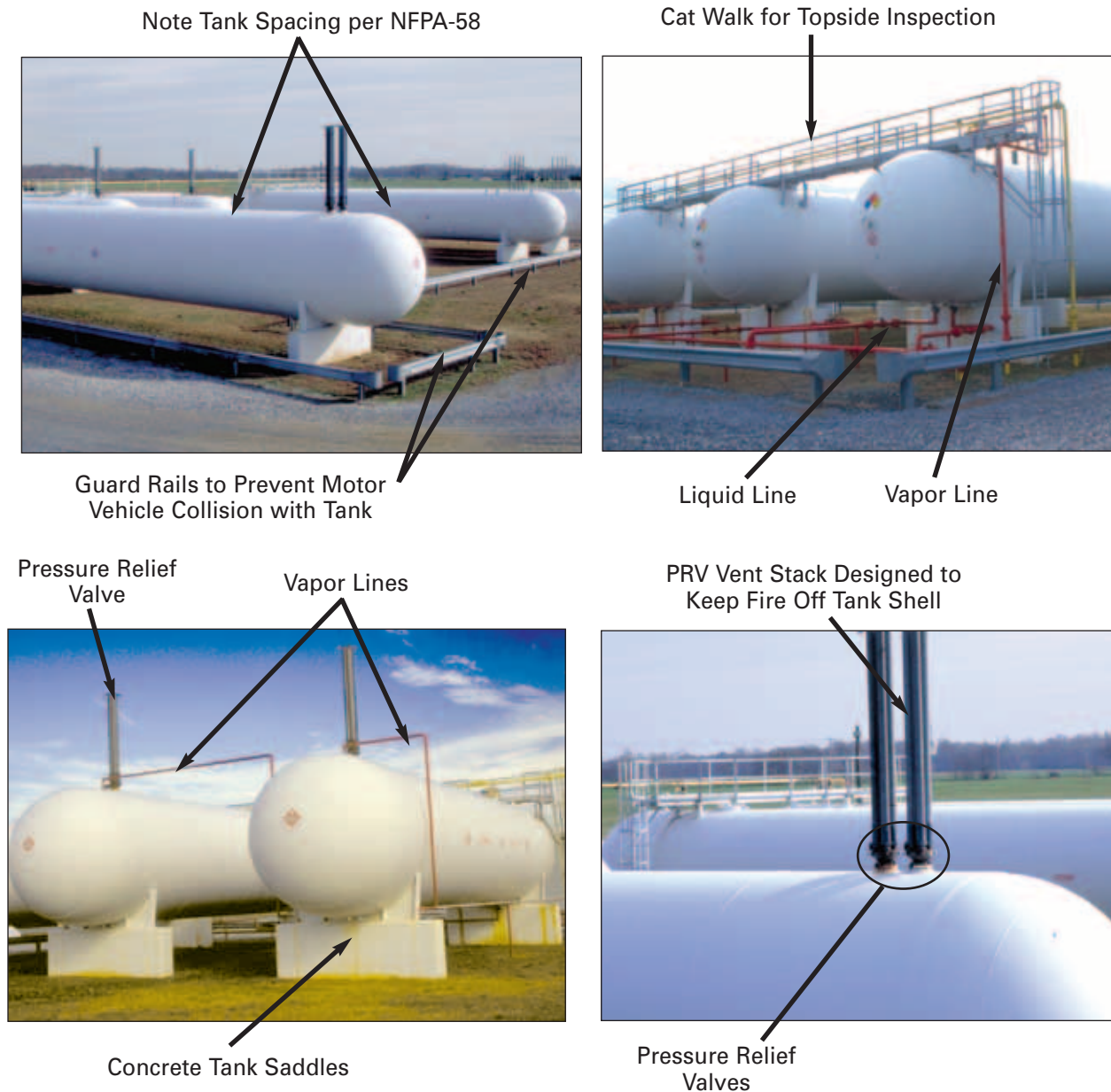


FIGURE 6-3 ASME bulk storage tanks.

there will be at least one valve for liquid transfer and one valve for vapor transfer. When vapor valves are located in the bottom of a tank, a large steel pipe inside the tank connects the valve to the vapor space. This pipe is called a stand-pipe. The valves and their related piping are often identified as “liquid” or “vapor” through the use of markings or color code. Although the pipe diameter may vary, it should be remembered that liquid piping is always larger than vapor piping.

Due to their larger volumes and types of service applications, ASME bulk containers over 4,000 gallon water capacity are subject to additional valve requirements than smaller containers. These can be referenced in NFPA 58, Section 5.7 (2004). Storage tank internal valves are typically classified according to their



means of operations, including manual, cable or pneumatic (e.g., air, nitrogen, propane). See Figure 6-4

The internal valve is a spring-actuated valve that is normally closed and requires either cable activation or pressure to a pneumatic actuator to remain open. In the event of a piping system failure, the internal safety valve can be closed by manually actuating a remote emergency valve control or by heat activation of a thermal element. The remote emergency valve control must be within 25 ft. of the transfer point. Fusible links must be within 5 feet of the liquid internal valve. If the internal valve is pneumatically actuated and incorporates the use of nylon tubing, a fire anywhere along the length of the tubing will cause the tubing to fail and ultimately lead to closing of the internal valve. See Figure 6-5.



**FIGURE 6-4** Internal valve on ASME storage tank.



In event of fire or leak, the Bulk Plant can be shut down by activating Emergency Shutdown.

When ESD activates, nitrogen bleeds down—activating shutdown of plant, closing all valves, and shutting

**FIGURE 6-5** Transfer areas have numerous safety features.

**Excess Flow Valves (EFVs)**—Excess flow valves are designed to close automatically when the flow of liquid reaches the volume specified in the design of the valve or when the flow pressure exceeds a preset value, such as a piping system failure. They are required on the liquid internal safety valve.

EFVs are an excellent safety tool, but also have some limitations. According to the *NFPA 58 LP-Gas Code Handbook*, excess flow valves cannot be relied upon to stop the flow of product in all cases for the following reasons:

- EFVs are designed to close automatically at the rated flow of liquid or vapor by the manufacturer. If there is only a partial break in the piping system or hose and it does not allow the specified rate for closure, the EFV will not close.
- EFVs are sometimes oversized to minimize closure during startup.
- If the liquid temperature is low, there may not be sufficient pressure in the container to reach the required pressure differential to close the EFV, even if there is complete breakage of the piping system or hose.

**Pressure Relief Valves (PRVs)**—Pressure relief valves are installed in the vapor space of the tank. Bulk plant storage tanks may have as many as four PRVs installed for protection of the tank. A properly operating PRV automatically relieves excess vapor pressure that may build up in the tank. To ensure that the vapors—if ignited—are directed away from both the involved tank and adjoining tanks, the relief valve outlets may have long pipes attached to them called stacks or risers. It should be noted that even with a relief valve operating, the internal tank pressure may exceed the set pressure of 250 psi. See Figure 6-6.

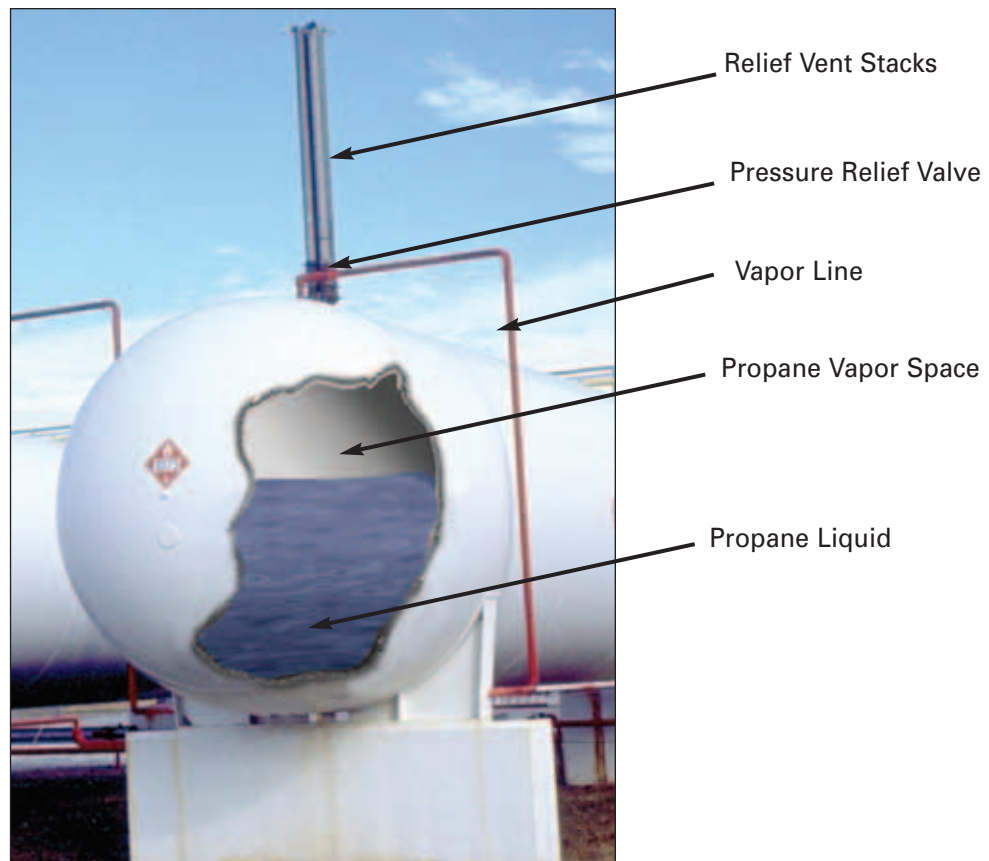


**FIGURE 6-6** Bulk storage tank contains propane in liquid and gas forms.



**Tank Accessories**—Bulk storage tanks greater than 4,000 gallon water capacity are required to be equipped with various gauges which may be installed in either end of the tank head, as well as the top or bottom of the tank barrel. These include:

- *Fixed Maximum Liquid Level Gauge*—These are fixed gauges that identify the specific quantity within the storage tank and are required on all tanks for calibration purposes. This gauge incorporates a dip tube at the 80% liquid level of the tank.
- *Variable Liquid Level Gauging Device*—These may be a float gauge, rotary gauge, slip tube gauge or a combination of these gauges.
- *Pressure Gauge*—Indicates the internal pressure of the container. It can also be used to estimate the temperature of a product when used with temperature/pressure curves.
- *Temperature Gauge*—Indicates the temperature of the product within the container. It may not reflect the ambient air temperature on the outside of the cargo tank. It can also be used to estimate the internal pressure when used with temperature/pressure curves.

## TANK MARKINGS

Bulk storage tanks are painted white, aluminum or other light reflective colors for both appearance and safety. These colors are used because they reflect heat. Some tanks are also painted with special fire protection coatings that reduce the possibility that they will rapidly overheat in the event of a fire. Marketers may also paint the company name or logo on the side of the tank.

Tanks may also be marked using the NFPA 704 marking system, which distinctively indicates the properties and potential dangers of hazardous materials stored in the tank. Some owners voluntarily use the NFPA 704 system even though it may not be required by local or state codes. See Figure 6-7.

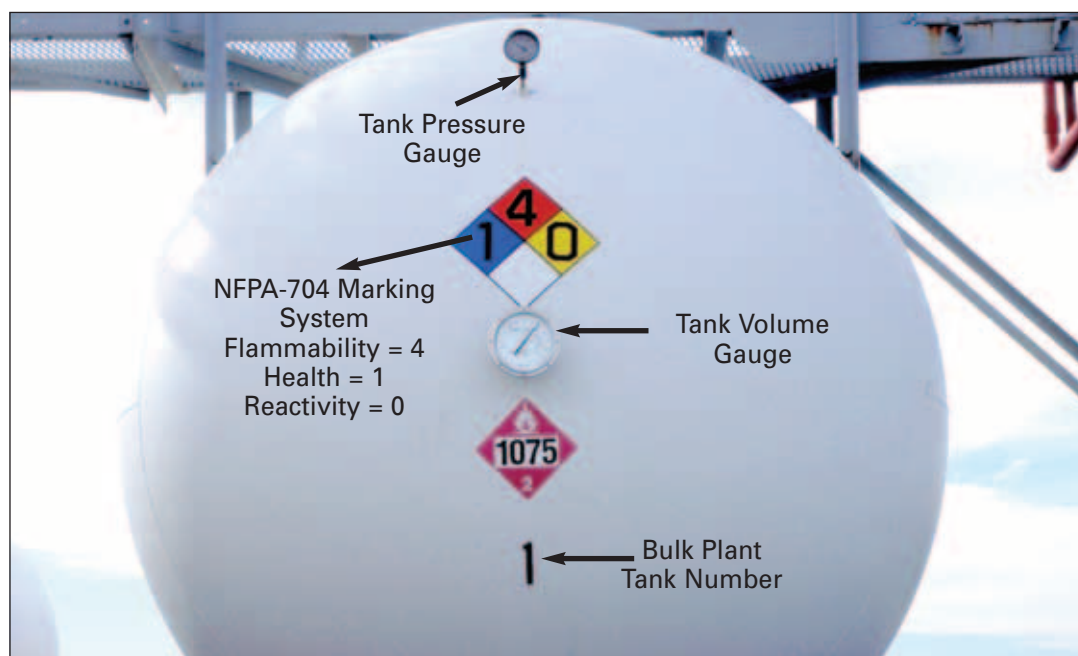


**FIGURE 6-7** Bulk storage markings.

## FIRE SAFETY ANALYSIS

### (PRODUCT RELEASE PREVENTION AND INCIDENT PREPAREDNESS REVIEW)

The propane industry has an excellent fire and safety record that is built upon the concept of total product control. Bulk plants and related facilities that have redundant automatic product control systems provide a high level of confidence that propane will not be released during an emergency. Therefore, not only will the storage facility be protected from a fire that could lead to container rupture, but major fires within the bulk plant would be prevented.

Section 6.23 of *The LP-Gas Code (NFPA 58)* addresses fire protection for LP-Gas storage containers and installations, and requires coordinating control measures with local emergency response agencies through an analysis of local conditions. NFPA 58 further stipulates that propane installations with an aggregate water capacity of more than 4,000 gallons of LP-Gas develop a written Product Release Prevention and Incident Preparedness Review. Prior to the 2004 edition of NFPA 58, this requirement was referred to as a Fire Safety Analysis (FSA).



Key points of the facility Incident Prevention Review include the following:

- The written review shall be submitted by the bulk plant owner, operator or designee to the authority having jurisdiction (AHJ) and local emergency responders.
- The Review shall be updated if the capacity of the bulk plant is increased or the installation is substantially reconfigured.
- The review shall be an evaluation of the total product control system. This shall include emergency shutoffs and internal valves equipped for remote closure and automatic shut-off using thermal actuated devices.

Items that should be considered as part of a facility-specific Incident Prevention Review include the following:

- Product control measures.
- Exposure hazards within the LP-Gas facility.
- External exposure hazards outside of the LP-Gas facility, including neighboring properties that present high life safety challenges.
- Capabilities of the local fire department
- Water supply requirements, including the availability, adequacy and reliability of the local water supply.

If the Incident Prevention Review determines that the hazard to adjacent structures and exposures exceeds the provisions provided under NFPA 58, special protection measures may be required. Special protection measures address flame impingement on a container that, in a worst-case scenario, could lead to a container failure. These include both passive and active measures.

The selection of special protection measures should be based upon an assessment of the facility and the overall risks. Special protection measures may be applied alone or in combination with other measures, and include the following:

- Applied insulating coatings. The selection of any insulation system must also consider the effects of weathering and the actions of hose streams upon the coating.

- Mounding. A mounded tank can be above or partially buried below the ground surface, but it must be completely covered by at least 1 ft. of earth, sand or other noncombustible, noncorrosive material.
- Burial. The tank(s) may be completely buried underground. In this case, there are additional requirements to ensure that the tank(s) are properly coated and provided with cathodic protection to address underground corrosion issues.
- Fixed water spray systems. When utilized, these shall have the capability for both automatic and manual actuation. Water spray systems shall comply with the requirements of NFPA 15—*Standard for Water Spray Fixed Systems for Fire Protection*.
- Fixed monitor nozzles that have the capability to apply water on all container surfaces that can be exposed to fire. Monitors shall comply with NFPA 15—*Standard for Water Spray Fixed Systems for Fire Protection*.
- Any other means that may be listed for this purpose. This includes redundant fail-safe product control measures (RFPCM), such as vehicle pull away protection, automatic shut-down system for all primary valves, installation of additional isolation valves on liquid and vapor openings, use of backflow check valves, and remote shutdown capability with stations within 15 ft. of the transfer point and 25 to 100 ft. away from the transfer point,

Propane industry representatives and marketers can receive additional information on how to meet the NFPA 58 requirements by acquiring a copy of the *Fire Safety Analysis Manual* jointly developed through the Propane Education and Research Council (PERC), the National Propane Gas Association (NPGA), and NFPA. A PDF-file of the *Fire Safety Analysis Manual* can be downloaded at the NPGA website at [www.npga.org](http://www.npga.org). Follow the links to “Publications” and “Fire Safety Analysis Manual.” Hard copies of the FSA Manual are also available for purchase.

## UNLOADING STATIONS

During peak seasons, propane may be delivered to a bulk plant several times each week, or even daily. Plant deliveries can be made at any time of day or night. Although some larger bulk plants may receive shipments by pipeline, the majority of bulk plant deliveries are normally made by propane transport cargo tank trucks or by railroad tank cars when the plant has a rail siding.

### TRUCK UNLOADING STATIONS

Bulk transport cargo tank trucks deliver propane at special designated unloading stations at the bulk plant. These unloading stations are called bulkheads or truck risers. The bulkhead is basically a small wall or rack built from reinforced concrete or steel. Each bulkhead has at least one vapor connection and one liquid connection. These connections are attached directly to vapor and liquid piping at the bulk plant. Piping is designed with a break-away feature to prevent valve breakage in the event of a truck pulling away with the hoses connected. In addition, the piping is equipped with the necessary check-valves, isolation valves and excess flow valves as required by state codes for the size and location of the facility.

The transport cargo tank truck parks next to the bulkhead when making a delivery to the bulk plant. Most transports carry special hoses for transferring propane, which the driver connects between the vapor and liquid connections of the transport tank truck and the bulkhead. See Figure 6-8.

Propane transport cargo tank trucks are unloaded using a power take-off (PTO) or hydraulically-driven liquid pump that is permanently mounted on the vehicle or trailer. Modern transport pumps can transfer as much as 300 gpm of liquid propane. Occasionally, bulk plant pumps or compressors may be used for the unloading operation. It should be noted that many transports operating in the western U.S. are equipped with compressors for unloading.

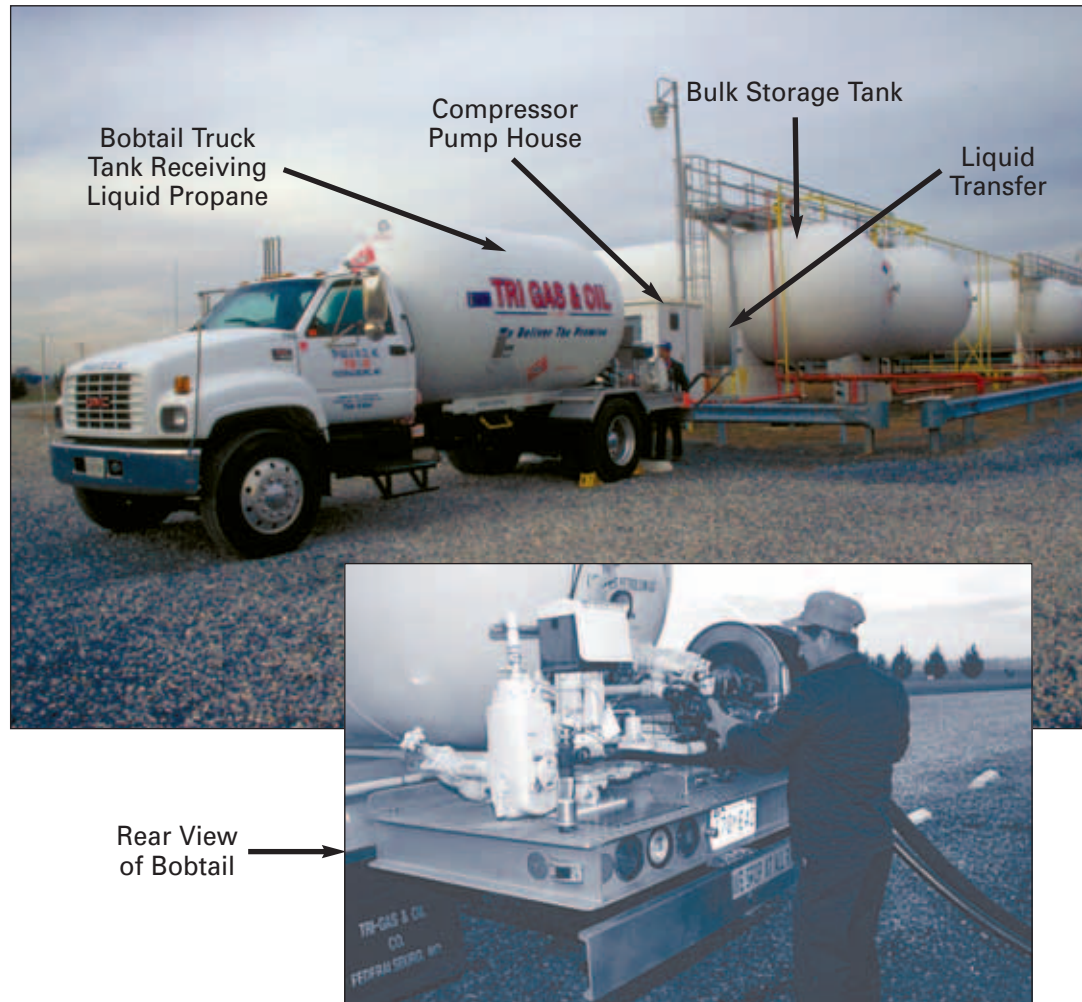


FIGURE 6-8 Bulk storage plant truck unloading station.

## RAIL UNLOADING STATIONS

Railroad tank car unloading stations are located on a railroad siding next to the plant. The siding is a small section of track off the main railway. The tank car is positioned next to a special unloading station called a tank car riser. The tank car riser has a ladder and a platform that provides access to the manway on the tank car. In addition, the tank car riser has liquid and vapor hose connections that are attached to the plant piping. Emergency shut-off valves are installed at the tank car



end of the liquid and vapor transfer hoses or connections where product flows in and out of the tank car. See Figure 6-9.

Unlike propane transport vehicles, tank cars do not have their own pumps. Instead, bulk plant equipment is used to unload the tank car. Although a pump is sometimes used, most bulk plants use a compressor for unloading tank cars. A compressor takes propane vapor from the bulk plant tank and forces it into the vapor space of the tank car. The vapor coming into the railroad tank car pushes propane liquid out of the tank car liquid valves and into the plant liquid piping.

An important benefit of the compressor over the pump is vapor recovery. When all liquid has been unloaded, the tank car is still filled with a large quantity of propane vapor. By switching one or more valves in a piping manifold, the compressor can recover this vapor and return it to the bulk plant tank. This vapor then condenses into several hundred gallons of propane liquid.

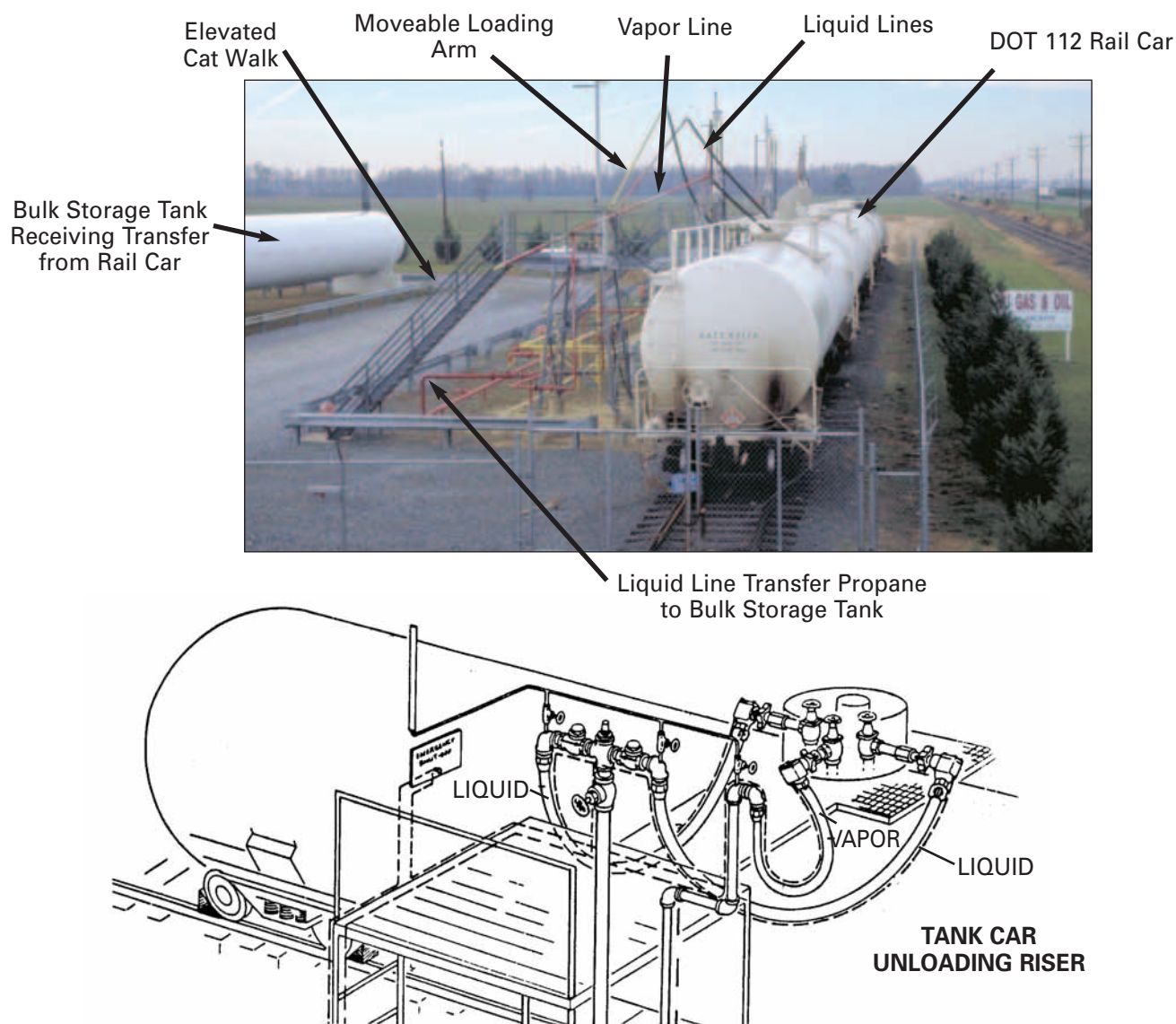


FIGURE 6-9 Bulk storage plant rail unloading station.



## DELIVERY SYSTEMS

An operational objective of a propane bulk plant is the delivery system to supply propane to customers. Propane can be delivered in bobtail cargo tank trucks to stationary customer tanks and cylinders. Customers may also use DOT/ICC portable or exchange cylinders. These cylinders are filled at the bulk plant and then delivered to the customer in cylinder delivery trucks. When a delivery is made, empty cylinders are picked up and returned to the bulk plant. Depending on the size of the bulk plant, a propane marketer may offer both bulk and cylinder delivery.

### BULK PROPANE DELIVERY SYSTEMS

The bulk propane delivery cargo tank truck or bobtail is the workhorse of most bulk plants. More propane is delivered to customers in bobtails than any other method or container. Bobtails can then be used to fill ASME tanks, stationary DOT/ICC cylinders and forklift cylinders at the customer's site. See Figure 6-10.

The MC-330/331 cargo tank is mounted directly on a vehicle chassis behind the truck cab. The structural integrity of the tank is not dependent upon the truck chassis for support. The typical bobtail has a water capacity between 750 and 6,000 gallons. Design and construction features of bobtail cargo tanks are discussed in detail in Section 5. In terms of propane distribution, bobtails have the necessary equipment for transferring propane to customer tanks and cylinders, including a pump, a liquid meter that measures the gallons of propane delivered, and special delivery hoses.



**FIGURE 6-10** The bobtail truck is the primary method of delivering propane to customers.

### BOBTAIL LOADING STATIONS

The bobtail must be filled at the bulk plant before delivering fuel to customers. Depending on the number of customers to be serviced by a bobtail, it may be filled and emptied as many as four times each day. See Figure 6-11. Most bulk plants have separate bobtail filling stations to ensure that the bobtails are filled quickly and safely. These stations are called loading bulkheads or truck risers. This bulkhead is almost identical to those used for unloading transports, except that propane is transferred through the bulkhead hoses and into the bobtail cargo tank.

A stationary bulk plant pump is generally used to fill bobtails. The pumps usually have a very high flow capacity, and many plant pumps can transfer as much as 300 gpm of liquid propane. Some bulk plants also use a special liquid meter when filling bobtails. The meter keeps track of the thousands of gallons of propane that pass through the plant each day.

After the bobtail is filled, the driver can then make propane deliveries at multiple customer locations. Filling a customer tank from a bobtail is similar to filling a bulk plant tank from a transport. Like the transport, the bobtail has all the equipment needed to transfer propane liquid into the customer tank or cylinder. The same precautions that are followed in unloading transports are generally followed in loading the bobtail.



**FIGURE 6-11** Bobtail loading station.

## CYLINDER FILLING STATIONS

Many bulk plants have separate equipment for filling cylinders. This equipment is usually located in a cylinder filling station or dock. The cylinder filling station usually has a concrete dock for loading and unloading cylinders on delivery vehicles. In many plants, the dock is covered by a roof and enclosed on three sides. The cylinder filling station is often large enough to store many cylinders and enclose the equipment to fill cylinders. See Figure 6-12.

Bulk plants involved in cylinder filling generally use a separate pump for this purpose. These cylinder pumps usually have a very low pumping capacity. Unlike the large pumps used to load bobtails, cylinder pumps transfer only 10 to 15 gpm of liquid propane.

Most stationary customer tanks, bobtail tanks, and bulk plant tanks are filled by volume. This means the tank is filled to a certain percentage of the overall water capacity of the tank. A fixed maximum liquid level gauge tells the bobtail driver or plant operator when the maximum filling level has been reached.

Portable and exchange cylinders are usually filled by weight. Before a cylinder is filled, a platform or beam scale is set at the weight of the cylinder when it is empty

(called tare weight) plus the weight of the filling valve and hose, and the maximum amount of propane liquid that can be put into the cylinder. Once the scale is set, the cylinder is placed on the scale. A liquid hose is then connected to the service valve on the cylinder. When the scale reaches the preset weight, the operator shuts a valve on the end of the hose, turns off the pump, and closes the cylinder valve. Many cylinder filling stations have special devices that automatically stop the filling operation when the scale reaches the preset weight. Exchange cylinders can weigh as much as 200 pounds when they are full and require cylinder handtrucks to move them.

Three types of cylinders are usually filled at cylinder filling stations: portable cylinders, exchange cylinders and forklift cylinders. Portable cylinders are usually brought by the customer to the cylinder filling station. Exchange and forklift cylinders are loaded onto cylinder delivery vehicles and then delivered directly to the customer.



**FIGURE 6-12** Cylinder filling station.

### OTHER SUPPORT BUILDINGS AND TANKS

Although every bulk plant is different, the bulk plant design and operations discussed in this section are typical of many marketer bulk plants. However, you should be aware that most propane marketers do not limit their customer services to storing and delivering propane. Many marketers sell, install, and service LP-Gas or electric appliances such as stoves, washer/dryers, gas grills, etc. Very often, a bulk plant may also have an appliance warehouse and showroom.

Some propane marketers also have other business lines located on the same site as the bulk plant. The facility may store and distribute other types of hazardous materials such as home heating oil, kerosene (K-1 and K-2), diesel fuel, and gasoline. Other marketers also sell farm products to agricultural customers, such as fertilizer and seed, and may have agricultural chemicals in showrooms or warehouses.



Finally, every bulk plant must have an administrative staff to coordinate all activities in the plant. The staff is normally located in the plant office building and can house dispatchers, bookkeepers, truck drivers, and administrative staff.

Regardless of the size of the bulk plant, emergency responders should become familiar with the general layout of the facility and know the location and hazards of the different types of hazardous materials that may be onsite. Most plant owners and operators welcome the opportunity to work with local fire departments on emergency planning and response issues, including plant familiarization tours and pre-incident planning. The information contained in this section will provide good background information for emergency responders before conducting an onsite tour.

## SUMMARY

A bulk plant is primarily a propane storage and distribution facility with at least 2,000 gallons of storage capacity. LP-Gas may be received by cargo tank truck, railroad tank car or pipeline, and then distributed to the end user by portable container delivery, by cargo tank truck, or through gas piping. Bulk plants have several common features, including: 1) bulk storage tanks; 2) unloading stations; and 3) filling stations.

Bulk storage tanks found in bulk plants are constructed to American Society of Mechanical Engineers (ASME) standards. Storage tanks range in size from 6,000 to 90,000 gallons but may be as large as 120,000 gallons. Several tanks of various sizes may be installed at a bulk plant. Small propane marketers may have only one or two 18,000 gallon tanks.

Bulk transport vehicles deliver propane at special designated unloading stations at the bulk plant. Most propane transport trailers are unloaded by a power take-off (PTO) or hydraulically powered liquid pump that is permanently mounted on the cargo tank truck or transport trailer.

Railroad tank car unloading stations are located on a railroad siding next to the plant. The siding is a small section of track off the main railway. The tank car is positioned next to a unloading station called a tank car riser.







# GENERAL EMERGENCY RESPONSE PROCEDURES

OBJECTIVES

- 1. Describe the importance of the Incident Command System (ICS) and the National Incident Management System (NIMS) as a tool for safely handling propane emergencies.
- 2. Define the terms strategy and tactics.
- 3. Describe the three operational modes of strategy and tactics for managing a propane emergency.
- 4. Describe the Eight Step Process® and its application as a tactical incident management tool for managing on-scene operations at a propane incident.
- 5. Describe the critical success factors in managing the first hour of a propane incident.

ABBREVIATIONS AND ACRONYMS

|       |                                                    |
|-------|----------------------------------------------------|
| Decon | Decontamination                                    |
| EOC   | Emergency Operations Center                        |
| HMRT  | Hazardous Materials Response Team                  |
| IC    | Incident Commander                                 |
| IAP   | Incident Action Plan                               |
| ICP   | Incident Command Post                              |
| ICS   | Incident Command System                            |
| NGO   | Nongovernmental Organizations                      |
| NIMS  | National Incident Management System                |
| OSHA  | U.S. Occupational Safety and Health Administration |
| PERO  | Post-Emergency Response Operations                 |
| PPA   | Public Protective Actions                          |
| SCBA  | Self-Contained Breathing Apparatus                 |
| SOP   | Standard Operating Procedure                       |

NATIONAL INCIDENT MANAGEMENT SYSTEM (NIMS)

This section will introduce emergency responders and propane marketers to the National Incident Management System (NIMS), and will discuss the basic principles of strategy and tactics as applied to propane emergency response. We will also present the Eight Step Process® as a basic tactical decision-making framework for managing propane emergencies. The information in this section will provide the foundation for understanding the material in Section 8, where we will discuss specific tactical issues and provide examples of different emergency scenarios involving various types of non-bulk and bulk propane containers.

Most propane related emergencies involve small cylinders and non-bulk containers. The majority of these incidents are handled safely and successfully by the local fire department with some technical assistance from the local propane marketer. However, larger scale emergencies such as cargo tank truck rollovers, train derailments, or fires involving large stationary tanks or bulk plants may require resources from a number of different agencies to resolve the problem. For example, a simple tank truck rollover involving a fully loaded MC-331 may involve the fire department, emergency medical services, law enforcement agencies, the state highway department, wrecker contractors, as well as propane and cargo tank specialists representing owners and operators.

Major propane incidents require coordination of information and resources among the various players in order to safely and efficiently resolve the situation. The National Incident Management System is an important tool and is the national benchmark for organizing roles and responsibilities at any emergency. Understanding how both NIMS and the incident command system (ICS) works is important for propane industry and public safety personnel from both a regulatory compliance and an operational point of view. OSHA 29 CFR 1910.120(q) requires that an incident management system be used for all hazardous materials emergencies, such as a propane incident. In addition, *Homeland Security Presidential Directive (HSPD) 5—Management of Domestic Incidents and a National Incident Management System* (February 28, 2003) directed the Secretary of Homeland Security to develop and administer a National Incident Management System that would provide a consistent nationwide template to enable all government, private sector, and nongovernmental organizations (NGOs) to work together during domestic incidents.

But beyond regulatory requirements, experience shows that using NIMS and ICS results in a safer incident scene. This is especially the case involving large-scale incidents where large numbers of personnel and equipment are working around hazardous conditions.

ICS is an organized system of roles, responsibilities, and procedures for the command and control of emergency operations. It is a procedure-driven system based upon the same business and organizational management principles that govern industrial organizations on a daily basis. As is the case with the day-to-day management of a corporation, ICS has both technical and “political” aspects that must be understood by the key players in the emergency response system.



**FIGURE 7-1** Major propane incidents will require coordination between various public safety and propane industry personnel.

In the past, these players were primarily concerned with the technical or operational aspects of an emergency. Today, however, the playing field has changed significantly. Large-scale incidents have very real political, legal, and financial effects on how both the public and the corporate shareholders view the company. Recent incidents at industrial facilities have taught us that an emergency can have a favorable technical or operational outcome and still be a public affairs or political disaster for both the facility owner and the local fire department.

## ICS ELEMENTS

ICS has seven common features which permit different organizations to work together safely and effectively in order to bring about a favorable outcome to the emergency. ICS is predicated on basic management concepts, including the following:

- **Common Terminology**—Everyone working at the emergency scene should understand and use common terminology for the roles of the key players (e.g., Incident Commander, Safety Officer, etc.). The exact titles used must be pre-determined in the local ICS Standard Operating Procedure and should be consistent with the NIMS guidance. Propane marketers should be familiar with the ICS Standard Operating Procedures used by emergency response organizations which serve their customers' jurisdictions.
- **Modular Organization**—ICS is a top-down driven organizational structure where one person is in charge of the overall emergency. In many political jurisdictions, this individual may be designated by state, county, or municipal laws or ordinances. At the emergency scene, the Incident Commander creates an organizational chart (either in his or her head or on a worksheet) and assigns personnel to perform specific response functions, such as Operations, Logistics, Safety, etc.
- **Predesignated Incident Facilities**—On small incidents, the Incident Commander runs the operation from the field near the scene of the emergency at an Incident Command Post (ICP). Representatives from the various agencies at the scene coordinate all of their activity through the ICP. On major incidents, an Emergency Operations Center (EOC) may also be activated away from the incident scene where issues like community, government, legal, and political affairs are managed.
- **Integrated Communications**—When more than one agency or organization responds to a major emergency, they usually have their own radios and cellular telephones with them. Quite often, these radios are on different frequencies. It is important that the Incident Commander be able to communicate with all on-scene response and supporting organizations. If radio interoperability is not possible, each agency should have one representative with a radio to operate at the ICP. That way, nobody is out of the loop.
- **Unified Command Structure**—Major incidents involving more than one government jurisdiction or organization will require a Unified Command structure. Unified Command simply means that the key agencies that have statutory or jurisdictional responsibility jointly contribute to the process of managing the problem. Although significant decisions are typically made jointly, unified command is NOT management by committee. There will always be a lead agency that has 51% of the vote as compared to the other players.
- **Consolidated Plan of Action**—Every incident needs some form of an Incident Action Plan (IAP). When multiple agencies or organizations are

involved at an incident, it is important that they all agree on a coordinated IAP for resolving the incident. Organizations may have different missions, charters, and agendas and it is the Incident Commander's job to make sure that everyone is in agreement concerning how the incident will be resolved, especially when life safety is involved.

- **Comprehensive Resource Management**—Major incidents can bring a large number of resources to the scene. Resources can include people, equipment, and supplies. It is important that all of these resources be coordinated and brought to bear on the problem. Resources that could have been used to resolve the incident sometimes sit idle because the people that needed them did not even know they were available. The concept of Comprehensive Resource Management is simply the process of: (1) identifying necessary resources; (2) acquiring these resources; and (3) ensuring they are deployed in an efficient manner. A needed resource is used without regard to which agency or organization owns it.

Most emergency responders already have a good working knowledge of ICS and NIMS, and have some form of ICS implemented in their jurisdiction. However, propane industry representatives who may be called to the scene of an emergency to provide technical product or container assistance may not be familiar with the major elements of NIMS and ICS, how they work, and how the propane representative will fit into the system. Depending upon the scenario and the capabilities of local responders, propane product or container specialists may function in one of the following positions within the ICS organization:

- Interface with the Liaison Officer as a on-scene liaison from the propane industry
- Function as a Technical Specialist reporting directly to the Incident Commander or Operations Section Chief.
- Function as a Technical Specialist reporting to the HazMat Group Supervisor. This reporting relationship is likely to occur when a public safety Hazardous Materials Response Team (HMRT) is on-scene.
- Function as the HazMat Group Supervisor and report to the Operations Section Chief. This reporting relationship may occur when there is no HMRT or Hazardous Materials Technician capability readily available.

Additional information on NIMS can be referenced at [www.fema.gov/nims](http://www.fema.gov/nims). Propane industry personnel who are involved in emergency response should complete the web-based IS100 Introduction to Incident Command and IS700 NIMS: An Introduction courses. These awareness level courses explain the NIMS components, concepts and principles, and can be accessed at [www.training.fema.gov/EMIWeb/IS/](http://www.training.fema.gov/EMIWeb/IS/).

## STRATEGY AND TACTICAL DECISION-MAKING

### STRATEGY

The terms strategy and tactics are sometimes used interchangeably, but they actually have very different meanings. A strategy is a plan for managing the incident. It becomes the Incident Commander's (IC) overall goal or game plan to control the incident. Like most goals, a strategy is usually very broad in nature and is selected



at the Command level. Several strategic goals may be pursued simultaneously during an incident. Examples of common strategic goals implemented at propane incidents include the following:

- **Rescue**—Finding disoriented, trapped or injured people and removing them to a safer area.
- **Public Protective Actions (PPA)**—Protecting the general public by sheltering-in-place, evacuation, or a combination of both tactics.
- **Spill Control (Confinement)**—A defensive strategy to keep a released material within a defined or specific area.
- **Leak Control (Containment)**—An offensive strategy to control a release at its source.
- **Fire Control**—Confining, controlling, and sometimes extinguishing the fire.
- **Recovery**—Recovering the hazardous material and/or its container for clean-up, recycling or disposal.

In contrast, tactics are the specific objectives the IC uses to achieve strategic goals. Tactics are normally decided at the Operations Section or group/division levels in the command structure.

If the IC hopes to have strategic goals understood and implemented, they must be packaged and communicated in simple terms. If strategic goals are unclear, tactical objectives will become equally confusing. Strategic goals and tactical objectives can be implemented from three distinct operational modes as outlined below. Criteria for evaluating and selecting operational modes include the level of available resources (e.g., personnel and equipment), the level of training and capabilities of both emergency responders and propane product or container specialists, and the potential harm created by the propane incident.

**Offensive Mode**—Offensive-mode operations commits the IC's resources to aggressive leak and fire control objectives. An offensive strategic goal/tactical objective is achieved by implementing specific types of offensive operations that are designed to quickly control or mitigate the problem. Although offensive operations can increase the risk to emergency responders, they may be justified if rescue operations can be quickly achieved, if the leak can be rapidly confined or contained, or if the fire can be quickly extinguished.

**Defensive Mode**—Defensive-mode operations commits the IC's resources (people, equipment, and supplies) to less aggressive objectives. A defensive strategic goal/tactical objective is achieved by using specific types of defensive tactics. As a general rule, defensive operations expose responders to less risk than offensive operations.

**Non-intervention Mode**—Non-intervention means taking no action other than isolating the area. The basic plan calls for emergency responders to wait out the sequence of events underway until the incident has run its course and the risks of intervention have been reduced to an acceptable level (for example, waiting for a propane container to burn off). This strategy usually produces the best outcome when the IC determines that implementing offensive or defensive strategic goals/tactical objectives will place emergency responders at an unacceptable risk. In other words, the potential costs of action far exceed any benefits.

In some situations, the nonintervention mode may be implemented until sufficient resources arrive on-scene and an offensive attack can be implemented.

Defensive tactics are always preferable over offensive tactics if they can accomplish the same objectives in a timely manner.



Leonard Deonarine

**FIGURE 7-2** Incident involving a propane pipeline that was struck during excavation operations. Firefighters initiated non-intervention operations given the remote location of the incident and the need to shutdown the pipeline.

## TACTICS

Tactical decision-making is about whether to use one tactic over another. Most hazmat incidents cannot be resolved using just one tactic. Effective tactical decision-making requires thinking ahead and planning various tactical options so that the right people with the right training and the right equipment are available at the appropriate time.

A well-defined tactic has a stated objective that can be implemented using specific tasks and procedures within a reasonable period of time. The tactical action plan must be easy to understand and laid out with straightforward objectives. When deciding which tactic to use, consideration should be given as to how long it will take to accomplish the specific objective. Conditions can change rapidly as the incident progresses along a natural timeline. What seemed like a good tactic early in the incident may no longer be an option as conditions change. Leaks can grow larger and fires can get worse as emergency responders gather their equipment and prepare to attack the problem.

The length of time required to implement tactical objectives at the task level must be compared to how long the “window of opportunity” will be open. As the clock ticks, tactical options to deal with the problem will often become more limited. Remember, all hazmat incidents follow a natural timeline. Propane incidents sometimes get worse before the situation gets better.

Some tactics can be employed to delay events or slow down the clock until entry teams are ready to implement the “final solution.” In other words, responders may buy time with less effective, but easy to implement, tactics until the most effective tactic can be implemented. Cooling containers with hoselines and master streams, using fog nozzles to control vapors, and flaring containers to reduce internal pressure are examples of this type of tactic.

**FIGURE 7-3** Fire control operations.

## TACTICAL DECISION-MAKING FRAMEWORK

Emergencies are handled safely and effectively when the responders are dependent on a predetermined and approved system for managing the emergency. Much like a football team which plays by a set of rules and executes plays on game day using the quarterback's playbook, the Incident Commander and emergency responders will be more effective when they are not dependent on one person to tell them what to do during every step of the operation. Once the Incident Commander commits to a general strategy (offensive, defensive, or nonintervention) emergency responders must be able to implement the IC's game plan without a great deal of direct supervision.

The Eight Step Process® is a widely used general Standard Operating Procedure (SOP) that has been adopted by many public safety and industrial Emergency Response Teams for managing hazardous materials emergencies. The procedure outlined below can serve as a general framework for systematically resolving a propane emergency. However, it will be most effective when it is adopted and incorporated into a local Emergency Response Plan, SOP or training program. Like the adoption of NIMS, understanding and implementing the fundamental concepts is more important than adopting the exact terminology as long as terms are consistent.

The basic order of the tactical decision-making process should include:

1. Site Management and Control
2. Identify the Problem
3. Evaluate the Hazards and Risks
4. Select the Proper Protective Clothing
5. Develop Plan of Action and Coordinate Resources
6. Implement Response Objectives
7. Decontamination and Clean-up Operations
8. Terminate the Emergency

A model tactical procedure for managing propane emergencies based on the Eight Step Process® is provided as a general guideline for preparing a local Standard Operating Procedure. The information is referenced from the textbook, *Hazardous Materials: Managing the Incident*, (3rd edition).

**NOTE:** For more information on the Eight Step Process®, consult Chapters 4 through 12 in the textbook *Hazardous Materials: Managing the Incident*, (3rd edition) (Oklahoma State University Fire Protection Publications, Stillwater, OK, 2005; available from Fire Protection Publications at 800-654-4055 or Red Hat Publishing at 800-603-7700).

## TACTICAL PROCEDURE BASED ON THE EIGHT STEP PROCESS®

### STEP 1: SITE MANAGEMENT AND CONTROL

**FUNCTION:** Site management and control is managing and securing the physical layout of the incident. Reality is that you cannot safely and effectively manage the incident if you do not have control of the scene. As a result, site management and control is a critical benchmark in the overall success of the response and is the foundation upon which all subsequent response functions and tactics are built.

**GOAL:** To establish the playing field so that all subsequent response operations can be implemented both safely and effectively.

#### CHECKLIST:

- ☐ During the approach to the incident scene, avoid committing or positioning personnel and units in a hazardous position. Assess the situation and consider having an escape route out of the area if conditions should suddenly deteriorate. Remember the basics—uphill and upwind.

**CAUTION:** Emergency responders must be aware that certain chemical releases may travel throughout the scene and impact response routes. In addition, LP-Gas and some other chemicals (e.g., anhydrous ammonia) may be mistaken for fog or other normal weather and environmental conditions. The danger area may extend beyond the visible vapor cloud.

- ☐ Establish command of the incident in accordance with the jurisdiction's Incident Management System procedure and establish an Incident Command Post. If other public safety units are already on-scene, ensure operations are coordinated and unified.
- ☐ Establish a Staging Area (Level I, II) for additional responding equipment and personnel.
- ☐ Establish an isolation perimeter (i.e., outer perimeter) to isolate the area and deny entry. Establish access control—restrict emergency site access to authorized essential personnel; all non-essential personnel should be isolated from the problem. Isolation perimeters should include land, water and air areas.



- ❑ Establish a hot zone or inner perimeter as the “playing field.” The location of the inner hot zone should be identified and communicated to all personnel operating on the site. Methods of identifying the restricted area would include visible landmarks, barricade tape, traffic cones, etc.
- ❑ Positive-pressure self-contained breathing apparatus (SCBA) and full protective clothing are required for personnel entering the hot zone. Rescue operations should follow the “two in two out” guideline.
- ❑ If civilians are injured or are casualties and personal contamination is suspected, isolate all personnel until emergency decon can be established.
- ❑ Initiate public protective actions (PPA).

#### **STREET SMART TIPS:**

- ❑ Site Management establishes the playing field for the players (responders) and the spectators (everyone else).
- ❑ The initial 10 minutes of the incident will determine operations for the next 60 minutes, and the first 60 minutes will determine operations for the first 8 hours.
- ❑ Don’t try to control more real estate than you can effectively isolate and control.
- ❑ Remember the basics. The more time, distance and shielding between you and the material, the lower the risk will be.
- ❑ Large releases of propane may travel great distances, find ignition sources and flash back to the source of the leak. During approach to the incident scene, avoid positioning personnel and vehicles in a hazardous position or location.
- ❑ Designate an emergency evacuation signal and identify rally points if emergency evacuation is necessary.
- ❑ Remember the *First Law of Hot Zone Operations* when dealing with propane and other hazardous materials: To play in the game you must:
  - Be trained to play
  - Be dressed to play
  - Have a buddy system with back-up personnel (minimum of 2 in/2 out)
  - Have decon established, as appropriate
  - Coordinate with Command and Safety

#### **STEP 2: IDENTIFY THE PROBLEM**

**FUNCTION:** Identify the scope and nature of the problem. This includes:

- Recognition, identification, and verification of the hazardous materials involved in the incident;
- Type of container, as appropriate; and
- Exposures.



Methods of identification include analyzing container shapes, markings, labels and placards, and facility documents (e.g., Material Safety Data Sheets or MSDS); using monitoring and detection equipment; and identifying by the senses (i.e., physical observations, smell, reports from victims and facility representatives, etc.). Responders should remember that even when the hazardous substances involved have been identified, the information should always be verified.

**GOAL:** To identify the scope and nature of the problem, including the type and nature of hazardous materials involved as appropriate.

**CHECKLIST:**

- ☐ Survey the incident—identify the nature and severity of the immediate problem, including the recognition, identification and verification of the material(s) involved, type of LP-Gas or other container involved, and any potential or existing life hazards. If multiple problems exist, prioritize them and make independent assignments.
- ☐ Clues for determining if LP-Gas is involved include:
  - Occupancy and location
  - Container shapes
  - Markings and colors
  - Placards and labels
  - Shipping papers or facility documents
  - Monitoring and detection equipment
  - Senses, including physical observations, smell, etc.
- ☐ Factors to consider in assessing the type of container involved include:
  - Bulk vs. non-bulk
  - Pressurized vs. non-pressurized
  - Number of compartments
  - Material(s) of construction
  - Pressure relief devices
- ☐ Conduct offensive or defensive reconnaissance, as necessary, to gather intel on the situation.

**STREET SMART TIPS:**

- ☐ What is the scope and nature of the problem? Considerations should include:
  - Is the problem a vapor release or a liquid release?
  - What is the source of the stress and container breach? Open valve, piping failure, container breach?
  - Fire or no fire scenario?
  - Is fire impinging upon the vapor space?
- ☐ A problem well-defined is half-solved. Assume that initial information may not be correct. Always verify your initial information. Verify—verify—verify.

- ☐ Conduct recon operations, as necessary.
  - *Defensive Recon.* Objective is to obtain information on site layout, weapon condition, physical hazards, access, and other related conditions from beyond the inner perimeter. This is normally obtained through threat assessments, interviews, physical observations, etc.
  - *Offensive Recon.* Objective is to obtain intel and incident information by physically entering the inner perimeter.
- ☐ Never permit responders to perform activities such as leak control inside areas where unignited propane has accumulated. Verify vapor concentrations with flammable gas detection and monitoring equipment.
- ☐ Be alert for the presence of improvised explosive devices (IED) and secondary events. IED clues can include:
  - Abandoned container out of place for the surroundings
  - Obvious explosive device components, such as batteries, timers, blasting caps, charges, etc.
  - Partially exploded devices found
  - Unusual or foreign devices attached to hazmat containers, especially liquefied and compressed gas cylinders, flammable liquid containers, bulk storage tanks and vessels, etc.
  - Unattended vehicles not appropriate to the immediate environment

### STEP 3: HAZARD AND RISK EVALUATION

**FUNCTION:** This is THE most critical function that emergency response personnel perform. The primary objective of the risk evaluation process is to determine whether or not responders should intervene, and what strategical objectives and tactical options should be pursued to control the problem at hand. You can't get this wrong. If you lack the expertise to do this function adequately, get help from someone who can provide that assistance, such as local HMRTs and propane product/container specialists.

**GOAL:** To assess the hazards present, evaluate the level of risk, and establish an Incident Action Plan (IAP) to make the problem go away.

#### CHECKLIST:

- ☐ Assess the hazards posed by the problem (health, physical, chemical, weapons, other). Pay particular attention to the unique properties of propane, including its flammable range (2.15% to 9.6%) and its vapor density (1.5).
- ☐ Collect, prioritize and manage hazard data and information from all sources, as appropriate, including:
  - Technical reference manuals
  - Technical information sources
  - Hazmat databases
  - Technical information specialists, such as product and container specialists

- MSDS
  - Monitoring and Detection Equipment
- ❑ Primary Technical Information Centers available to public safety personnel include:
- CHEMTREC—(800) 924-9300
  - National Response Center (NRC) serves as the federal single point-of-contact for accessing federal assistance
  - State single point-of-contact
  - LP-Gas product or container specialists, including local propane marketing and distribution representatives
- ❑ Air monitoring and the *General Hazmat Behavior Model* are critical in implementing a “risk-based response.” Understand the relationship between the container and the hazmat(s) involved.
- Stress
  - Breach
  - Release
  - Engulf
  - Impingement
  - Harm
- ❑ If fire is involved, how long has the fire been burning? If there fire impingement upon any containers? Is an adequate, sustained and reliable water supply available?
- ❑ Based upon the risk evaluation process, develop your IAP. Determine whether the incident should be handled offensively, defensively, or by non-intervention. Remember that offensive tactics increase the risks to emergency responders.
- **Offensive Tactics**—Require responders to control/mitigate the emergency from within/inside the area of high risk. In a fire situation, this will include the ability to provide a reliable and sustained water supply.
  - **Defensive Tactics**—Permits responders to control/mitigate the emergency remote from the area of highest risk.
  - **Non-Intervention Tactics**—Pursuing a passive attack posture until the arrival of additional personnel or equipment, or allowing the fire to completely burn itself out.

| STRATEGY                  | OFFENSIVE | DEFENSIVE | NON-INTERVENTION |
|---------------------------|-----------|-----------|------------------|
| Rescue                    | X         |           |                  |
| Public Protective Actions | X         | X         | X                |
| Spill Control             | X         | X         |                  |
| Leak Control              | X         |           |                  |
| Fire Control              | X         | X         |                  |
| Clean-up and Recovery     | X         | X         |                  |

**STREET SMART TIPS:**

- ❑ Focus on those things that you can change and that will make a positive difference to the outcome.
- ❑ Every incident will arrive at some outcome...with or without your help. If you can't change the outcome, why get involved?
- ❑ There's nothing wrong with taking a risk. If there is much to be gained, there is much to be risked. If there is little to be gained, then little should be risked.
- ❑ Public safety personnel should view their roles as that of risk evaluators, rather than risk takers where hazardous materials are involved. Bad risk takers get buried; effective risk evaluators come home.
- ❑ Hour One Priorities within the IAP are:
  - Establish Site Management and Control
  - Determine the materials/agents involved
  - Ensure the safety of all personnel from ALL hazards
  - Ensure that PPE is appropriate for the hazards
  - Initiate tactical objectives to accomplish initial rescue, decon, medical, and public protective action needs
  - If criminal activities are involved (e.g., terrorism incidents), maintain the integrity of potential evidence

**STEP 4: SELECT PERSONAL PROTECTIVE CLOTHING AND EQUIPMENT**

**FUNCTION:** Based upon the results of the hazard and risk assessment process, emergency response personnel will select the proper level of personal protective clothing and equipment. Structural firefighting protective clothing is adequate for LP-Gas fires and releases, but if additional hazardous materials are involved (e.g., poison liquids or gases, corrosive liquids), chemical splash or vapor protective clothing may be required.

**GOAL:** To ensure that all emergency response personnel have the appropriate level of personal protective clothing and equipment for the expected tasks.

**CHECKLIST:**

- ❑ The selection of personal protective clothing will depend upon the hazards and properties of the materials involved, and the response objectives to be implemented (i.e., offensive, defensive or non-intervention). In evaluating the use of specialized protective clothing, the following factors must be considered:
  - The hazard to be encountered, including the specific tasks to be performed
  - The tasks to be performed (e.g., entry, decon, support)
  - The level and type of specialized protective clothing to be utilized
  - The capabilities of the individual(s) who will use the PPE in a hostile envi-

ronment. Remember—fighting a large propane fire can place great deal of both physiological and psychological stress on an individual.

- ❑ The following levels of personal protective clothing are typically utilized by emergency responders at hazmat incidents, as appropriate:
  - **Structural Firefighting Clothing**—Includes helmet, fire retardant hood, turnout coat and pants, personal alert safety system (PASS device), and gloves. Positive-pressure, SCBA should be considered the minimum level of respiratory protection.
  - **Chemical Vapor Protective Clothing**—Specialized chemical protective clothing, which when used in conjunction with air supplied respiratory protection devices offers a sealed, integral level of full-body protection from a hostile environment. It is primarily designed to offer protection from both gases and vapors, as well as total body splash protection. It may also be referred to as EPA Level A chemical protective clothing.
  - **Chemical Splash Protective Clothing**—This is specialized protective clothing that protects the wearer against chemical liquid splashes but not against chemical vapors or gases. It is primarily designed to provide personal protection against liquid splashes, solids, dusts and particles. It can be found in both single and multi-piece garment arrangements, and may also be referred to as EPA Level B chemical protective clothing when air supplied respiratory protection is provided or EPA Level C chemical protective clothing when air purifying respirators (APR) are provided.
- ❑ Ensure that all emergency response personnel are using the proper protective clothing and equipment equal to the hazards present. **Do not place personnel in an unsafe emergency condition.**
- ❑ Order additional personnel and other specialized equipment and expertise early in the incident. If you are unsure what your requirements are, always call for the highest level of assistance available. Do not wait to call for emergency assistance.

#### **STREET SMART TIPS:**

- ❑ Remember that structural firefighting protective clothing is not designed to provide protection against chemical hazards.
- ❑ There is no one single barrier that will effectively combine both chemical and thermal protection.
- ❑ Wearing ANY type and level of impermeable protective clothing creates the potential for heat stress injuries.
- ❑ Personal protective clothing is your LAST line of defense!!!!

### **STEP 5: INFORMATION MANAGEMENT AND RESOURCE COORDINATION**

**FUNCTION:** Refers to proper management, coordination, and dissemination of all pertinent data and information within the ICS in effect at the scene. In simple terms, this function cannot be effectively accomplished unless a unified ICS organization



is in-place. Of particular importance is the ability to determine the incident factors involved, which functions of the Eight Step Process® have been completed, what additional information must be obtained, and what incident factors remain unknown.

**GOAL:** To provide for the timely and effective management, coordination, and dissemination of all pertinent data, information and resources between all of the players.

**CHECKLIST:**

- ☐ Confirm that the Incident Command Post is in a safe area. The ICP must be physically separated from all emergency response personnel and units involved in the tactical operation.

**NOTE:** Personnel not directly involved in the overall command and control of the incident should be removed from the ICP area.

- ☐ Confirm that a unified command organization is in-place and all key response and support agencies are represented directly or via a liaison officer.
- ☐ Expand the ICS and create additional branches, divisions or groups, as necessary.
- ☐ Ensure that all appropriate internal and external notifications have been made. Coordinate information and provide briefings to other agencies, as appropriate.
- ☐ Confirm emergency orders and follow through to ensure that they are fully understood and correctly implemented. Maintain strict control of the situation.
- ☐ Make sure that there is continuing progress toward solving the emergency in a timely manner. Do not delay in calling for additional assistance if conditions appear to be deteriorating.
- ☐ Ensure that all appropriate internal and external notifications have been made, as required. While it is the spiller's responsibility to make the necessary notifications, not all propane marketers may be familiar with the correct local or state agencies that need to be contacted. Emergency responders may be able to provide assistance in identifying the proper agencies.
- ☐ If activated, provide regular updates to the local Emergency Operations Center (EOC).

**STREET SMART TIPS:**

- ☐ Consider the security of the ICP and all other incident response areas (e.g., Staging, Rehab) of the incident.
- ☐ Don't look stupid because you didn't have a plan.
- ☐ Bad news doesn't get better with time. If there's a problem, the earlier you know about it the sooner you can start to fix it!

- ❑ Don't allow external resources to "free-lance" or do the "end run."
- ❑ Don't let your lack of a Planning Section become the Achilles Heel of your response. Establish it early, particularly if the incident has the potential to become a "campaign event."
- ❑ Play nice together!

## STEP 6: IMPLEMENT RESPONSE OBJECTIVES

**FUNCTION:** The phase where responders implement the best available strategic goals and tactical objectives, which will produce the most favorable outcome. If the incident is in the emergency phase, this is where we "make the problem go away." Common strategies to protect people and stabilize the problem include rescue, public protective actions, spill control, leak control, fire control, and recovery operations. In simple terms, these strategies are typically implemented by fire and rescue units, with law enforcement responsible for all security and criminal-related issues.

If the incident is in the post-emergency response phase, the focus of response personnel will likely become scene safety, clean-up, evidence preservation (as appropriate), and incident investigation. Specific tasks will include (1) initial site entry and monitoring to determine the extent of the hazards present; (2) an evaluation of the scene to locate evidence that can be used to reconstruct the events leading up to the incident; (3) identification of the contributing factors that caused the incident; (4) interviewing of on-scene personnel and witnesses to corroborate the information obtained and opinions formed based on the available data; and (5) documentation of preliminary results.

**GOAL:** To ensure that the incident priorities (i.e., rescue, incident stabilization, environmental and property protection) are accomplished in a safe, timely and effective manner.

### CHECKLIST:

- ❑ Protect exposures at the emergency scene. Anticipate accidental ignition of propane vapor releases. Exposures should be evaluated and prioritized so that water supplies and response resources are conserved and used correctly. Exposures should be prioritized in the following manner:
  - Primary Exposures:* Vessels, piping systems or critical support structures exposed to direct flame impingement. Failure of adjacent vessels, containers and piping systems is likely unless cooling water is applied.
  - Secondary Exposures:* Vessels, piping systems or critical support structures exposed to radiant heat. Failure of structural components is possible if cooling water is not applied.
  - Tertiary Exposures:* Noncritical equipment without life safety implications.
- ❑ Once exposures have been prioritized, the Incident Commander should develop a water supply plan as required, in conjunction with propane facility personnel. The Water Supply Leader should ensure that fire pumps are operating (at fixed facilities) and that an uninterrupted water supply can be delivered for the duration of the emergency.

- ❑ Implement response objectives. Remember that offensive tactics increase the risks to emergency responders; evaluate the risks of offensive control tactics before sending emergency response crews into the hazard area.
  - **Offensive Tactics**—Require responders to control/mitigate the emergency from within/inside the area of high risk. In a fire situation, this will include the ability to provide a reliable and sustained water supply.
  - **Defensive Tactics**—Permits responders to control/mitigate the emergency remote from the area of highest risk.
  - **Non-Intervention Tactics**—Pursuing a passive attack posture until the arrival of additional personnel or equipment, or allowing the fire to completely burn itself out.

| STRATEGY                  | OFFENSIVE | DEFENSIVE | NON-INTERVENTION |
|---------------------------|-----------|-----------|------------------|
| Rescue                    | X         |           |                  |
| Public Protective Actions | X         | X         | X                |
| Spill Control             | X         | X         |                  |
| Leak Control              | X         |           |                  |
| Fire Control              | X         | X         |                  |
| Clean-up and Recovery     | X         | X         |                  |

**NOTE:** Rapidly changing incident conditions may require using multiple tactics simultaneously or switching from one tactic to another. Defensive tactics are always desirable over offensive tactics, if they can accomplish the same objectives.

- ❑ Ensure that properly equipped back-up personnel wearing the appropriate level of personal protective clothing are in-place before initiating operations.
- ❑ Ensure that Entry Teams have been briefed prior to being allowed to enter the hot zone. Coordinate with the Incident Safety Officer. For propane emergencies, this should include the following:
  - Objectives of the entry operation
  - Safety procedures, including radio communications, SCBA and PPE checks, and personal accountability.
  - Emergency procedures, including placement of back-up teams, escape signals and escape corridors
  - Decontamination area location, set-up and procedures

**CAUTION:** Always conduct operations as safely as possible. Do not enter the hazard area unless properly trained and equipped for the hazard(s) present and the specific task(s) to be performed.

- ❑ If adequate resources are available, the Incident Commander should implement a plan of action that permits facility personnel to remotely isolate the source of the release, while emergency responders protect exposures and prevent possible ignition of the propane vapors.
- ❑ Firefighting Operations: As a general guideline:
  - Protect primary and secondary exposures to the fire.
  - Isolate the propane source feeding the fire.
  - Reduce the operating pressure of the line or vessel feeding the fire.
  - Permit the fire to self-extinguish and consume residual propane inside the vessel or piping system.
  - Control and extinguish secondary fires.
- ❑ Conduct regular monitoring of the hazard area to determine if conditions are changing.

#### **STREET SMART TIPS:**

- ❑ Positive pressure ventilation (PPV) can be used to significantly reduce flammable vapor levels within a building and increase the safety of emergency responders who must enter a structure to effect rescue operations.
- ❑ Never touch or handle anything in a clandestine lab operation until the area has been evaluated and cleared by bomb squad personnel who have proper training in identifying booby traps.
- ❑ What will happen if I do nothing? Remember—this is the baseline for hazmat decision-making and should be the element against which all strategies and tactics are compared.
- ❑ Surprises are nice on your birthday but not on the emergency scene. Always have a Plan B in case Plan A doesn't work!

## **STEP 7: DECON AND CLEAN-UP OPERATIONS**

**FUNCTION:** Decontamination (decon) is the process of making personnel, equipment, and supplies “safe” by reducing or eliminating harmful substances (i.e., contaminants) that are present when entering and working in contaminated areas (i.e., hot zone or inner perimeter). Although decon is commonly addressed in terms of “cleaning” personnel and equipment after entry operations, response personnel should remember that in some instances, due to the nature of the materials involved, decontamination of clothing and equipment may not be possible and these items may require disposal.

All personnel trained to the First Responder Operations level should be capable of delivering an emergency decon capability. At most “working” hazmat incidents, decon services will be provided by HMRTs or fire and rescue units working under the direction of a Hazmat Technician. Questions pertaining to disposal methods and procedures should be directed to environmental officials and technical specialists, based on applicable federal, state, and local regulations.

**GOAL:** To ensure the safety of both emergency responders and the public by reducing the level of contamination on-scene and minimizing the potential for secondary contamination beyond the incident scene.

**CHECKLIST:**

- ☐ Ensure that the decon operations are coordinated with tactical operations. This should include the following tasks:
  - The decontamination area is properly located within the warm zone, preferably up-slope and upwind of the incident location.
  - The decontamination area is well-marked and identified.
  - The proper decontamination method and the type of personal protective clothing to be used by the Decon Team have been determined and communicated, as appropriate.
  - All decon operations are integrated within the ICS organization.
- ☐ Ensure proper decon of all personnel before they leave the scene. For example, propane liquid and vapors can saturate protective clothing and be carried into "safe" areas. Flushing PPE with water will remove residual products and odorants.
- ☐ Establish a plan to clean-up or dispose of contaminated supplies and equipment before cleaning up the site of a release. Federal and state laws require proper disposal of hazardous waste.

**STREET SMART TIPS:**

- ☐ Establishing an emergency decon capability should be part of the Incident Action Plan for any incident where hazardous materials are involved.
- ☐ Never transport contaminated victims from the scene to any medical facility without conducting field decon. At best, the hospital folks will be pretty mad at you; at worst, you will completely shutdown the emergency room and the hospital.

**STEP 8: TERMINATE THE INCIDENT**

**FUNCTION:** This is the termination of emergency response activities and the initiation of post-emergency response operations (PERO), including investigation, restoration, and recovery activities. This would include the transfer of command to the agency who will be responsible for coordinating all post-emergency activities.

**GOAL:** To ensure that overall command is transferred to the proper agency when the emergency is terminated, and that all post-incident administrative activities are completed per local policies and procedures.

**CHECKLIST:**

- ☐ Account for all personnel before securing emergency operations.
- ☐ Conduct incident debriefing session for on-scene response personnel.



- ❑ Conduct incident debriefing session for on-scene response personnel. Provide background information necessary to ensure the documentation of any exposures.
- ❑ Command is formally transferred from the lead response agency to the lead agency for all post-emergency response operations.
- ❑ Ensure that the following elements are documented:
  - All operational, regulatory, and medical phases of the emergency, as appropriate.
  - All equipment or supplies used during the incident.
  - Obtain the names and telephone numbers of all key individuals. This should include propane representatives, contractors, public officials, and members of the media.
- ❑ Ensure that all emergency equipment is re-serviced, inspected and returned to proper locations. Provide a point-of-contact for all post-incident questions and issues.
- ❑ Conduct a critique of all major and significant incidents based upon local protocols.

#### **STREET SMART TIPS:**

- ❑ Although every organization has a tendency to develop its own critique style, never use a critique to assign blame (public meetings are the worst time to discipline personnel).
- ❑ Organizations must balance the potential negatives against the benefits that are gained through the critique process. Remember—the reason for doing the critique in the first place is to improve your operations.

## **SUMMARY**

Most propane related emergencies involve small cylinders and non-bulk containers. The majority of these incidents are handled safely and effectively by the local fire department with some technical assistance from the local propane marketer. Larger scale emergencies such as cargo tank truck rollovers, train derailments, or fires involving large stationary tanks or bulk plants may require resources from a number of different agencies to resolve the problem.

The National Incident Management System (NIMS) is an important tool for organizing roles and responsibilities at any propane emergency. Understanding how the NIMS works is important for propane industry and public safety personnel from both a regulatory compliance and an operational point of view.

A strategy is a plan for managing the incident. It becomes the Incident Commander's overall goal or game plan to control the incident. Like most goals, a strategy is usually very broad in nature and is selected at the Command level. Tactics are the specific objectives the IC uses to achieve strategic goals.

Strategic goals and tactical objectives can be implemented from three distinct operational modes: (1) offensive mode of operations commits the IC's resources to

mits the IC's resources (people, equipment and supplies) to less aggressive objectives; and (3) Non-intervention calls for taking no action other than isolating the area and waiting out the sequence of events underway until the incident has run its course and the risk of intervening has been reduced to an acceptable level.

The Eight Step Process<sup>®</sup> is a tool used for the tactical management of hazardous materials emergencies. It serves as an example of a structured system that can be used by response personnel at incidents involving hazardous materials and propane. Although the level of equipment, training, and personnel may vary among organizations, there are fundamental functions and tasks that must be evaluated and implemented on a consistent basis. The Eight Step Process<sup>®</sup> provides a framework necessary to translate planning and preparedness into the delivery of an effective system for responding to and investigating incidents where propane may be involved.

The eight functions are:

1. Site Management and Control
2. Identify the Problem
3. Hazard and Risk Evaluation
4. Select Personal Protective Clothing and Equipment
5. Information Management and Resource Coordination
6. Implement Response Objectives
7. Decon and Clean-Up Operations
8. Terminate the Incident



# TACTICAL RESPONSE GUIDELINES FOR PROPANE EMERGENCIES

## OBJECTIVES

- 1) Describe the concept of hazard assessment and risk evaluation as it applies to propane emergencies.
- 2) Given a scenario involving propane, identify and describe the critical safety considerations to be evaluated, including:
  - Potential for multiple hazards
  - Risk of container failure
  - Vulnerability to external heating
  - Requirements for adequate water supply
  - Risks from secondary exposures
  - Risks from pressure-fed fires
  - Risks from exposure to liquid propane
  - Risks from confined spaces
  - Protective clothing and equipment requirements
- 3) Describe the basic tactics for managing the most common types of propane fire and leak emergency scenarios.

## ABBREVIATIONS AND ACRONYMS

|       |                                          |
|-------|------------------------------------------|
| BLEVE | Boiling Liquid Expanding Vapor Explosion |
| GPM   | Gallons Per Minutes                      |
| NPT   | National Pipe Thread                     |
| PRV   | Pressure Relief Valve                    |
| psig  | Pounds Per Square Inch Gauge             |
| WC    | Water Capacity                           |

## HAZARD AND RISK EVALUATION

This section will provide emergency responders with some specific guidelines for handling common types of propane emergencies involving both non-bulk and bulk transportation containers. We will begin by discussing the importance of hazard and risk assessment and some important safe operating principles which apply to all types of propane emergencies. We will also present twenty different types of tactical scenarios so that you can see how these principles may be applied in the field.

In order to understand how to handle different types of propane emergencies, you must be familiar with both the physical properties and behavioral characteristics of propane, as well as the basic design and construction features of propane tanks. This material is covered in detail in Section 2, "Physical and Chemical Properties and Characteristics of Propane," Section 4, "Non-Bulk and Bulk Container Design and Construction Features," and Section 5, "Bulk Transportation Design and Construction Features." If you familiarize yourself with the material in these sections before you tackle the tactical material in Section 8, you will have a solid foundation for understanding why some tactics work and some don't.

In Section 7 we introduced some general emergency response procedures and outlined the Eight Step Process® as a tactical decision-making framework for managing propane emergencies. The cornerstone of the Eight Step Process® is hazard and risk assessment.

Hazard and risk assessment is a definitive step taken by the Incident Commander to identify the hazards involved in the incident and to evaluate the potential risks of each tactical option being considered. For example, given the hazards of propane, what are the risks involved in using offensive tactics versus defensive tactics? What happens if we do nothing and simply wait for the incident to run its course?

Hazard and risk assessment should be an on-going process used by the Incident Commander along the entire timeline of the incident. It begins with the first arriving officer at the emergency scene and continues along the incident timeline until the problem has been safely resolved and the incident is terminated.

## HAZARD ASSESSMENT

The terms hazard and risk are often used interchangeably; however, they are actually two distinctly different processes. The “hazard” side of the evaluation focuses on the material’s known physical and chemical characteristics. For example, when evaluating the hazards of propane, emergency responders should consider characteristics like flammable range, vapor density, expansion ratio, ignition temperature, etc. (In Section 2, “Physical and Chemical Properties and Characteristics,” we go into a lot of detail about the basic hazards of propane.) At the incident scene, this information is usually obtained from references such as hazardous materials reference manuals and Material Safety Data Sheets, through propane and container product specialists, or through the basic knowledge emergency responders have acquired through training programs.

An important point to note about the properties and characteristics of propane or any other hazardous material is that their hazards are fairly consistent and do not change from one emergency to the next. That is, the laws of physics and chemistry dictate that propane’s flammable limits, expansion ratio, etc., will vary only in a very small range.

## RISK ASSESSMENT

Risk refers to the probability of suffering harm or loss. Risks are dynamic and can change from one incident to the next. Risks can also change throughout the incident as conditions improve or degrade. For example, in the early stages of a fire involving a propane tank, the risk to emergency responders may be very high as cooling water is applied to the tank. If the tank is adequately cooled, the level of risk will decrease. If cooling water is inadequate, the level of risk could increase to the point that the container’s pressure relief valve will activate. The container may eventually fail, causing injury and property damage.

## SIZING-UP RISKS

When sizing-up risks at a propane incident, keeping track of times and key events is critical. Flammable gas incidents often start out as vapor releases which may eventually ignite once they come in contact with an ignition source. It is important that the Incident Commander acquire the following information during the size-up process:

- **Time the incident started.** Remember, this may not necessarily be the same time the incident was reported.



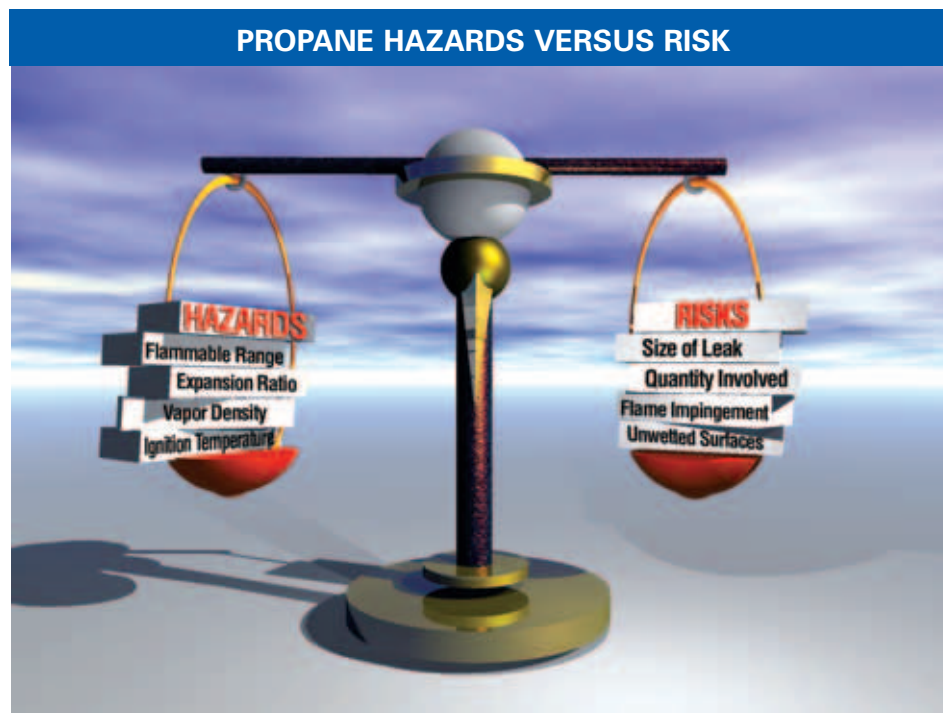


**FIGURE 8-1** The hazards of the emergency must be weighed against risks.

- **Time responders arrived on scene.** The difference between when the leak or fire started and when you arrived may tell you how much propane may have been released or how long the fire has been burning. Tanks with flame impingement upon the vapor space that have been burning 10 to 20 minutes present higher risks that must be factored into the plan of action.
- **Layout of the incident.** Size and type of container involved. Factors that should be considered include the container size, nature of the stress (e.g., thermal, mechanical), type of container or system breach, types of pressure relief devices present, and the ability to isolate the source of the leak/fire.
- **Valves and control points being stressed by the fire or damaged by impact.** Presence of any fixed or semifixed fire protection systems, including water-spray systems, access to fire hydrants, etc. If you cannot deliver an uninterrupted water supply to cool the tank's heated surface area, consideration should be given to switching to a non-intervention strategy before exposing emergency responders to a high-risk situation.
- **Identify and prioritize exposures.** How close are exposures? Are there other propane tanks, buildings, hazardous materials, or utilities being exposed? Exposure evaluation should include identifying and prioritizing exposures (e.g., flame impingement, radiant heat exposure). Remember that the highest priority should be given to flame impingement on unwetted vessels, piping, and critical support structures.

Size and type of area being affected by the vapor release or fire.

- Probability that the problem will be confined to its present size.
- Resources available to combat the problem, including the ability to rapidly deliver a sufficient and uninterrupted water supply at the point of flame impingement

- Factors affecting evacuation issues (schools, hospitals, etc.).

## SAFETY

Before discussing specific tactics, let's review some basic safe operating principles and safety issues. The following fundamental safe operating principles can be applied to most emergencies where propane is involved:

### 1. Propane may not be the only hazard present.

Propane emergencies can involve a wide variety of situations at both transportation or fixed facilities. Any incident involving propane may also involve other types of hazardous materials. These materials may present an even greater danger to emergency responders than propane. Consider the following examples:

- **Fixed Facility Incidents**—Some propane marketers also handle other hazardous materials such as gasoline, diesel fuel, methanol, and “farm chemicals” such as fertilizers and pesticides. Fires involving loading docks and warehouses may involve other hazards which can generate toxic smoke, runoff, etc. Don't assume that propane is the only hazard present, look around for other hazards.
- **Highway Incidents**—Cargo tank truck accidents often involve leaks from motor fuel tanks such as gasoline and diesel. There may be energized electrical power lines down. If other vehicles are involved, they may be carrying hazardous materials. In particular, oxidizers are quite dangerous in the presence of propane. Controlling these hazards must be addressed before attempting to upright or off-load a propane cargo tank truck.

Emergency responders should also be aware that anhydrous ammonia is commonly transported in MC-331 cargo tank trucks. These trucks are equipped with steel fittings whereas the MC-331 hauling propane will usually be equipped with brass fittings. Don't assume that the MC-331 contains propane or LPG; it may actually contain ammonia. You need to verify the contents of the truck using standard identification methods.

- **Rail Incidents**—Train derailments involving propane tank cars often involve other rail cars containing various types of bulk hazardous materials, such as corrosives, poisons, radioactive materials, oxidizers, etc.

DOT-112 rail cars also transport anhydrous ammonia. Like the MC-331 just described, don't assume that the rail car always contains LPG; it may actually contain ammonia. You need to check and verify the contents of tank cars using standard identification methods.

### 2. Containers may eventually fail when exposed to fire.

Most emergency responders are very familiar with the potential for closed container failure hazards associated with large bulk LPG containers like railroad tank cars. However, emergency responders sometimes do not recognize the comparable hazards and the potential for container failure when dealing with smaller propane cylinders and tanks. Small containers have caused serious injuries and fatalities because emergency responders did not understand the hazards and risks involved.

## BOILING LIQUID EXPANDING VAPOR EXPLOSION (BLEVE)

### BACKGROUND AND HISTORY

The term BLEVE is actually an acronym which stands for Boiling Liquid Expanding Vapor Explosion. A BLEVE is defined as a container failure with a release of energy, often rapidly and violently, which is accompanied by a release of gas to the atmosphere and propulsion of the container or container pieces due to an over-pressure rupture.

The term BLEVE first appeared in fire service publications in the first of a two part series written by Wilbur L. Walls in *"Fire Command"*, a fire service magazine published by the National Fire Protection Association. See Walls, Wilbur, L., "The BLEVE—Part 1," *Fire Command*, pp. 22–24, May 1979, and, "The BLEVE—Part 2," *Fire Command*, pp. 22–24, June 1979.]

In the 1960s and 1970s there were several BLEVE incidents involving LPG rail cars in the United States. Sadly, some of these incidents resulted in firefighter deaths and injuries. Some of the more widely publicized incidents involved LPG and other flammable products like vinyl chloride.

Lessons learned from accident investigations of major train derailments revealed that during high speed train derailments, some rail car couplings disconnected from the coupling of the rail car in front of them as the train rapidly came to a stop. This sudden deceleration often caused the disconnected rail car coupling to puncture a hole in the rear head of the rail tank car in front of it. When the escaping LPG found an ignition source and ignited, the result was that other LPG rail cars were subjected to intense flame impingement on the vapor space. In many instances, this eventually led to a failure of the tank car and subsequent BLEVE.



### IMPROVEMENTS IN RAIL CAR SAFETY

In the late 1970s and early 1980s, the LPG and railroad industries began making major modifications and improvements to the LPG tank car fleet design to minimize the likelihood of a tank car breach and BLEVE. Following the recommendations of the National Transportation Safety Board, LPG and other flammable gas tank cars were equipped with the following:

- **Head Shields**—These are heavy 1/2-inch steel plates mounted on the tank head. Depending upon the tank car, they may be mounted on the outside of the tank and be visible, or they may be integrated within the outer jacket of the tank car and not be visible. The head shield is designed to absorb the impact of a train derailment and prevent a car coupler or any other object from puncturing the head of the propane tank car.

- **Shelf Couplers**—Conventional rail car couplers ride up and down freely and can disengage in a derailment and puncture an adjacent tank car. Shelf couplers reduce the potential for coupler disengagement and head punctures by placing a heavy steel plate, or shelf, above and below the coupling device. As a result, tank cars tend to remain coupled when involved in a derailment scenario.
- **Thermal Protection**—All DOT tank cars used for propane transportation are provided with thermal protection to minimize the tank shell's exposure to flame impingement and fire. Thermal protection is designed to keep tank metal temperatures below 800°F for 100 minutes if the exposure is from a pool fire or 30 minutes if the exposure is from a torch fire.

Thermal protection can be provided in two ways—sprayed-on insulation or jacketed protection. Sprayed-on thermal protection is applied onto the outside of a nonjacketed tank car. This insulation is designed to expand when exposed to high temperatures. Jacketed thermal protection consists of mineral wool or fiberglass insulation that is installed and kept in place by an outer metal jacket. This outer jacket is 1/8-inch steel and is designed to hold only the insulation and thermal protection in place.

It should be noted that since these improvements in rail car safety were made in the 1980s, there have been no U.S. firefighter fatalities from railroad tank car BLEVEs.

## IMPROVEMENTS IN FIREFIGHTER SAFETY AND AWARENESS TRAINING

In conjunction with industry rail car safety improvements, many fire service organizations initiated a major nationwide training effort to make firefighters aware of the hazards and risks of closed container failure. The lessons learned from the LPG rail car experience were passed on to a generation of firefighters. LPG safety training initiatives implemented by the fire service became the forerunner of many of the hazardous materials safety training programs currently in use today.

## INCIDENTS INVOLVING NON-BULK CONTAINERS

Since 1993 there have been at least three significant BLEVE incidents in the United States and Canada which have involved non-bulk stationary LPG storage tanks in a rural farm setting. These include incidents at Ste. Elisabeth de Warwick, Quebec, Canada on June 27, 1993, which resulted in the death of three firefighters; Burnside, Illinois on October 2, 1997, which resulted in two firefighter fatalities; and Albert City, Iowa, on April 9, 1998, which resulted in the death of two firefighters. In each of these incidents, the pressure relief valves were operating upon arrival of the fire department. [See NFPA Alert Bulletin, Number 98-1, December 1998, National Fire Protection Association.] For more information on these incidents contact NFPA Fire Investigations using e-mail at [investigations@nfpa.org](mailto:investigations@nfpa.org). For a copy of NFPA's Albert City, Iowa Report contact NFPA's Library at (617) 984-7445 or e-mail at [library@nfpa.org](mailto:library@nfpa.org).

While the LPG and railroad industry have done an excellent job re-engineering railroad tank cars and bulk storage tanks and the fire service has aggressively implemented firefighter safety training programs directed at the hazards and risks of BLEVEs, we need to continue our efforts to address the hazards and risks of the smaller stationary LPG tanks. The main goal of this book and the companion training program is to help firefighters and propane industry responders understand how to respond safely to propane emergencies.

## RESEARCH ON BLEVEs

During the summers of 1992 to 1994, the Department of Mechanical Engineering of Queens University, Kingston, Ontario, and the Canadian Transport of Dangerous Goods Directorate



conducted medium-scale fire tests of 80 to 100 gallon (325 l to 400 l) ASME code pressure vessels. The tanks were filled to 80% capacity with commercial propane and were exposed to different combinations of torch and pool fire impingement in order to force container rupture. The primary objective of the study was to develop a better understanding of the BLEVE phenomenon and to quantify the hazards associated with BLEVEs. (See "Fire Tests of Propane Tanks to Study BLEVEs and Other Thermal Ruptures: Detailed Analysis of Medium Scale Tests Results," Report No. TP12498E, November 1997. Source: Transportation Development Centre [TDC], 800 Rene Levesque Blvd. West, 6th Floor, Montreal, Quebec, H3B1X9.

A total of forty fire tests were conducted of unprotected containers. Six of these tests resulted in no tank failure (i.e., the pressure relief valve emptied the tank). Twenty-one tests resulted in the tank splitting and burning off in a jet flame, and 13 tests resulted in BLEVEs.

A significant finding of the research was that even though these tests were designed to force the container to fail, only 32% of the failures actually produced a BLEVE. Clearly, the test showed that not every non-bulk propane tank exposed to flame impingement will result in a BLEVE.

The Queens University tests also revealed some significant information which will help firefighters understand the hazards and risks of small propane containers. Among the more important findings are the hazards and risks of projectiles caused by a BLEVE. The study revealed the following findings which relate to firefighter safety:

**Projectiles from BLEVEs are the major hazard.** Data and analysis from the study of 13 induced BLEVEs show that rocket-type projectiles from 80 to 100 gallon propane tanks can reach distances of up to 30 times the fireball radius.

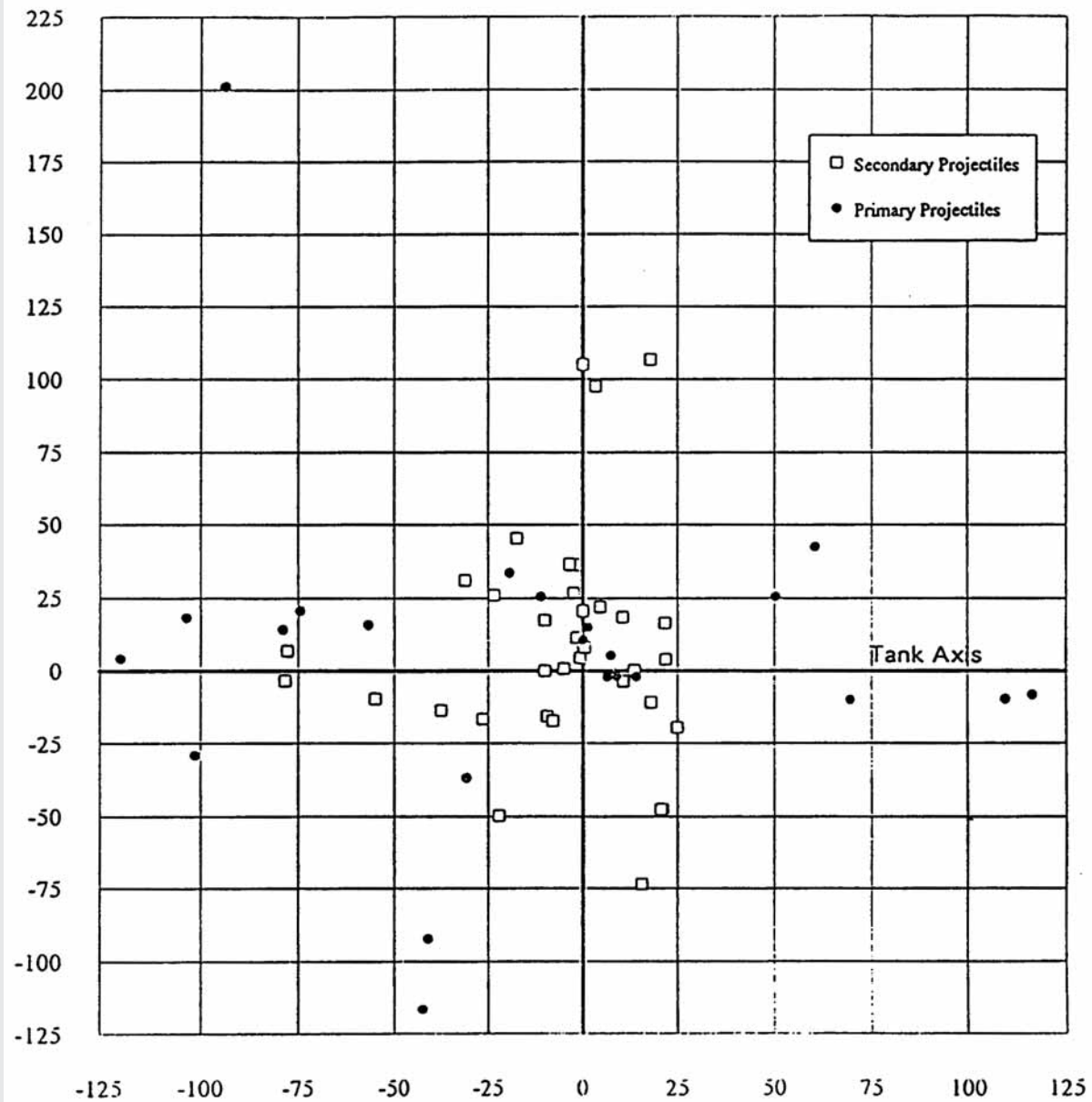
Tanks which BLEVE'd during the tests experienced a common failure mode. The cylindrical section was flattened on the ground, and the ends were either thrown off or remained attached. (These findings concerning the size and shape of the projectiles are consistent with the behavior of railroad tank cars that have BLEVE'd.) In other cases the ends bounced and rolled large distances up to 722 feet (220 m). In one case, the flattened cylindrical section was thrown 407 feet (124 m).

A map showing the pattern of significant projectiles was produced from the 13 induced BLEVEs. (Figure 8-2). The map shows the distribution plot for 64 projectiles as measured in the tests. (Note: The map does not show dispersion patterns for small nuts and bolts.)

As can be seen from the map, projectiles from the ends of the tank tend to go further than the side projectiles. This information is very useful for determining which areas around a burning tank should be evacuated first. Note the wide dispersion of projectiles off of the sides of the tank. There is a wide dispersion of projectiles over an area up to 328 feet (100m) [Most master streams have an effective range of 150 feet.]

It should also be noted that the map does not plot smaller missiles such as bolts and small sections of pipe. These smaller projectiles obviously place emergency responders at risk.





**Note:** Distances in meters

**FIGURE 8-2**

Observed projectiles from 13 BLEVEs of 400 l propane tanks (Birk et al, 1995)

**CONCLUSION:** Approaching a burning 80 to 100 gallon propane tank from the sides with flame impingement in the vapor space is not a guarantee that you will be safe from projectiles or missiles if the tank BLEVEs. Test results suggest that a minimum safe approach distance from the sides of a burning tank to avoid the majority of projectiles would be about 300 feet (approximately 90 meters) and even at that distance, there is still risk of exposure to some projectiles. Many of these hazards and risks can be applied to larger containers.

3. **The nature of pressure vessels and containment systems makes them vulnerable to external heating.**

A propane tank contains liquid and vapor. Any external fire creating direct flame impingement on the vapor space will heat the tank's shell. The fire will heat the tank shell in the vapor space area more rapidly than in the area in contact with the liquid. As temperatures rise, the tank shell's temperature in the vapor space quickly reaches 752°F (400°C). Above 1,112°F (600°C) steel weakens significantly. By the time the steel reaches 1,800°F (982°C) it has lost 90% of its strength. Thinned and weakened from the fire, the tank will eventually relieve pressure to the outside either through a split in the tank in the form of a jet flame or the container will fail.

In most cases, the tank's pressure relief valve (PRV) will function early in the fire. As the PRV functions, gas escapes, lowering the liquid level inside the tank even further, thus exposing a larger surface area of the tank in the vapor space.

**Firefighters should be aware that a functioning pressure relief valve on a burning propane tank is not a reliable indication that the tank is safe to approach or a reliable indicator of when or if a tank may fail.** Likewise, a container may fail at pressures below the pressure relief valve setting if the metal is heated sufficiently.

Rapid application of cooling water on the outside of the tank at the point of flame impingement and on the top half of the tank shell above the liquid level can reduce the likelihood of container failure by lowering the external temperature of the shell of the exposed tank. However, cooling water applied to the tank shell will not necessarily lower the temperature of the liquid inside the container. Basically, the liquid acts as a heat sink and protects itself. This is why failure of a tank in the liquid space is extremely unlikely. This principle is often illustrated in fire science classes using a Styrofoam cup filled with water. A flame from a small heating torch is applied to the bottom of the cup and the water inside is brought to a full boil without burning through the cup. However, when the torch is moved to the upper portion of the cup above the liquid level, the cup fails and burns through in seconds. The same physical principle applies to a propane storage container.

Any decision to approach a propane tank showing direct flame impingement on its vapor space must be made on a case-by-case basis after evaluating the hazards and risks and determining if an adequate water supply is available to support firefighting operations. Bulk storage tanks can fail within 10 to 20 minutes of direct flame impingement if the containers are not adequately cooled.

4. **Successful propane tank fire control requires an adequate and reliable water supply.**

Emergency responders must determine if: (a) an adequate and uninterrupted water supply is available to deliver the volume of sustainable water required for cooling the container and exposures; and (b) there is adequate pumping capacity to provide the required water volume and pressure at the fire scene. If an adequate water supply is not available, the Incident Commander should consider immediate withdrawal of all personnel from the hazard area.

Effectively placed hose streams can lower the pressure in most containers (e.g., cylinders); however, the risks associated with advancing hose lines or monitors may exceed the possible benefits when bulk containers are involved in fire and pressure relief valves are functioning. Tank shells exposed to high-velocity jet flame in the vapor space (i.e., pressure fed fire) will require a minimum of 500 gallons per minute of water at the point of impingement. Exposures to radiant heat with no direct flame contact will require 0.10 to 0.25 gallons per minute per square foot to maintain the integrity of exposed tanks.

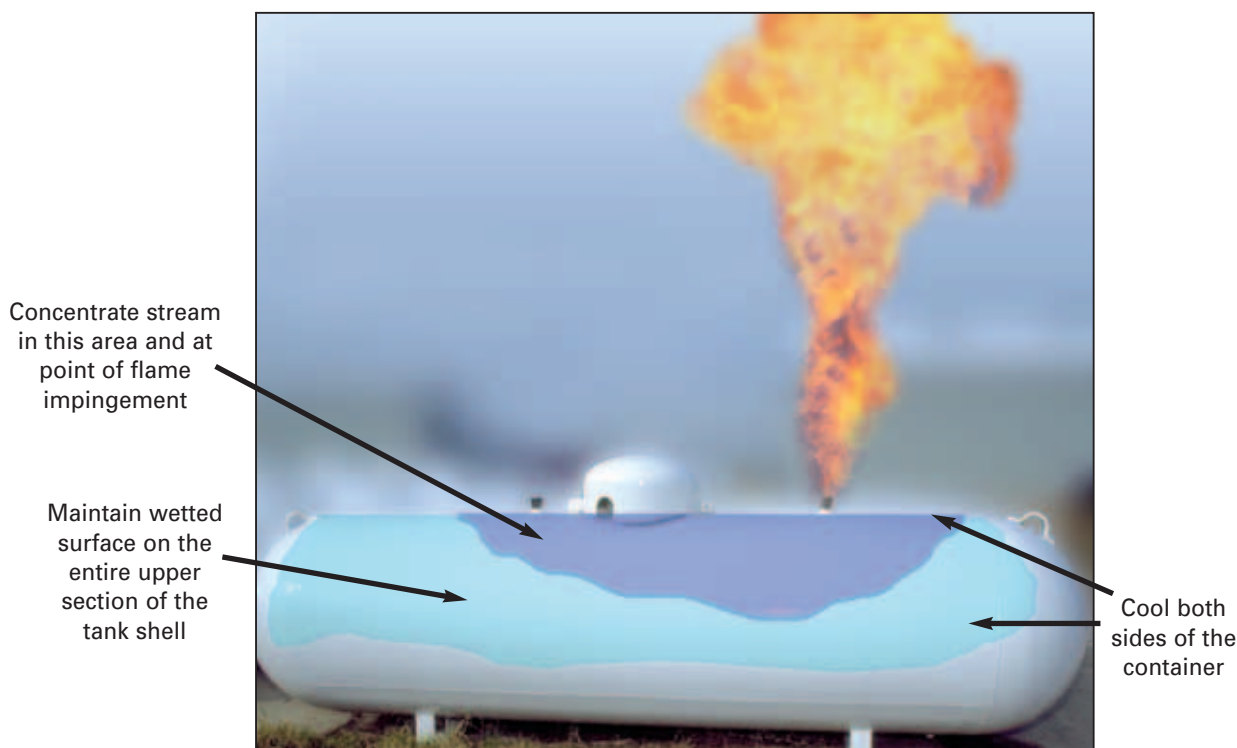


**FIGURE 8-3** Cooling water must be applied at the point of impingement and on the entire upper half of the tank shell.

**5. Fires involving propane tanks can cause secondary exposure problems which can significantly increase risks to emergency responders.**

Large pressure-fed bulk propane storage tank fires can expose adjacent tanks to radiant heat or may produce direct flame impingement and activate their relief valves. Unprotected tanks may fail catastrophically within 10 to 20 minutes of exposure. Bulk container failures (18,000 to 30,000 gallons) can produce severe fire and fragmentation risks over 3,000 feet. The Incident Commander must evaluate the potential for container failure early in the fire and throughout the incident and should take actions designed to minimize the risk to emergency responders and the public.

**6. Never extinguish an unisolated pressure-fed flammable gas fire.**

Propane fires should not be extinguished unless the fuel source can be isolated. If the fuel source is not shut off and the fire is extinguished, the leaking gas can migrate away from the container and may find an ignition source. Unignited flammable gases escaping under pressure may form an uncon-

fined vapor cloud which may be reignited by ignition sources in the area. Explosions of unconfined vapor clouds can cause major structural damage and quickly escalate the size of the emergency beyond responder capabilities. Isolate the source of the gas and permit the fire to self-extinguish, thereby consuming any residual gas inside the vessel or piping system.

**7. Unignited propane is heavier than air and may accumulate in low areas and inside buildings.**

In normal circumstances, propane dissipates quickly in open air. The use of fire hoses and master streams with nozzles on full fog can rapidly disperse flammable propane gas in air under most conditions. However, propane is 1-1/2 times heavier than air and leaks may briefly accumulate in low areas like drainage ditches, along stream beds, etc. Propane trapped in confined spaces can create a dangerous flammable atmosphere or an oxygen deficient atmosphere.

The OSHA Confined Space regulation (29 CFR 1910.146) defines a confined space as “area that has limited or restricted means for entry or exit; is large enough and so configured that an employee can bodily enter and perform assigned work; and is not designed for continuous employee occupancy.” Confined spaces present three potential hazardous materials risks. These include flammable, toxic, and oxygen-deficient or enriched atmospheres.

**Flammable Atmospheres**—OSHA and most national consensus standards consider a flammable atmosphere containing concentrations of 10% or less of the lower flammable (explosive) limit (LFL) as acceptable for conducting rescue operations. Areas with flammable concentrations of 10% to 20% of the LFL are considered hazardous and should not be entered by rescue teams unless they have proper PPE and respiratory protection and fire protection (e.g., back-up hose line), and all electric equipment is rated for Class 1, Division 2 atmospheres. As flammable readings rise above 20%, the level of risk to responders also rises. Rescue personnel operating in flammable concentrations of 25% of the LFL are at risk from an explosion hazard and should leave the area.

**Oxygen-Deficient Atmospheres**—Oxygen-deficient confined spaces exist when the concentration of oxygen in air is less than 19.5%. The risk of entering an oxygen-deficient atmosphere is similar to entering a toxic atmosphere. Obviously, the lower the oxygen content, the greater the risk to the rescue team if there is an air supply problem. While propane by itself is not toxic, it is heavier than air and may displace oxygen in a confined area.

**8. Full protective clothing and self-contained breathing apparatus is required for propane fire and leak control operations.**

Structural firefighting gear can offer sufficient protection to the wearer engaged in propane firefighting and leak control if the user is fully aware of the hazards being encountered and the limitations of the protective clothing. However, traditional leather firefighter work gloves will provide only minimal protection against burns from exposure to liquid propane.

For the purposes of this text, the definition of full protective clothing for propane firefighting includes a helmet, positive-pressure self-contained breathing apparatus (SCBA), PASS device, turnout coat and pants, gloves and boots, and a hood made of a fire-resistant material. This ensemble shall meet the requirements of *NFPA 1500—Fire Service Occupational Safety and Health*. See Figure 8-4.



Emergency responders who fail to use full protective clothing meeting NFPA 1500 requirements are placing themselves at considerable risk. The use of helmet ear flaps or three-quarter length firefighter boots is not an acceptable alternative from a safety perspective.

Turnout coats and pants shall be constructed with a vapor barrier, usually neoprene, Goretex™, or similar materials. A hood made of a fire-resistant material, such as Nomex™ or Kevlar™, will provide additional thermal protection for the head, ears, neck, and throat.

Positive pressure self-contained breathing apparatus must be the minimum level of respiratory protection used by emergency responders during propane firefighting and leak control. There are several reasons for this requirement:

- While propane is nontoxic, experience shows that other hazardous materials may be involved in an emergency which requires a higher level respiratory protection.

Propane leaks can ignite and flash back to their source exposing the respiratory system to high temperatures. Research and experience indicates that the use of positive pressure SCBA provides a higher level of protection to the facial area and the respiratory system, especially when used in conjunction with a properly worn fire-resistant hood. When worn properly, a hood does not interfere with the SCBA face seal.

- Propane can displace oxygen and create an oxygen-deficient atmosphere in confined spaces.

Live propane training props and evolutions should be consistent with the requirements of NFPA 1403—*Live Fire Training Evolutions*. This should include the use of full protective clothing and SCBA by all of the students involved in the evolutions.



**FIGURE 8-4** NFPA 1500 compliant PPE and SCBA is required for propane leak and firefighting.



**FIGURE 8-4A**



This section will review twenty different types of emergency response scenarios involving propane. They range from fairly common types of propane leak and fire emergencies to full scale major incidents. Scenarios 1 through 5 represent the more common types of propane related emergencies.

Each scenario in this section follows a similar format. First we will present the scenario, then review the basic container design and construction features, then describe the tactical objectives, and then discuss the general methods of leak control or fire extinguishment. We will also point out some special considerations for each incident.

It should be noted that the information presented in the scenarios is not intended to establish Standard Operating Procedures for any individual emergency response organization. Each organization should develop its own SOPs based on local rules, regulations, policies, and available resources.

## SCENARIO #1

### CYLINDER OVERFILL INCIDENT IN A HOME

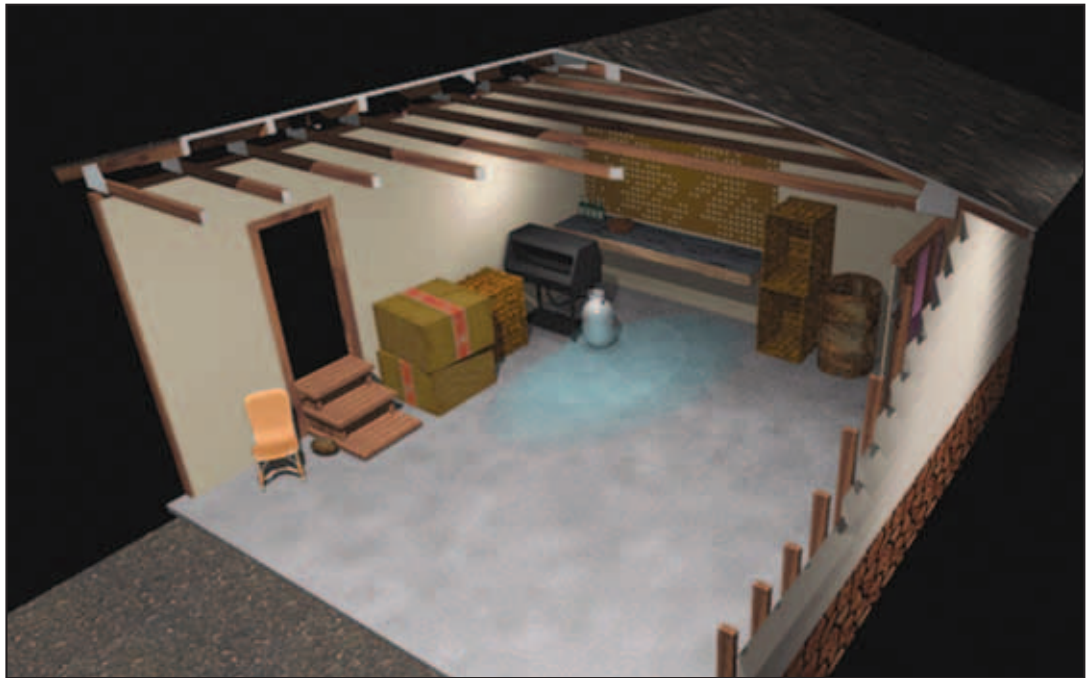


FIGURE 8-5

The owner of a home has improperly stored their BBQ grill inside the garage with a full 20 pound propane cylinder connected to the grill. The valve was left open on the cylinder and the grill's control knob is still partially open. After the garage door is closed the owner smells gas and calls the fire department.

When you arrive on the scene, you meet the owner, who informs you that everyone has been safely evacuated from the house. The owner advises you that the house is heated with an oil burner. The only potential source of gas in the home is the propane grill.

**SAFETY NOTE:** Propane cylinders should never be stored inside a residential occupancy. BBQ grills and space heaters are the most common source of leaks. Always store propane cylinders and propane powered appliances outside of residential occupancies with the valve in the closed position.

## SUMMARY OF CYLINDER CONSTRUCTION FEATURES

Portable 20-pound propane cylinders are widely used for barbecue grills and space heaters. They are usually refilled at cylinder filling stations and transported home and hooked up by the user.

The 20-pound class cylinder is usually of two-piece welded steel construction. Cylinders generally have one fitting welded in the service end of the cylinder. The fitting is threaded to a female NPT and is raised above the surface of the cylinder. NFPA requires that all 20-pound propane cylinders be equipped with an Overfill Prevention Device (OPD).

## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

The primary tactical objectives are to isolate sources of ignition inside the home, ventilate the interior space, determine the source of the gas leak, and control the leak by closing the valve if it is safe to accomplish this task.

### METHODS OF SECURING THE BUILDING AND ISOLATING THE LEAK

Using a two person team in proper protective clothing and equipment (PPE), a quick walk around of the exterior of the building should be made to confirm that there are no other sources of either natural gas or propane supplying the building. If other sources of gas (propane or natural gas) are discovered, they should be isolated by closing the valve(s). Propane cylinder valves can be closed by turning the valve clockwise (right to tight.)

A two-person entry team in PPE should gain access to the building and use a combustible gas indicator (CGI) to determine the level of flammable vapors inside the structure. If CGI readings exceed 10% of the lower limit, the entry team should withdraw and ventilate the building using positive pressure ventilation. Ventilating the interior space will lower the level of flammable vapors inside the structure.

When combustible gas indicator (CGI) readings indicate levels lower than 10% of the lower limit, the entry team can search the interior of the building to locate the BBQ grill and 20 pound cylinder. The cylinder's valve should be closed and the BBQ grill and cylinder should be moved outside and secured in a safe area.

Additional factors to consider for this operation include:

- Propane's odorant, ethyl mercaptan, can be smelled by the average person if the atmosphere is 1/5 the lower flammable limit or 2.4%. Consequently, building occupants are alerted at fairly low levels.

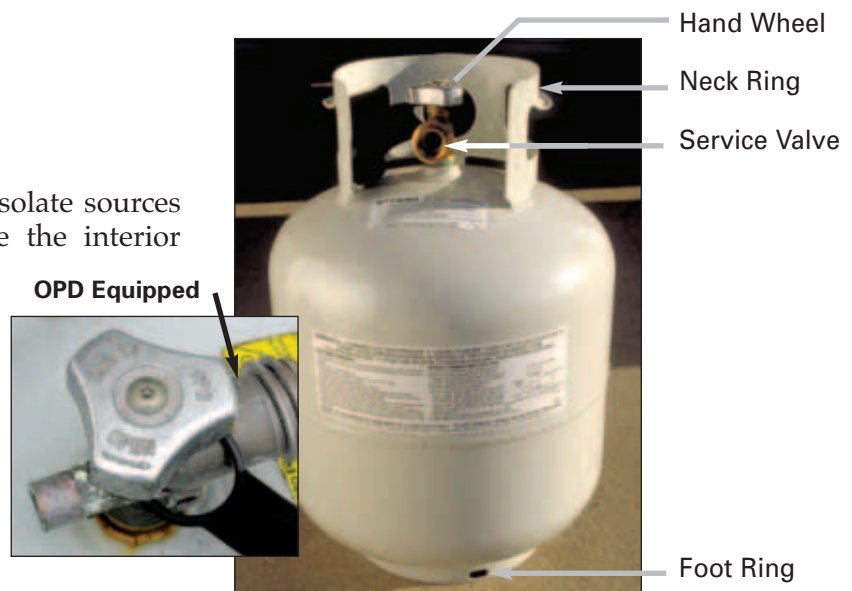


FIGURE 8-6-A

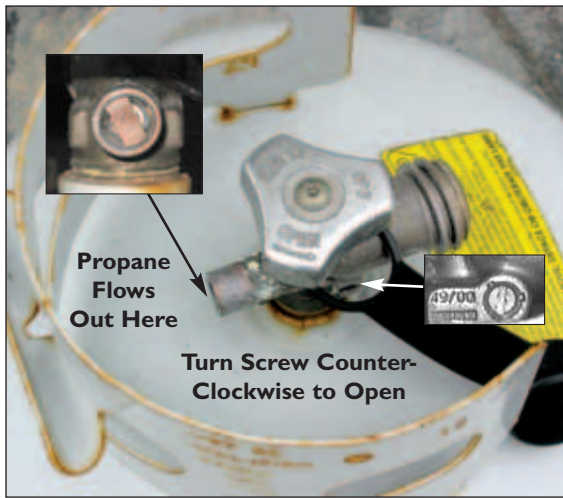


FIGURE 8-6B Cylinder Service Valve.

The human “sniff test” is not a consistent, safe, and reliable way for emergency responders to determine if an area is safe, unsafe, or dangerous. A combustible gas indicator should be used to determine the level of flammability throughout the incident.

When combustible gas indicator (CGI) readings indicate levels of 10% of the lower flammable limit or greater, charged hoselines should be in place as a precautionary measure.

Ventilate interior spaces using natural methods by opening doors and windows. Positive pressure ventilation should be used by blowing fresh air into the space. **Never place ventilators inside the building** and “suck air out.” (Negative ventilation draws potentially flammable mixtures through the ventilator creating a potential ignition source.)

- When combustible gas indicator (CGI) readings indicate detectable levels of flammability, do not activate light switches, garage doors, or interior heating and air conditioning or ventilating equipment.

**CAUTION:** a) If the atmosphere is above the Upper Flammable Limit (rich with flammable gas) the gas concentrations will come down through the flammable range as fresh air is introduced, b) As cooler air enters the structure, the inside temperature will decrease and thermostat switches may close, activating burners, which are an ignition source. Special consideration should be given to isolating energy sources from the exterior of the building if this is possible. A safety perimeter should be maintained outside the building during ventilation.

### SCENARIO #1

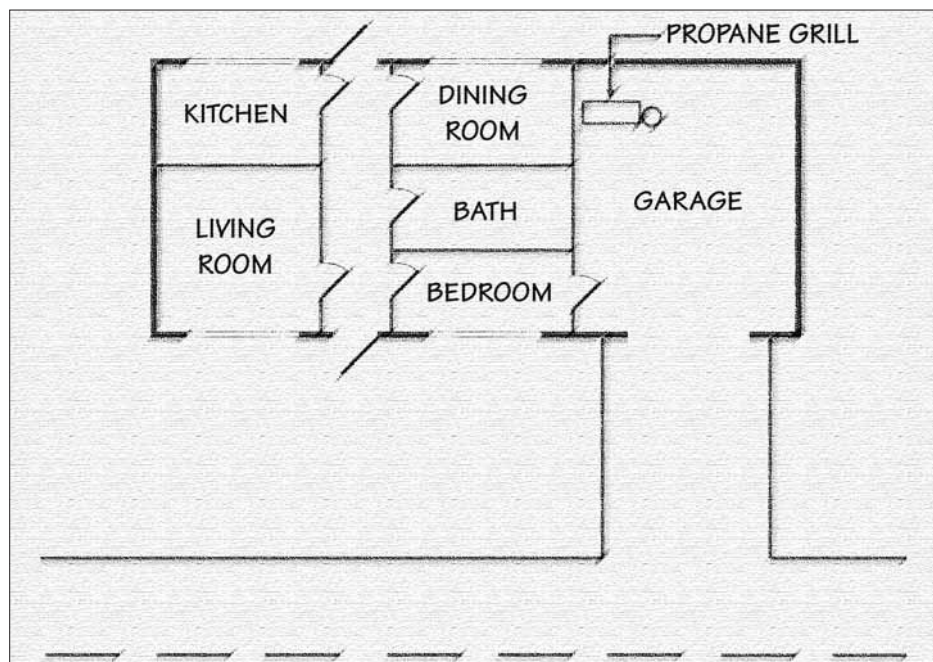


FIGURE 8-7



# SCENARIO #2

## CARBON MONOXIDE INCIDENT IN AN AUTO SHOP



FIGURE 8-8

A 500 gallon ASME propane tank is used to supply an interior space heater at an automobile repair shop. During extremely cold weather, the shop's mechanics park cars needing repair the next day inside the garage before they go home so they will be warm and ready for work the next shift. The garage's interior space heater thermostat is normally set on 70°F.

At 6:30 A.M., the first mechanic arrives at the shop and makes a pot of coffee. About 15 minutes after arrival, the mechanic becomes dizzy and sits down on a chair to rest. He subsequently goes unconscious and falls to the floor.

At 6:45 A.M., the second mechanic arrives at work, enters the garage, and finds his partner unconscious on the floor. He tries to awaken his partner but gets no response. The second mechanic dials 911 for an ambulance.

At approximately 6:55 A.M. a fire department ambulance arrives on the mechanics. One EMT begins to feel dizzy, and a decision is made to leave the building immediately and call for additional assistance.

The call for assistance brings a Command Officer, an Engine Company, an Advanced Life Support Unit (ALS), and a Rescue Squad to assist the EMTs already on scene. Upon arrival, the EMTs brief the Incident Commander on the possible carbon monoxide atmosphere and the location of the mechanics inside the building.

## SUMMARY OF CONSTRUCTION FEATURES

A 500 gallon ASME horizontal storage tank can be equipped with either a single stage or two-stage regulator system, although two stage regulation systems are now required on new installations. The regulator(s) are designed to decrease the gas vapor pressure from the variable container pressure to the lower pressure required to safely operate the appliance. In this scenario the appliance is an interior space heater. See Figure 8-9.

Most gas appliances like furnaces require venting systems to properly discharge products of combustion to the exterior of the building. If appliances and venting systems malfunction due to age or poor maintenance, there is a risk that combustion products can vent to the interior spaces of the building. Carbon monoxide (CO) is a major by-product of incomplete combustion.

According to the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) (Ventilation Standard 62–89), a concentration of no more than 9 parts per million (ppm) of CO is permissible in residential living spaces.

## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

The primary tactical objective is to rescue the mechanics who have been overcome with carbon monoxide, secure ignition sources, and ventilate the interior of the building.

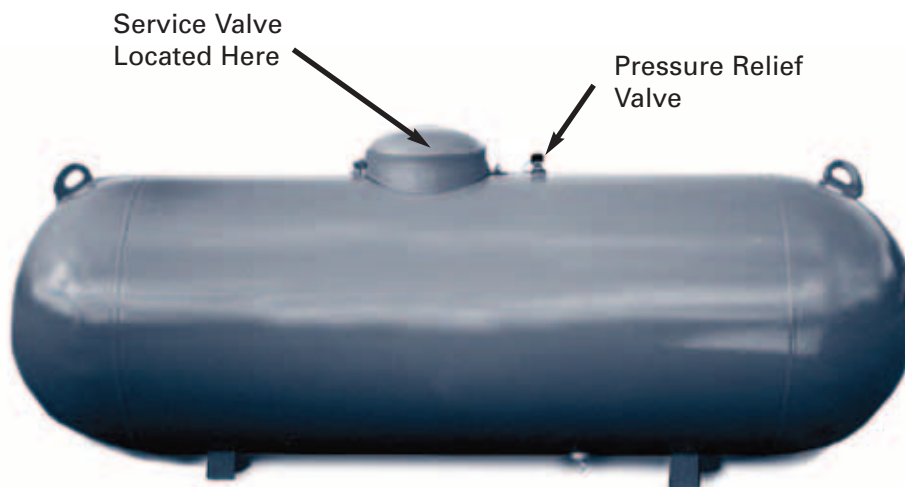


**FIGURE 8-9** Construction features of ASME 500 gallon tank.

## METHODS OF SECURING THE BUILDING AND ISOLATING THE PROBLEM

The Incident Commander (IC) assigns the Rescue Squad to enter the building in full protective clothing and SCBA to locate and remove the two mechanics trapped in the garage. One member of the rescue team takes a tri-gas monitoring instrument with him that measures flammability, oxygen deficiency and enrichment, and carbon monoxide.



As the rescue team enters the garage, the tri-gas meter's CO alarm activates. The CO reading is 800 parts per million (ppm).

While the rescue team is making entry for an emergency rescue, the IC orders the Engine Company to establish a water supply and deploy a charged handline as a precautionary measure. One person is directed to close the service valve on the 500 gallon propane tank to isolate and shut down the fuel supply to the heater. See Figure 8-9.

After the mechanics are removed from the building, paramedics establish an airway and begin administering supplemental oxygen at the highest possible concentration. Both patients are treated for shock and transported to the hospital by ambulance. The EMT who felt dizzy will be checked for CO poisoning at the hospital.

Additional factors to consider for this operation include:

- **It should be recognized that neither the 500 gallon propane tank nor the propane system is the cause of the carbon monoxide problem; rather it is the space heater that has not been properly maintained and is malfunctioning.**

Closing off the supply of propane will shut down the heater, which will stop the production of carbon monoxide. However, only time and proper ventilation of the area will reduce the carbon monoxide in the air to safe levels. Carbon monoxide build-up in a closed, poorly ventilated area takes time. In the scenario used, the garage was closed up for 12 hours with the space heater in almost continuous operation. Note that a typical home has air exchange rates of about 0.5 air exchanges per hour (ACH).

- Because carbon monoxide gas is odorless, colorless, and tasteless, it cannot be detected by body senses. Carbon monoxide can only enter the body through the respiratory system. Inhaled carbon monoxide is absorbed into the blood and then combines with the hemoglobin of the blood to exclude oxygen. Symptoms of exposure include headache, nausea, chronic fatigue, confusion, and dizziness. The harmful effects of CO exposure depend on the concentration of the gas in the air, exposure time, and factors such as age, health, size, and sex.
- According to NIOSH, the maximum allowable concentration for continuous exposure to carbon monoxide in any 8-hour period (TLV-TWA) is 35 ppm (0.0035%). At 1,200 ppm, carbon monoxide is considered Immediately Dangerous to Life and Health (IDLH). At 800 ppm, the initial reading used in this scenario, a person would experience a headache in 10 minutes after exposure and death in 40 to 45 minutes. See Figure 8-10. [Source UL-2034, Page A19, Figure 38.1]
- It is important to note that carbon monoxide is flammable and has a wide explosive range! The Lower Flammable Limit for CO is 12.8% (128,000 ppm) and the Upper Flammable Limit is 74% (740,000 ppm). Note in Figure 8-10 that a CO reading of 10,000 ppm would be 1% of the atmosphere or 7.8% of the Lower Flammable Limit; this would be within the safety limit for conducting a rescue in an indoor area using full protective clothing and SCBA.
- Many Emergency Medical Systems have formal protocols established for carbon monoxide poisoning whereby patients suffering from CO poisoning are transported to hospitals equipped with hyperbaric oxygen therapy facilities. When carbon monoxide poisoning is suspected, consideration should be given nearly in the incident to transporting the patient directly from the scene to a hyperbaric therapy facility. Speed is of greatest importance.

## Concentration Levels and Physiological Effects of Carbon Monoxide

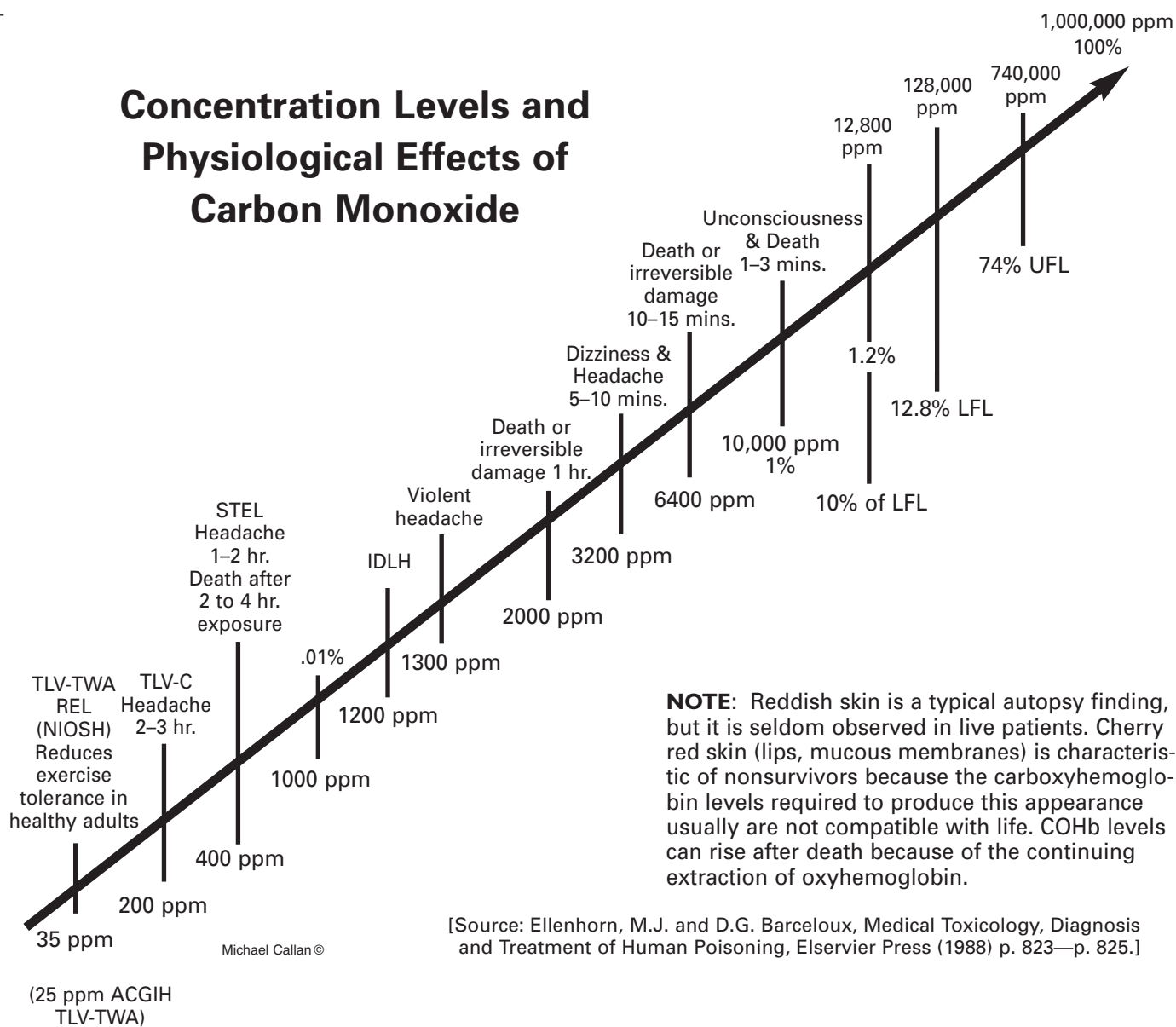


**FIGURE 8-10** Concentration levels and physiological effects of carbon monoxide.

**NOTE TO EMTs AND PARAMEDICS:** Carbon monoxide easily binds itself to the hemoglobin molecule. It has an affinity for hemoglobin 200 times that of oxygen. Once bound, receptor sites on the hemoglobin can no longer transport oxygen to the peripheral tissues. The result is hypoxia at the cellular level and, ultimately, metabolic acidosis. Hyperbaric oxygen increases the  $\text{PaO}_2$ , which promotes increased oxygen uptake on parts of the hemoglobin molecule which has not yet been bound by carbon monoxide. (Source: *Paramedic Emergency Care*, 3rd edition, by Bledsoe, Porter, and Shade, pp. 596–597.)

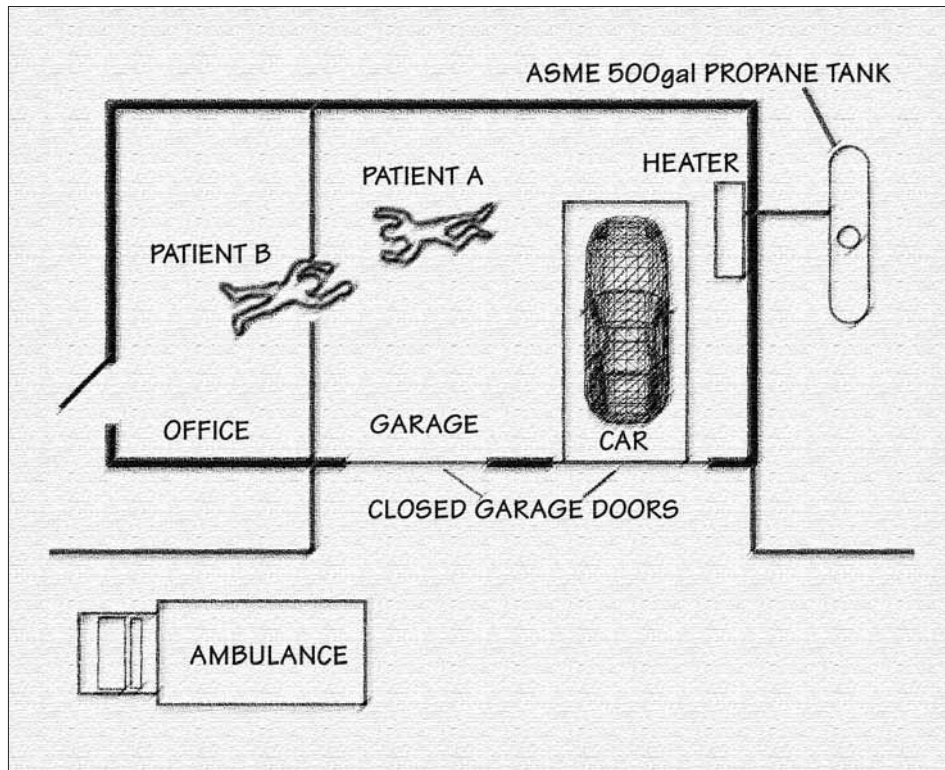


FIGURE 8-11

## SCENARIO #3

### REMOVING EXPOSED PROPANE TANKS FROM A STRUCTURE ON FIRE



FIGURE 8-12

A fire started in the kitchen area of a diner at an interstate highway truck stop at 8:10 A.M. The fire was reported via 911 at 8:13 A.M. At 8:15 A.M. the fire department dispatched a first alarm assignment consisting of two Engine Companies and a Water Tanker.

At 8:18 the first engine company arrives on the scene. The company officer finds the diner evacuated, with heavy fire blowing out the windows at the rear of the restaurant. The cook tells the company officer that a grease fire started on the grill and spread into the exhaust duct. The fixed extinguishing system failed to activate.

While firefighters begin establishing a water supply with the tanker, the company officer goes to the rear of the diner to size-up the situation. The officer observes two 100 gallon (420 lb.) propane tanks installed against the outside wall. Fire has burned through the wall of the diner and is venting to the outside. While the propane tanks are not directly involved in fire at this time, the company officer is concerned that the fire is rapidly spreading and the propane containers will eventually become involved.

#### SUMMARY OF CONSTRUCTION FEATURES

A 100 gallon (420 lb.) propane cylinder can typically hold a water capacity (w.c.) of 1,000 lb. It is commonly referred to as a 420 lb. cylinder in the propane industry.





**FIGURE 8-13** 100 gallon (420 lb.) propane tanks.

## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

The primary tactical objectives are to cool the outside of the tank so that the internal cylinder pressure does not increase and activate the tank's pressure relief valve. The secondary objective is to disconnect and remove the two 100 gallon cylinders from the rear of the diner so that they do not become involved in the fire.

### METHODS OF REMOVING CYLINDERS

If there is evidence that the tanks have been exposed to flame impingement (blistering or discoloration of paint), hoselines should be used to cool the tanks before taking additional action. If frost can be seen on the lower half of the tank, this is an indication that a large amount of gas has already been discharged from the tank byway of the pressure relief device. This may also be an indication that there has been a break in the gas line. If there is evidence of overheating, **DO NOT STAND IN THE DISCHARGE PATH OF THE PRESSURE RELIEF VALVE** since it may open at any time to relieve the tank's internal pressure.

Before attempting to move the tank, the service valve should be closed by turning it clockwise. If the valve appears to be closed already, verification can be made by opening the valve slightly (counterclockwise) and then closing it. This may alert you to the fact that the valve may be jammed open. The copper tube line can be easily disconnected and capped or cut with a bolt cutter. Two firefighters in full protective clothing and SCBA can safely move a 100 gallon tank by tipping the tank onto its side and rolling it out of the fire area. As the tank is being rolled, avoid standing over the head of the tank where the pressure relief valve is located. Remember, a 100 gallon propane tank can weigh up to 800 pounds. Be careful rolling tanks downhill.





**FIGURE 8-14** Firefighters disconnect and roll away two 100 (420 lb.) gallon tanks.

Additional factors to consider for this operation include:

- Care should be taken to be sure that the cylinder's valve is actually closed and not accidentally opened while moving it. When a propane cylinder is in a horizontal position, opening the valve will allow liquid to escape. 1 part of liquid = 270 parts vapor. Use caution; liquid propane can cause freeze burns.
- Always return propane cylinders and tanks to their full upright position and secure them after they have been moved. The local propane dealer should be notified for technical assistance.

### SCENARIO #3

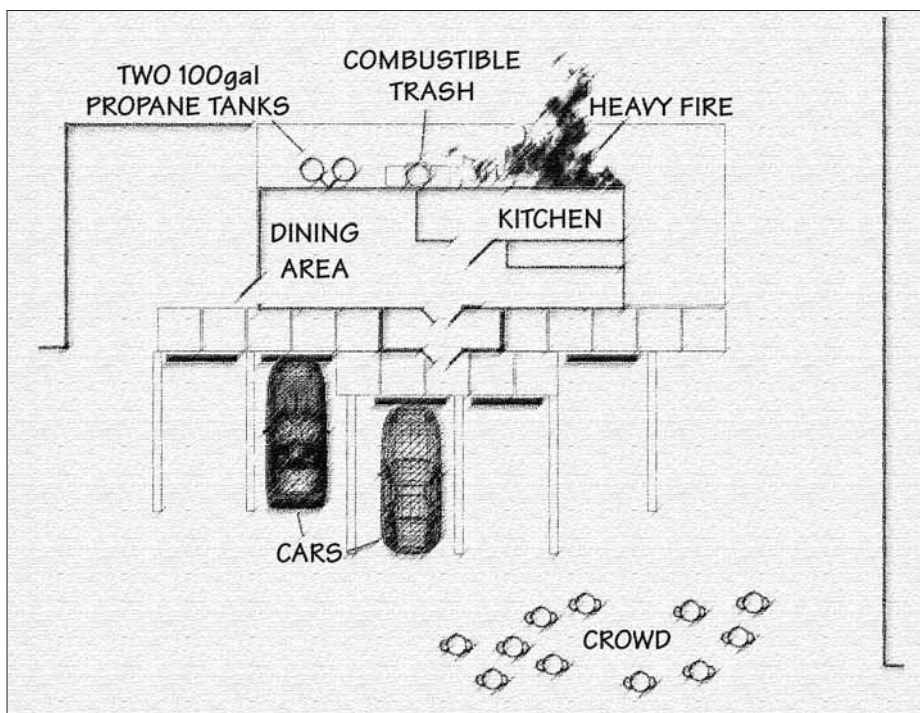


**FIGURE 8-15**

# SCENARIO #4

## UNDERGROUND PROPANE TANK LEAK



FIGURE 8-16

A end loader grading a yard for installation of a swimming pool in the rear of a new home accidentally struck the top access of a 500 gallon underground propane tank. The end loader operator immediately left the area and notified the homeowner, who called the fire department.

Upon arrival at the scene, the Incident Commander observes that propane vapor is shooting up in the air and there is no fire. The diesel engine on the end loader is still running. The underground tank riser is exposed and is bent on an angle. The home is about 100 feet away and there is a crowd of spectators standing in the front yard.

### SUMMARY OF CONSTRUCTION FEATURES

#### VALVE FITTINGS

Most underground tanks under 2,000 gallons water capacity have one opening in the top of the tank. The opening has a pipe attached to it called the riser. The top of the riser is threaded to a 2-1/2 inch male NPT. Usually, a large combination valve is installed on the top of the riser. The combination valve contains a filler valve, vapor equalizing valve, service valve, pressure relief valve, fixed maximum liquid level gauge, and an optional pressure gauge. A liquid withdrawal valve is usually in a

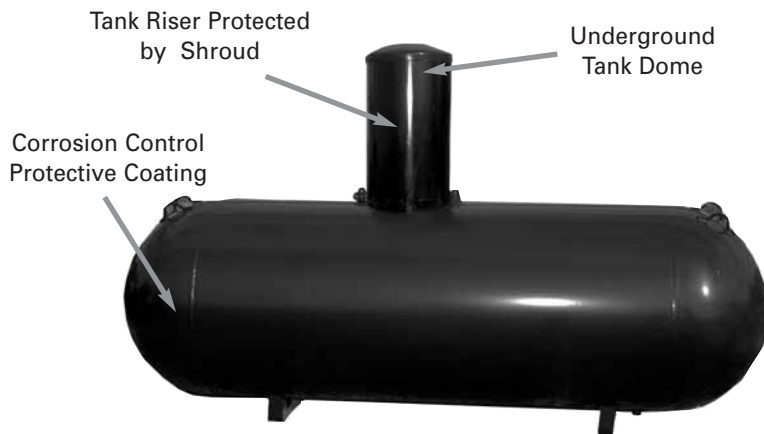


**FIGURE 8-17** Basic features of ASME underground tank.

separate location away from the combination valve and riser.

A shroud is used to protect the “riser” as well as the combination valve on the top of the riser. The riser length on a typical underground tank is 14 to 28 inches. A shroud includes a hinged lid that surrounds the riser. This is a key identification feature for emergency responders. See Figure 8-17.

## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

The primary tactical objectives are to protect bystanders exposed to the propane vapor release and to disperse the propane vapors being released from the underground tank using fog streams from hoselines. The secondary objective is to repair the damaged riser with the assistance of the local propane dealer.

### METHODS OF CONFINEMENT AND LEAK CONTROL

The first initial action by the Incident Commander should be to implement site management procedures (e.g., isolate the area and deny entry, remove bystanders to a safe area, and establish Hazard Control Zones).

A call for technical assistance from the local propane dealer should be made as soon as possible. The dealer should be briefed on the nature of the problem so that the proper personnel and resources are dispatched to the scene.

Firefighters in full protective clothing and SCBA should deploy hoselines to disperse the flammable gas away from the primary source of ignition (the end loader). Two 1-1/2 or 1-3/4 inch hoselines flowing 100 gpm or higher are recommended. Fog nozzles should be placed on narrow angle fog patterns to aid in dispersing the flammable gas. A combustible gas indicator (CGI) should be used to determine if hoselines are effective in dispersing the gas.

Additional hoselines are recommended to backup the team dispersing the flammable gas and to stand by to protect exposures in case of accidental ignition.

Shutting down the end loader should not be attempted until hoselines have sufficiently dispersed the flammable gas and a CGI has confirmed that the area is within safe limits. Levels below 10% of the Lower Flammable Limit are considered safe for rescue and emergency operations.

Once the end loader has been safely removed, repair crews can gain access to the opening in the top of the tank and the riser. A qualified propane repairperson with proper protective clothing and equipment can make emergency repairs by replacing either the damaged piece of pipe, the ball valve, or the entire assembly. The top of the riser is threaded to a 2-1/2 inch male NPT. A temporary ball valve can be screwed into the pipe opening with propane vapor still flowing out. Note: The base of the riser is welded to the tank. If the riser has been sheared or damaged where it is connected to the tank, other techniques will have to be employed by container specialists.



All emergency repair operations must be done under the protection of wide-angle fog from a hoseline dedicated to the protection of the repair crew working on the pipe removal and replacement. Once the replacement parts are in place the area should be checked with a CGI before the hoselines can be shut down.

Additional factors to consider for this operation include:

- The scenario described is a common problem with underground tanks, even with proper installation and adequate protection. Damage to underground tank risers is usually caused by heavy construction equipment, or snow-plows.
- When an underground tank's riser is damaged and the pipe shears, there is an initial "blow-off" of the propane as the tank rapidly depressurizes. Once this initial blow-off occurs, the tank may go into auto refrigeration and the rate of release of flammable gas will slow down significantly. Rapid vaporization of the propane will also frost the underground tank's shell and freeze the ground around the area where the tank is exposed. The fact that the tank is in auto-refrigeration gives repair crews under the protection of hoselines time to change out the damaged parts, which are dispersing flammable vapors from the repair area. For a detailed explanation of auto-refrigeration and how it works, see Scan Sheet 9-B on page 260.
- Hoselines should be positioned so that they are effective in dispersing the flammable gas; however, if possible, keep water away from the tank shell and damaged riser. Water flooding the area can create mud and make repairs more difficult. Water can also warm the tank.
- Where possible, the back-up or standby hoseline should be supplied from a water supply which is independent of the primary hoselines dispersing flammable vapors in case the primary handline loses its water supply.
- During the course of the operation, and before leaving the scene, buildings and adjacent areas should be checked for flammable vapors using a combustible gas indicator (CGI).

#### SCENARIO #4

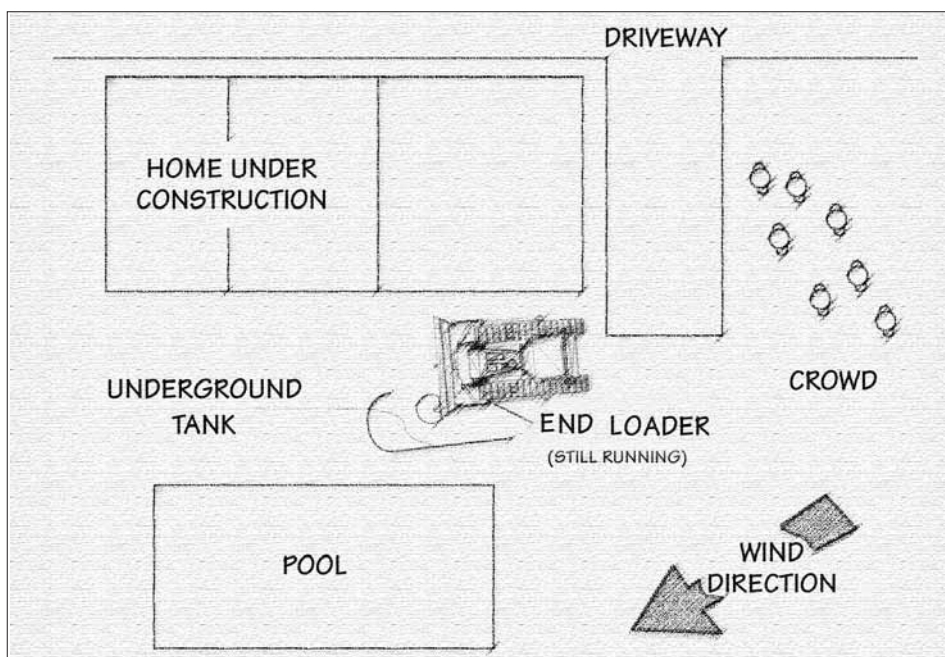


FIGURE 8-18

# SCENARIO #5

## MC-331 TRANSPORT CARGO TANK TRUCK WITH PROPANE LIQUID LEAK



FIGURE 8-19

A driver of an automobile lost control of his vehicle at high speed, and drove under the right side of an oncoming MC-331 transport cargo tank truck, which was making a righthand turn onto a bridge.

Upon arrival at the scene, the Incident Commander (IC) sizes up the situation. Under the protection of hoselines and in full protective clothing and SCBA, firefighters approach the accident site and find the automobile wedged under the propane truck, with the car's roof crushed level with the dashboard. A quick survey of the driver's injuries confirms that he has received fatal injuries. The propane truck driver has received minor injuries which will require medical treatment at the hospital.

Inspection of the damaged tank truck reveals the truck is placarded "1075" (the correct placard for propane). The truck is painted with the name of the propane transport company.

Under the protection of hoselines, a fire department officer observes that the truck's piping is severely damaged and has cracked open. The valve stem appears to be bent and is producing a vapor cloud. A liquid propane leak is observed on the bottom, lower section of the tank.



## SUMMARY OF TANK TRUCK CONSTRUCTION FEATURES

MC-331 cargo tanks for propane service have a design pressure of 250 psig [49 CFR 178.337-1(b).] They are constructed from steel metal sheets that are formed into a cylindrical shape, and then welded along the seams. Hemispherical or elliptical tank heads are welded to the barrel to form the tank. See Figure 8-20.

All MC-331 cargo tanks have pressure relief valves; temperature, pressure and liquid level gauges; liquid and vapor transfer lines and valves; and remote emergency valve controls.

Openings for transferring propane liquid and vapor are located in the bottom of the tank, either in the underside of the shell and/or in bottom half of the rear head. Openings for the pressure relief valves are located in the top of the tank.

Most propane cargo tanks are uninsulated and are required to have the upper two-thirds of the tank painted white, aluminum, or a similar heat reflective color.

## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

The primary tactical objective for this operation is to control or stop the propane liquid from escaping the bottom of the cargo tank truck. The secondary objective is to maintain site safety until the propane in the damaged tank truck can be transferred to another cargo tank truck.



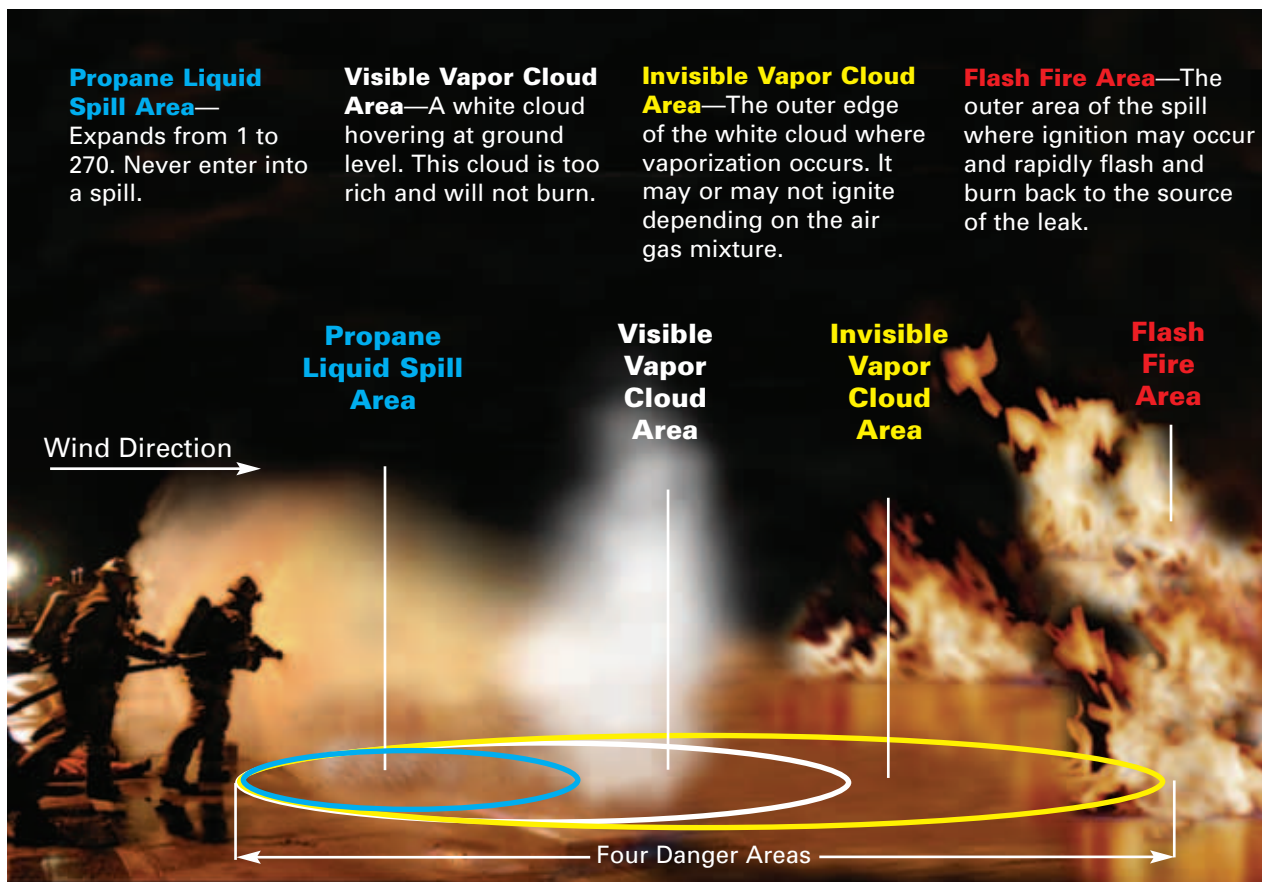
FIGURE 8-20 MC-331 transport cargo tank truck.

### METHODS OF LEAK CONTROL

The first initial action by the Incident Commander should be to implement site management procedures, (e.g., isolate the area and deny entry, remove bystanders to a safe area, and establish Hazard Control Zones.)

A call for technical assistance from the propane transport company should be made as soon as possible. The transport owner should be briefed on the nature of the problem so that the proper personnel and resources are dispatched to the scene.

Firefighters in full protective clothing and SCBA should deploy hoselines to disperse and dilute the flammable gas away from and off of the bridge. Two 1-3/4 inch hoselines flowing 100 gpm or higher are recommended; however larger hoselines or master streams may be necessary. A combustible gas indicator (CGI) should be used to determine the effectiveness of hoselines in dispersing the gas. If temperatures are expected to rise, water for container cooling as well as vapor suppression should be provided.



Concept by Hugh Keepers

**FIGURE 8-21A** The four danger areas of a propane emergency.

Given that the tank truck's piping and valves are severely damaged and there is a visible propane liquid leak on the bottom half of the tank, the cargo tank will have to be unloaded. Considerable time may pass until a compatible MC-331 is available on scene for product transfer. In the meantime, some attempt should be made to slow down or stop the leaking propane on the damaged tank.

Additional factors to consider for this operation include:

- When the ambient temperature is above 90°F, hosewater fog played on the top of the tank can be effective in keeping the tank's shell cool. The average temperature of hydrant water is 52°F. When ambient temperature is below 40°F water will warm the tank.
- Flammable vapors can present well beyond the visible vapor cloud area. See Figure 8-21A.
- Combustible gas indicator (CGI) readings should be taken throughout the incident to ensure that hoselines are effective in dispersing flammable vapors.

The Incident Commander has two tactical options for leak control:

- 1 **Fiberglass Wrap**—A vapor leak can be stopped with the use of a commercial fiberglass wrap material known as "Stop It"™. Field experience has shown that fiberglass wrap kits work successfully on most propane vapor leaks. The roll of Fiberglass Wrap is wetted and wound around the damaged pipe or valve.

When the wrap sets up it will stop a vapor leak up to 200 psig. However, if there is a liquid leak producing a vapor cloud that can be seen, these kits will not work.

2. **Freeze Wrap**—A liquid leak can sometimes be sealed off by the use of a freeze wrap which forms an ice patch over the leak area. A towel or fabric wrap is wetted, and then wrapped around the leaking valve or pipe. The wet cloth will freeze due to the propane liquid's very low temperature. **CAUTION:** Firefighters must wear heavy neoprene gloves suitable for working with low temperatures to avoid frostbite. Cloth or leather gloves can absorb liquid propane and result in injury. Freeze wraps should be monitored for reapplication. See Figure 8-21B.

Wet towel  
placed around  
leaking valve



FIGURE 8-21B Liquid leaks may be controlled by freeze wrap.

## SCENARIO #5

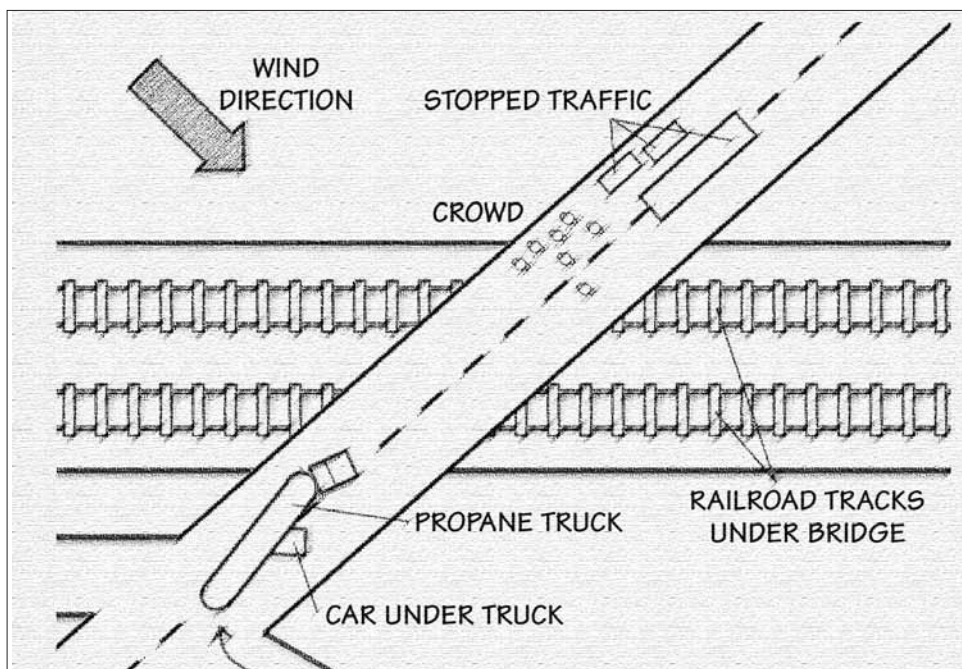


FIGURE 8-22



## SCENARIO #6

### BBQ GRILL FIRE NEXT TO A HOME



FIGURE 8-23

A barbecue grill supplied by a 20 pound portable propane cylinder has developed a leak at a loose connection and has ignited. The cylinder is being heated by direct flame impingement from the fire at the loose connection and has caused the pressure relief valve to operate. The burning BBQ grill is located next to a garage which is attached to a home. Fire is threatening to extend to the structure.

#### SUMMARY OF CYLINDER CONSTRUCTION FEATURES

Portable propane cylinders are widely used for small hand torches, barbecue grills, weed burners, space heaters, etc. They are usually refilled at cylinder filling stations and transported home and hooked up by the user.

Portable cylinder propane capacities range from a nominal pounds to 100 pounds. The nominal one pound cylinders are commonly used for torches, gas lanterns, and camping stoves. The 20 and 30 pound cylinders are mainly used for barbecue grills and space heaters. The 20 to 100 pound class cylinders are usually of two or three piece welded steel construction. Cylinders generally have one fitting welded in the service end of the cylinder. The fitting is threaded to a female NPT and is raised above the surface of the cylinder. One combination service valve and pressure relief valve are installed in the fitting. NFPA requires that all 20-pound propane cylinders be equipped with an Overfill Prevention Device (OPD). See Figure 8-24.



FIGURE 8-24

## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

The primary tactical objective is to cool the outside of the portable cylinder protecting the shell and reduce the pressure to the point that the pressure relief valve closes and the cylinder valve can be manually closed. The secondary objective is to protect exposures, extinguish any structural fires, and check for extension of the fire.

### METHODS OF EXTINGUISHMENT

A 20- to 100-pound class portable cylinder can be adequately cooled with 50 gpm. This can be provided through a 1-1/2 or 1-3/4 inch attack line flowing 100 gpm or higher. Once the tank is adequately cooled, the internal pressure will drop and the relief valve should reset. The primary attack crew can then approach the cylinder under the protection of handlines and manually close the tank valve. The approach should be perpendicular or opposite the relief valve discharge. A second handline should be used as a back-up line to initially cover the approach of the crew closing the valve on the tank and to protect exposures. Once the tank valve is closed, cooling water should be maintained to prevent reignition. The back-up crew can then shift to structural firefighting operations as required.

Additional factors to consider for this operation include:

- Where possible, the back-up handline should be supplied from a water supply which is independent of the primary attack line in case the primary handline loses its water supply.
- Heavier hose streams and fire flows may be required if the fire has spread to the structure.
- Check for fire extension inside the building, especially between the interior and exterior wall spaces and in the attic and void spaces.
- Portable cylinder valves are right-to-tight, left-to-loosen. Make sure you are turning the valve off, not on. Note that many valve hand wheels are plastic



or white metal and melt with flame impingement. Hand tools may be needed. Twelve-inch water pump pliers will turn the valve stem when the handle is broken.

- If copper gas lines are damaged, crimp off the line with pliers after the cylinder valve has been closed. The other alternative is to simply disconnect the line and plug the valve opening using a POL plastic plug.
- Continue to cool the tank until well after the fire has been extinguished. The metal surface should be cool enough to touch.
- The area around the cylinder and inside the adjacent structure should be monitored for flammable vapors using a combustible gas indicator (CGI).
- Notify the local propane supplier and obtain technical assistance.

### SCENARIO #6

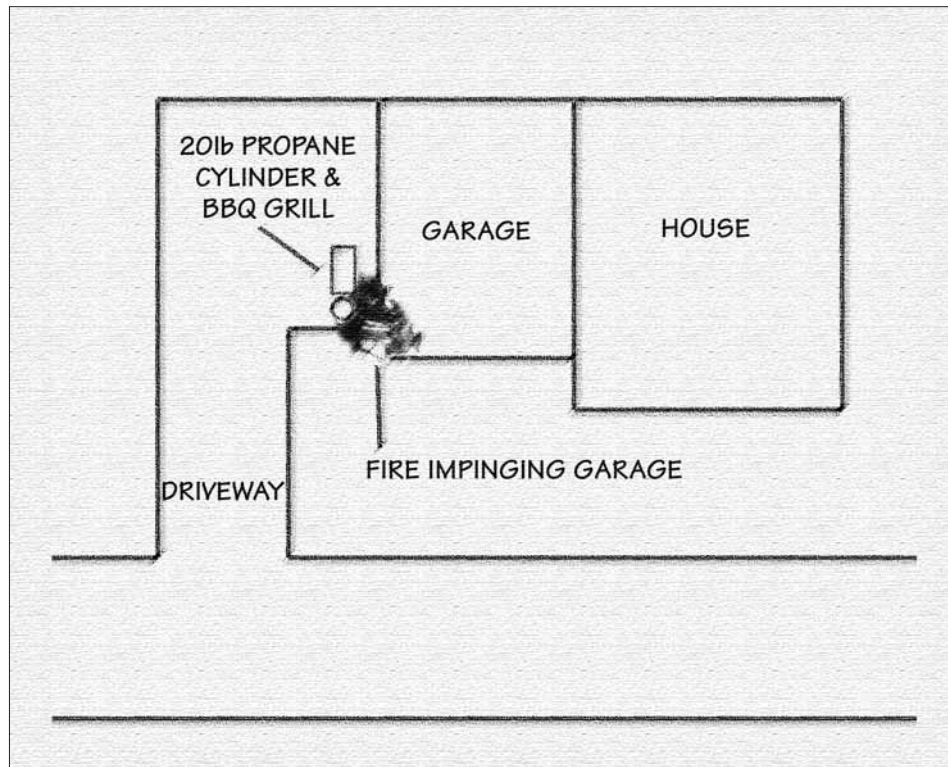


FIGURE 8-25

# SCENARIO #7

## FIRE INVOLVING STATIONARY TANK ON A FARM



FIGURE 8-26

A broken gas line near the bottom of a 1,000 gallon ASME stationary propane tank in agricultural service has resulted in a gas-fed propane fire. The fire is impinging on the outside shell of the tank below the liquid level. The tank's pressure relief valve is functioning intermittently and a plume of gas has ignited and is burning above the relief valve. The nearest exposure is a horse barn 75 feet away from the tank.

### SUMMARY OF TANK CONSTRUCTION FEATURES

ASME stationary tanks can be found at homes and at commercial, industrial, and agricultural facilities. Stationary tanks can also be found at service stations for refilling recreational and motor fuel tanks. Stationary tanks are normally filled from a bobtail truck.

Most stationary tanks are built by welding two heads to a barrel. Their capacities typically range from 250 to 2,000 gallons, with most tanks being less than 1,000 gallons. The normal working pressure for stationary propane service is 250 psig. Fittings for valves under 2,000 gallons capacity are normally threaded. Threaded attachments are commonly 1/4 inch to 2-1/2 inch female NPT with some special flanges for liquid level gauges. Openings are normally located on top of the tank. See Figure 8-27.

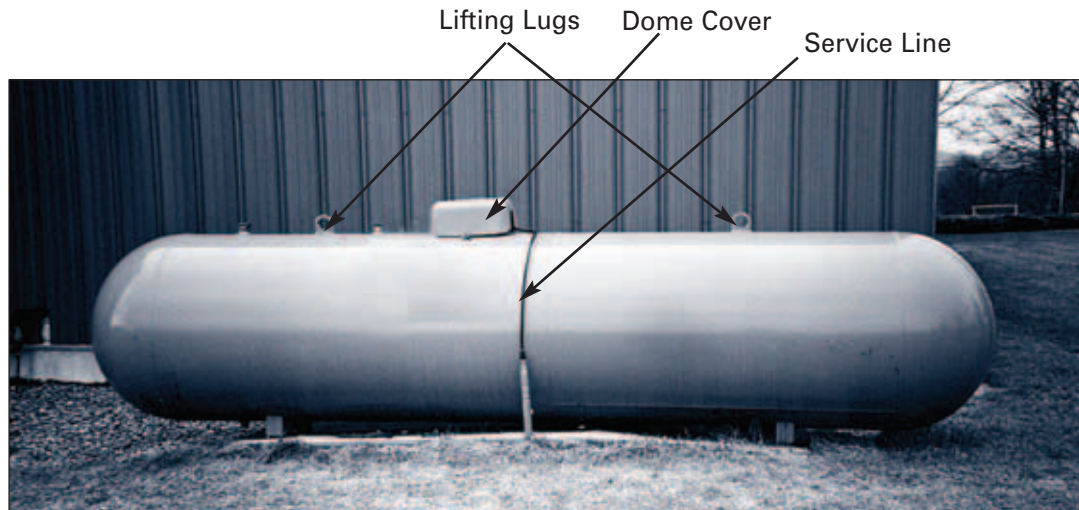


**FIGURE 8-27** 1,000 gallon ASME stationary tank.

## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

The primary tactical objective for this operation is to cool the outside of the stationary tank's shell at the point of flame impingement so that the internal tank pressure drops to the point where the relief valve closes and the tank valve can be manually closed. The secondary objective is to protect exposures, extinguish any ground or structural fires, and check for extension of the fire.

### METHODS OF EXTINGUISHMENT

A 1,000 gallon propane tank requires a minimum continuous flow of 100 gpm to adequately cool the tank shell. This can be provided through a 1-1/2 or 1-3/4 inch attack line flowing 100 gpm or higher. Two handlines are recommended to attack and extinguish the fire. The first line should be placed in service as soon as possible and be played evenly on the tank shell to keep it cool while the second line is being deployed. A third back-up line is recommended to protect the attack crews and protect exposures. The back-up line should be in service before the attack begins.

Crews should continue cooling the tank shell until the relief valve closes. Once the relief valve has closed, both attack teams will simultaneously advance toward the burning tank from the side of the tank, under the protection of fog patterns (a.k.a. power cone.) Nozzle patterns should be adjusted so that they overlap and provide the broadest possible protection as crews advance. When the tank is reached, a designated crew member should close the valve on the tank. This will isolate the broken gas line. Residual gas inside the broken line will burn off quickly and the fire will be extinguished.

Additional factors to consider for this operation include:

- If a fixed mounted master stream such as a deck gun on a pumper can be placed in service immediately, it should be directed onto the burning tank until hand-lines are deployed.
- It is important that nozzles on handlines match so that there is a constant flow and nozzle patterns are compatible. If variable gallonage nozzles are being used and are being supplied from two different pumpers, the driver/

- operators must ensure that they are maintaining a coordinated line and water flow.
- The back-up handline should be supplied from a water supply which is independent of the primary attack line in case the primary handline loses its water supply.
  - In rural water supply operations, it is important that pumpers be adequately resupplied so that water supplies are not expended once the initial attack begins. Water supplies obtained from portable drafting basins and shuttle tankers must be able to meet the required fire flows and be capable of supporting the fire attack. Request additional water resources in accordance with local practices early in the incident. If you doubt that the fire attack can be supported with an adequate water supply, switch to a non-intervention strategy.
  - Heavier hose streams and line and water flows may be required if the fire has communicated to the structure (e.g., in this scenario, the barn is a primary exposure).
  - Stationary tank valves are right-to-tight, left-to-loosen. Make sure you are turning the valve off, not on.
  - If copper gas lines are damaged, crimp off the line with pliers after the tank's valve has been closed. Another alternative is to plug the valve using a left-handed thread POL plug.
  - Continue to cool the tank until well after the fire has been extinguished. The initial application of water to the super-heated steel will generate steam. When steam no longer appears it is an indication the situation is coming under control. The metal surface should be cool enough to touch.
  - The area around the tank and inside the adjacent structure should be monitored for flammable gas using a combustible gas indicator (CGI.)

### SCENARIO #7

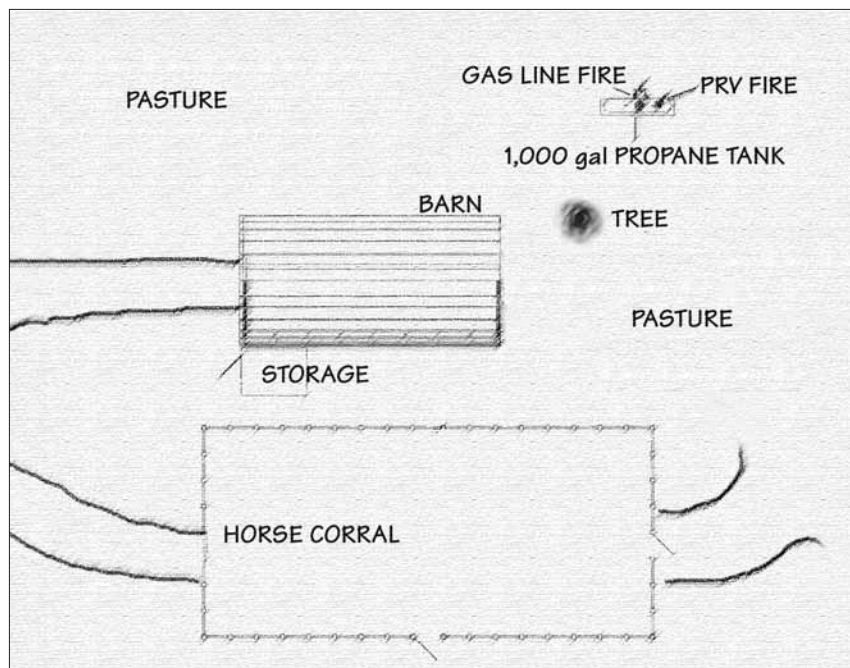


FIGURE 8-28



# SCENARIO #8

## PROPANE FUELED DELIVERY TRUCK FIRE



FIGURE 8-29

A propane-powered box-type delivery truck has failed to negotiate a turn and has struck a utility pole. The engine compartment is on fire and the driver is unconscious and pinned inside the cab behind the steering wheel. A propane-fed fire in the engine compartment has also ignited the left front tire of the vehicle. Fire from the burning tire is impinging on the truck's left side propane fuel tank. The propane pressure relief device has not activated and there are visible signs that the tank has been stressed.

### SUMMARY OF TANK CONSTRUCTION FEATURES

Propane motor fuel tanks may be installed in cars, vans, pick-up trucks, and buses. While propane-fueled vehicles have been around for decades, they are now entering the national fleet in significant numbers. They serve the same purpose as gasoline, diesel, or natural gas fueled vehicles, except the fuel is propane. Many propane-powered motor vehicles are dual fueled and may also be equipped with gasoline tanks, which allow the operator to switch fuels based on availability and price.

Propane motor fuel tanks are manufactured in a variety of shapes to accommodate different vehicle designs. Their capacities range from 4 to 65 gallons, with most trucks and automobile tanks ranging from 35 to 65 gallons capacity. Many of these tanks are mounted in automobile trunks.



Motor fuel tanks have a maximum working pressure of 250 or 312.5 psig, depending upon whether they are mounted in an “open” or “enclosed” configuration. *NFPA 58—Liquefied Petroleum Gas Code* requires that relief valves be vented to the outside of the vehicle. Relief valve discharge points on passenger cars shall be directed upward or downward within 45 degrees of vertical. Responders should locate the discharge points and avoid standing in this area. Relief vent piping on trucks often vents at the top of the truck.

Most valve fittings are threaded and are limited to 1/4-inch, 3/4-inch, or 1 inch female NPT. Mobile tanks usually have a maximum of five threaded openings. Fittings must also be vented to the outside of the vehicle when the tank is installed in a confined area like a trunk or inside a camper shell or shall be gas tight with respect to the driver or passenger compartments and to any space containing radio transmitters or other spark-producing equipment. In some vans and cars, the tank installation may consist of two or three tanks manifolded together.

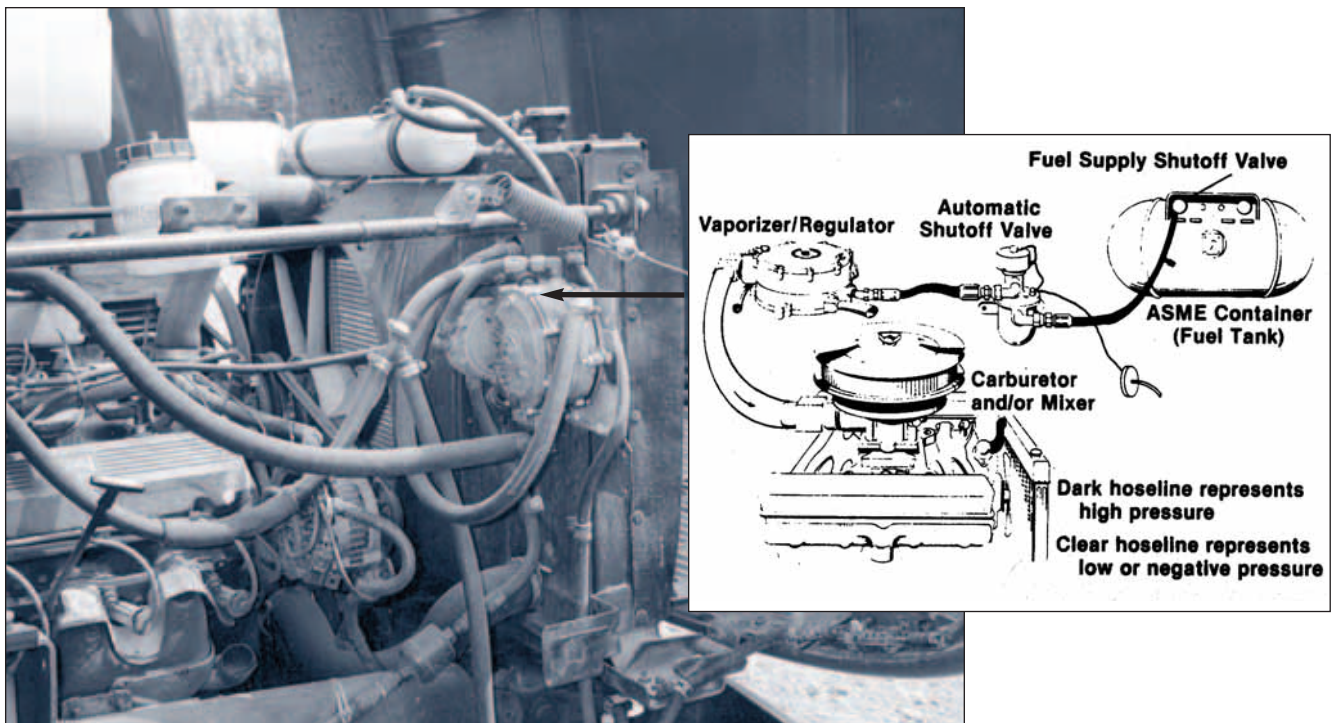


**FIGURE 8-30** Typical installations of propane fuel containers and piping on motor vehicles.

## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

The primary tactical objective for this operation is to protect and rescue the injured driver inside the truck cab by rapidly attacking and extinguishing the engine compartment and tire fire, which are exposing the propane motor fuel tank to flame impingement. The secondary objective is to locate and manually close the fuel shut-off valve on the propane fuel tank and continue to cool the propane tank while the driver is being extricated and receives emergency medical care.

## METHODS OF EXTINGUISHMENT

Fire water flows of 100 gpm are adequate for cooling motor fuel tanks of under 65 gallons capacity. Two 1-1/2 or 1-3/4 inch attack lines flowing 100 gpm or higher are recommended to cool the motor fuel tank, protect the occupant inside the vehicle, and attack and extinguish the engine compartment and tire fires.

Because the truck driver is pinned behind the steering wheel and will require extrication, an initial attack crew should place their line in service as soon as possible and rapidly attack and extinguish the tire fire on the left side of the vehicle, which is exposing the motor fuel tank to flame impingement. Controlling the tire fire will also reduce the driver's exposure to toxic smoke generated from the burning rubber. Once the fire is brought under control, the attack crew should remain stationed on the left side of the truck and continue to cool the propane motor fuel tank. The crew should locate and close the fuel supply shut-off valve. A second crew should attack and extinguish the engine compartment fire, then cover the rescue and emergency medical team while they rescue and treat the truck driver.

Additional factors to consider for this operation include:

- Rescue is always the highest priority and the decision to rescue and extricate an injured person from a burning vehicle is a judgment call. As a general rule, unless the patient is in immediate life-threatening danger from burning or smoke inhalation, it is usually better to attack and extinguish the fire which is threatening the driver's life, then provide life saving emergency care. You must weigh the risk of seriously injuring the driver by simply pulling him or her from the vehicle (e.g., spinal cord injury versus the risk of exposure to smoke and heat) while attempting to extinguish the fire. This decision has to be made on a case-by-case basis based on actual conditions.
- Tire fires on motor vehicles can present significant exposure problems. Remember that one tire contains about 15,000 BTU's per pound of energy (double the output of class-A combustibles) and can generate intense heat and toxic smoke. A combination hoseline and dry chemical extinguisher attack is an effective combination for quickly extinguishing tire fires.
- Propane fires in engine compartments can be controlled by stopping the engine and shutting off the supply valve on the fuel tank. Remember, even though the supply valve has been shut off, the fuel line still contains propane. It will take every short period of time for the leak or fire to stop, depending on the size of the fuel line and leak. See Figure 8-31.
- Motor fuel tank shut-off valves are right-to-tight, left-to-loosen. Make sure you are turning the valve off, not on.
- Continue to cool the tank until well after the fire has been extinguished. The metal surface should be cool enough to touch.
- Secondary hazards should be evaluated including energized power lines, traffic control, the integrity of the damage utility pole, etc.
- Once the fire has been extinguished, the area around the tank should be monitored for flammable gas using a combustible gas indicator.
- Contact the local propane marketer for technical assistance.

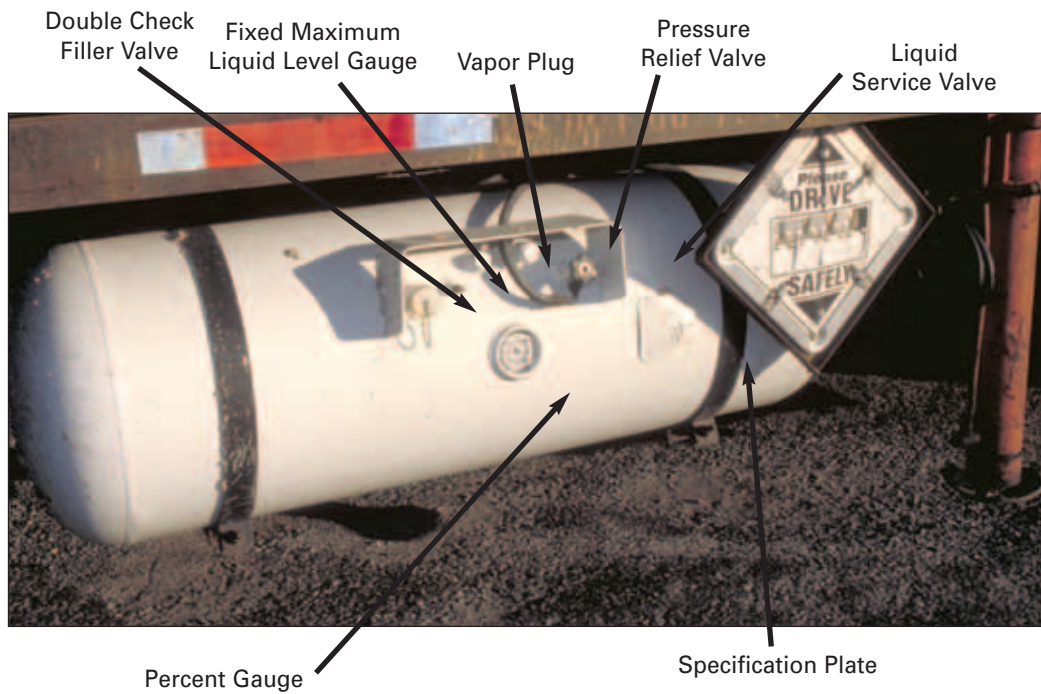


FIGURE 8-31 Key features of motor fuel tanks.

## SCENARIO #8

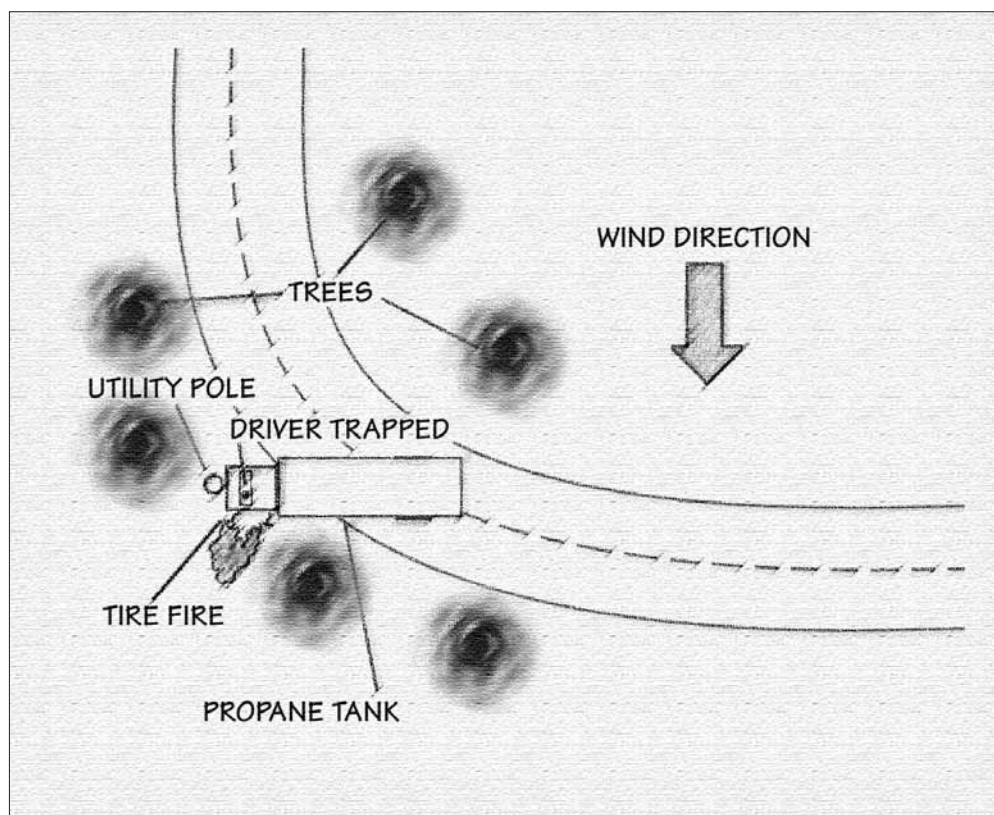


FIGURE 8-32



## SCENARIO #9

### FIRE INVOLVING BOBTAIL DELIVERY TRUCK



FIGURE 8-33

A bobtail propane delivery truck has been involved in an accident on a two-lane highway. The bobtail stopped at an intersection for a red light and was struck from the rear by a cargo truck. The severe impact produced a liquid propane leak at the rear of the bobtail truck. The propane gas has ignited and flames are impinging on the back of the tank. Two pressure relief valves (PRVs) are intermittently opening and gradually closing down. The wind is blowing toward the bobtail's tank at about 15 mph.

The driver of the cargo truck is still in the cab, slumped down over the steering wheel. The driver of the bobtail truck is not injured and has offered to shut a valve that will extinguish the propane fire.

#### SUMMARY OF TANK CONSTRUCTION FEATURES

A bobtail propane delivery truck is essentially a bulk storage tank on wheels. It is the primary vehicle used to deliver propane from bulk plants to customers. The average bobtail truck has a capacity of 750 to 6,000 gallons. The basic vehicle consists of two parts: the truck and the propane tank. Pressure relief valves (PRVs) are installed in the vapor space of the tank and are set to function at 250 psi.

The tank is also protected by an excess flow valve, back flow check valve, and emergency shut-offs. Temperature, pressure, and liquid level gauges are installed



on the side or rear head of the tank. Vapor connections are generally in the lower rear of the bobtail truck and communicate with the vapor space by means of a standpipe. They are protected by an excess flow device as well as a valve with a manual mechanism and a fusible link. The main liquid withdrawal appurtenance is generally in the belly (bottom) of the tank and is protected by an internal valve with an excess flow feature to which a pump is attached. The liquid fill line is generally found in the lower rear of the tank near the vapor connections.

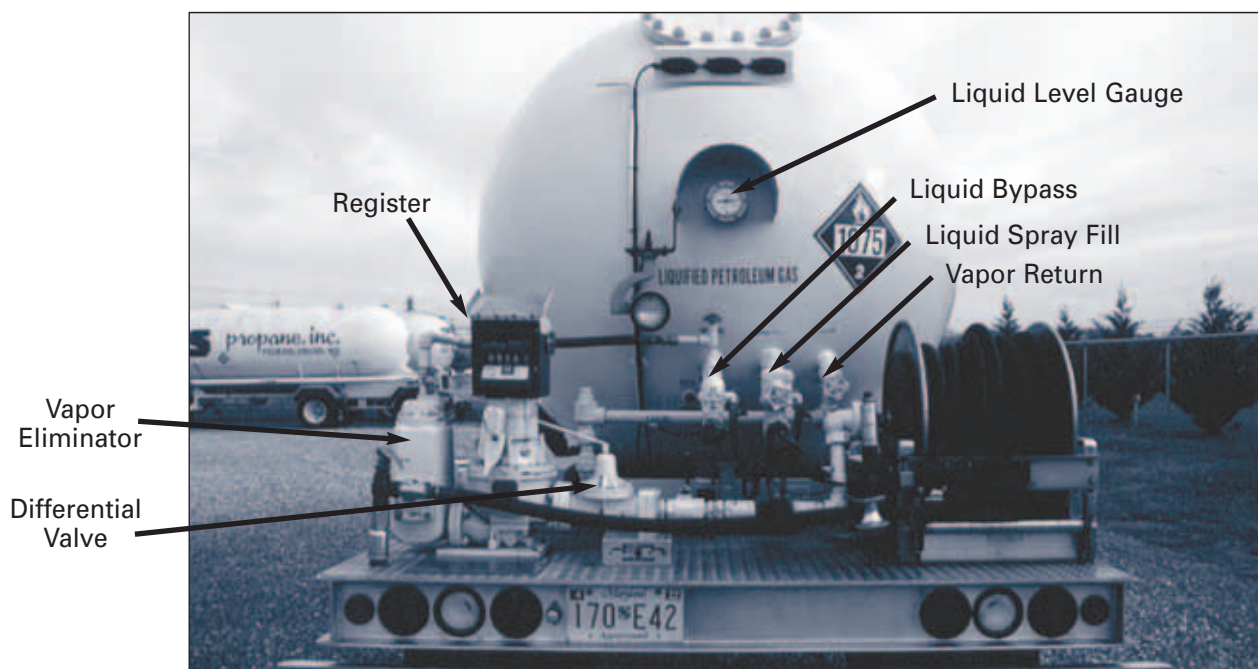


FIGURE 8-34 Features of bobtail (rear view).

## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

The primary tactical objectives for this operation are to control the fire and hold it in check until the driver is rescued and the propane leak can be stopped.

### METHODS OF CONTROL AND EXTINGUISHMENT

While a crew is assigned to rescue the driver of the cargo truck, the bobtail driver should be consulted to determine what options there are to stop the flow of propane using the bobtail's valves and safety devices. For example, what is feeding the fire? It is probable that some part of the bobtail's meter or pumping circuit has been damaged by the rear-end collision. In these types of scenarios, less than 10 gallons of propane remains in the pumping system, depending on the hose size and length. The fire should burn no more than 15 minutes before running out of fuel.

The driver should be questioned to confirm that the emergency shut-off has been activated; otherwise the fire may continue to be fed.

Since PRVs work intermittently at their preset pressure of 250 psi, it is likely that the situation will stabilize quickly as soon as the fire has been extinguished. Hoselines should be deployed to control the fire at the rear of the bobtail and protect the rescue crew.

Fire water flows of 200 gpm are adequate for cooling bobtail delivery vehicle tanks with capacities under 5,000 gallons. Streams should be directed at the point of flame impingement and on the upper half of the tank shell of the entire tank. Four 1-3/4 inch or larger handlines are recommended to cover the rescue crew, cool valving and piping at the rear of the truck, extinguish any spot fires, and cool the vapor space on the propane tank. Firefighters should continue cooling the tank shell until the fire is extinguished or the pressure relief valve remains closed or evidence of refrigeration is present. The tank should be cool to touch.

Additional factors to consider for this operation include:

- Another common source of fires on a bobtail involving side or rear low-speed collision accidents is the vehicle's on-board fuel system. Many propane bobbails use propane as a motor fuel. The propane may be taken from a small shut-off valve near the bottom of the front head of the cargo tank. A simple shut-off is located at the tank's entrance. Other variations use a separate motor fuel tank, which is usually mounted on the driver's side frame, just behind the cab. The valve is screwed directly into the tank. Generally, a hose runs under the cab and up to the filter-lock and then into the vaporizer (the mixer and the throttle body of the carburetor or fuel injection system). The line feeds liquid propane to the vaporizer, which changes the liquid to vapor. When the truck's ignition key is turned off, the filter-lock closes off the fuel supply. If the engine stops for any reason, the flow of propane stops. The tank also has an excess flow valve on it. So, if a bobtail is involved in a fire, make sure that the vehicle's ignition system key is turned completely off.
- If a fixed mounted master stream such as a deck gun on a pumper can be quickly placed in service, it should be directed onto the bobtail's burning tank at the point of flame impingement until handlines are deployed.
- It is important that nozzles on the attack crew's handlines match so that there is a constant flow and nozzle patterns are compatible. If variable gallonage nozzles are being used, and are being supplied from two different pumpers, the driver/operators must ensure that they are maintaining a coordinated fire flow that is delivering at least 100 gpm to both handlines.
- When possible, handlines from the primary attack crews should be supplied from two different water supplies. If either handline loses its water supply, the crew will still be protected by at least one functioning line.
- Larger diameter hose streams and master streams can be used as an alternative to the use of four handlines.
- Propane tank truck tank valves are right-to-tight, left-to-loosen. Make sure you are turning the valve off, not on. On some bobbails, valves may be quarter turn lever handles.
- Continue to cool the tank until well after the fire has been extinguished. The metal surface should be cool enough to touch. Ensure that adequate water supplies are established to support prolonged cooling operations.
- Contact the bobtail owner for specialized technical expertise in evaluating the damaged vehicle.

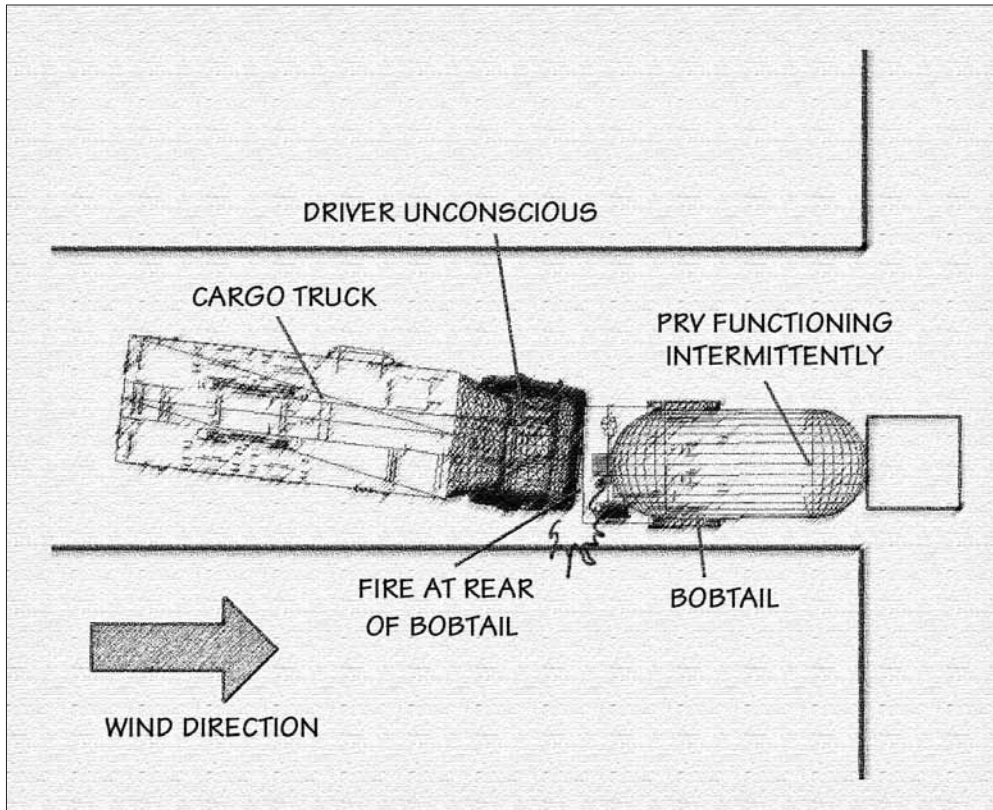


FIGURE 8-35

# SCENARIO #10

## OVERTURNED RAILROAD TANK CAR WITH FIRE



FIGURE 8-36

A DOT-112 railroad tank car transporting propane has been involved in a high-speed derailment in a remote rural area approximately 500 feet from a two-lane road. The rail car is overturned on its right side and the car's topside pressure relief valve is below the liquid level in the tank. An adjacent rail car of acetone has been breached and is on fire. A running pool fire of burning acetone is exposing the propane rail car to intense heat. The propane rail car's pressure relief valve is functioning due to the increased internal pressure in the car.

Since the pressure relief valve is below the liquid level, liquid propane is being forced out of the relief valve and is exposing the upper half (right side) of the car to heavy fire.

### SUMMARY OF TANK CONSTRUCTION FEATURES

Railroad tank cars are a principal means of moving bulk propane from refineries and gas plants to bulk plants. The rail car is simply a large cargo tank on a rail car chassis. Small rail cars have water capacities between 11,000 and 12,000 gallons, while modern "Jumbo" tank cars can have capacities as high as 34,500 gallons. Like propane cargo tank trucks, rail cars are equipped with a topside pressure relief valve. To measure product temperature, pressure, and liquid, gauging devices are installed on the top of the tank. The liquid and vapor connections on the tank are protected and enclosed inside a dome cover. No openings of any kind are permitted on the bottom of any propane rail car.



## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

The primary tactical objective for this operation is to evaluate the potential for container failure, begin immediate withdrawal of the area, and start an evacuation.

### METHODS OF EXTINGUISHMENT

This incident has almost everything working against emergency responders. Additional factors to consider for this operation include:

- The rail car is being exposed to heavy fire impingement in the vapor space. Sources include both the pressure-fed liquid fire escaping from the propane car's relief valve and the flowing acetone fire. These fires will intensify rapidly over time and subject the propane car tank shell to even higher temperatures.
- The relief valve is venting liquid propane. Under normal circumstances, the relief valve would be positioned in the vapor space and would be venting propane vapor, not propane liquid. However, since the rail car is on its side, the relief valve is below the liquid propane level inside the tank. Consequently, as the internal pressure increases, the valve will function and vent liquid out onto the ground. It is very important to recognize that one cubic foot of propane will boil off into approximately 270 cubic feet of vapor (1 gallon of propane = 37 cubic feet of vapor). Therefore, the pressure-fed liquid propane fire will rapidly grow in intensity.

It is also important to understand that venting of liquid will not lower the pressure in the container. Pressure will continue to rise as energy is applied to the liquid in the tank. It should be noted that similar conditions could exist when propane tank trucks are overturned since the relief valves are on top of the truck.

- The train derailment has occurred in a remote rural area with limited site access and limited water supplies to support firefighting operations. Unless adequate cooling water can quickly be placed on the burning propane and acetone rail cars, the propane rail car will very likely fail (the BLEVE scenario).
- The derailment is located near a rural two-lane road. Spectators and emergency response vehicles will quickly back up on the road. Given the size of the fire, limited water supply, and limited access to the derailment site, the Incident Commander should use the available emergency response resources to isolate the area and begin evacuation of people on the highway. The minimum initial evacuation zone should be 3,000 feet based on the DOT Emergency Response Guidebook. (Note: This recommendation is consistent with findings based on actual projectile distances from 52 actual LPG rail car BLEVEs. Projectiles traveled up to 2,700 feet [823 m]. See Campbell, J. A., Estimating the Magnitude of Macro-Hazards, Society of Fire Protection Engineers, Report 81-2, Boston, Massachusetts, 1981.) This initial evacuation area may need to be expanded based on actual hazards and risks encountered.



FIGURE 8-37 DOT-112 rail car.

- Contact railroad authorities and ensure that the rail line has been closed upstream and downstream of the derailment and that railroad response specialists have been notified.

**SCENARIO #10**

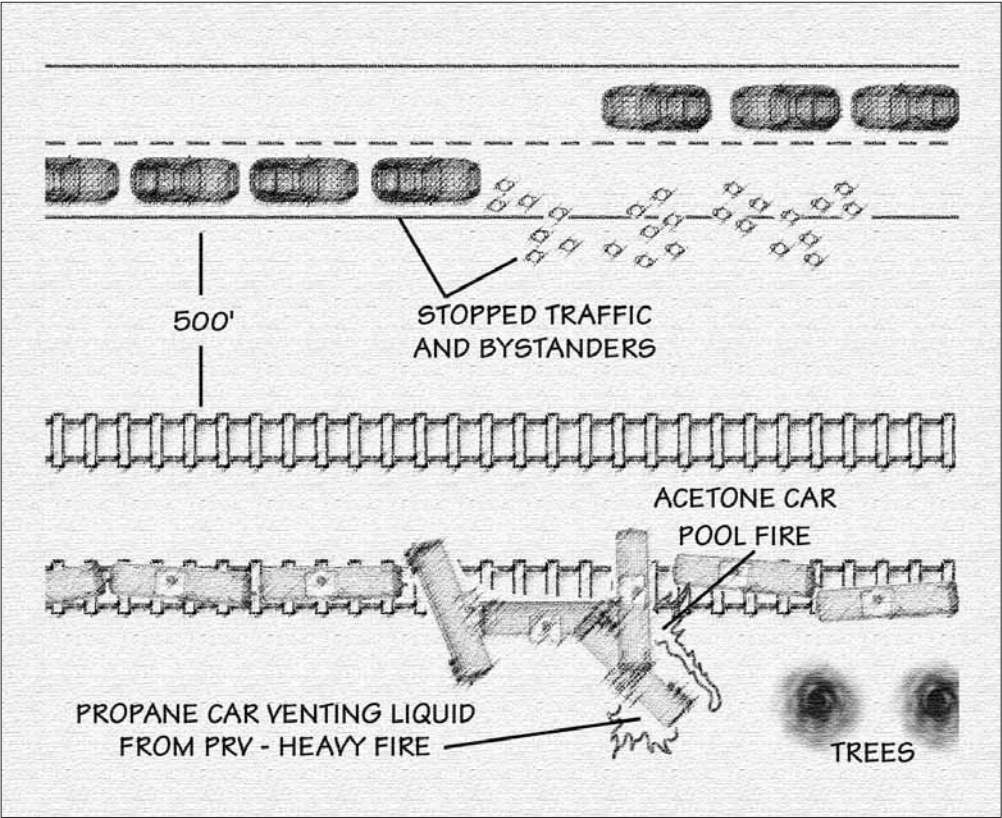


**FIGURE 8-38**

# SCENARIO #11

## GAS RELEASE INVOLVING STATIONARY TANK



FIGURE 8-39

A propane leak has occurred under the dome cover of a 1,000 gallon ASME stationary aboveground tank. The propane gas is drifting slowly away from the tank and is settling in the area between the tank and the wall of a factory, 25 feet away from the tank. An adjacent 1,000 gallon storage tank is next to the leaking tank but is not involved. A church, grocery store and gasoline station are across the street. The 911 caller informed the emergency responders that they saw children playing around with the tank just before the leak occurred. The incident has occurred in the early morning, and the temperature is 48°F. The weather forecast calls for steadily increasing temperatures to 70°F by 3:00 pm.

### SUMMARY OF CONSTRUCTION FEATURES

ASME stationary tanks can be found at homes and at commercial, industrial, and agricultural facilities. Stationary tanks can also be found at service stations for refilling recreational and motor fuel tanks. Stationary tanks are normally filled from a bobtail truck.

Most stationary tanks are built by welding two heads to a barrel. Their capacities typically range from 250 to 2,000 gallons, with most domestic tanks being less than 1,000 gallons. ASME tanks are designed for different working pressures depending on their intended service. The normal working pressure for stationary propane service is 250 psig. Fittings for valves under 2,000 gallons capacity are threaded. Threaded appurtenances are commonly 1-1/4 inch female NPT for multiple valves or 2-1/2 inch female NPT for multiple valves with some special flanges for liquid level gauges. Openings are normally located on top of the tank.

## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

The primary tactical objectives are to control ignition sources and disperse the flammable vapors being released from the aboveground tank using fog streams from hoselines.

The secondary objective is to secure the leak and repair the damaged container with the assistance of the local propane dealer.

### METHODS FOR CONTROL OF LEAKING GAS (NO FIRE)

The first initial action by the Incident Commander should be to implement site management procedures, (e.g., isolate the area and deny entry, remove bystanders to a safe area, and establish Hazard Control Zones.)

A call for technical assistance from the local propane dealer should be made as soon as possible. The dealer should be briefed on the nature of the problem so that the proper tools and parts are dispatched to the scene.

Firefighters in full protective clothing and SCBA should deploy hoselines to disperse and dilute the flammable gas away from the primary source of ignition. Two 1-1/2 or 1-3/4 inch hoselines flowing 100 gpm or higher are recommended. Fog nozzles should be placed on narrow angle fog patterns to aid in dispersing the flammable gas. The placement of the hoselines should be such that the propane gas is directed away from the wall of the factory.

- A Combustible Gas Indicator (CGI) should be used to determine if hoselines are effective in dispersing the gas. Readings should be taken with potential exposures in mind; (e.g., downwind areas where severe exposures could exist, inside occupied areas or locations where the gas could travel, downhill, below grade and other confined areas.)
  - (a) A reading should be taken downwind to see if the gas is dispersed. When Combustible Gas Indicator (CGI) readings indicate levels of 10% of the lower flammable limit or greater, additional charged handlines should be in place as a precautionary measure.
  - (b) A reading should be taken outside and inside the building to determine if propane gas has migrated into the building. If CGI readings exceed 10% of the lower flammable limit, the entry team should withdraw and ventilate the building using positive pressure ventilation. Ventilating the interior space will lower the level of flammable vapors inside the structure.
  - (c) When Combustible Gas Indicator (CGI) readings indicate detectable levels of flammability, responders should not activate potential ignition sources (e.g., light switches, garage doors, or interior heating and air conditioning or ventilating equipment).
  - (d) Other readings should be taken to assure that the propane gas is not drifting towards other exposures, structures or hazards.
  - (e) Propane gas dissipates rapidly but may settle in low unventilated areas. Readings should be taken in sewers, manholes, or below grade areas.
- Flammable Atmospheres—OSHA and most national consensus standards consider a flammable atmosphere containing concentrations of 10% or less of the lower flammable (explosive) limit (LFL) as acceptable for conducting rescue operations.



- (a) Areas with flammable concentrations of 10 to 20% of the LFL are considered hazardous and should not be entered by rescue teams unless they have proper PPE.
- (b) As flammable readings rise above 20%, the level of risk to responders also rises. Rescue personnel operating in flammable concentrations of 50% of the LFL or greater should immediately leave the hazardous area.
- Additional hoselines are recommended to back-up the team dispersing the flammable gas and to stand-by to protect exposures in case of accidental ignition.
- A repair crew can gain access to the dome cover and valve on the top of the tank. A qualified propane repair person with proper protective clothing and equipment can determine the problem and make emergency repairs by either shutting the valve or replacing the damaged equipment. All emergency repair operations must be done under the protection of wide-angle fog from a hoseline dedicated to the protection of the repair crew. Once the replacement parts are in place the area should be checked with a CGI before the hoselines can be shutdown.

Additional factors to consider for this operation include:

- Hoselines should be positioned so that they are effective in dispersing the flammable gas.
- Where possible, the back-up or standby hoseline should be supplied from a water supply that is independent of the primary hoselines dispersing flammable vapors in case the primary handline loses its water supply.
- Before leaving the scene the interior of buildings in the area should be checked again for flammable vapors using a Combustible Gas Indicator (CGI). There should be no reading on the CGI.

## SCENARIO #11

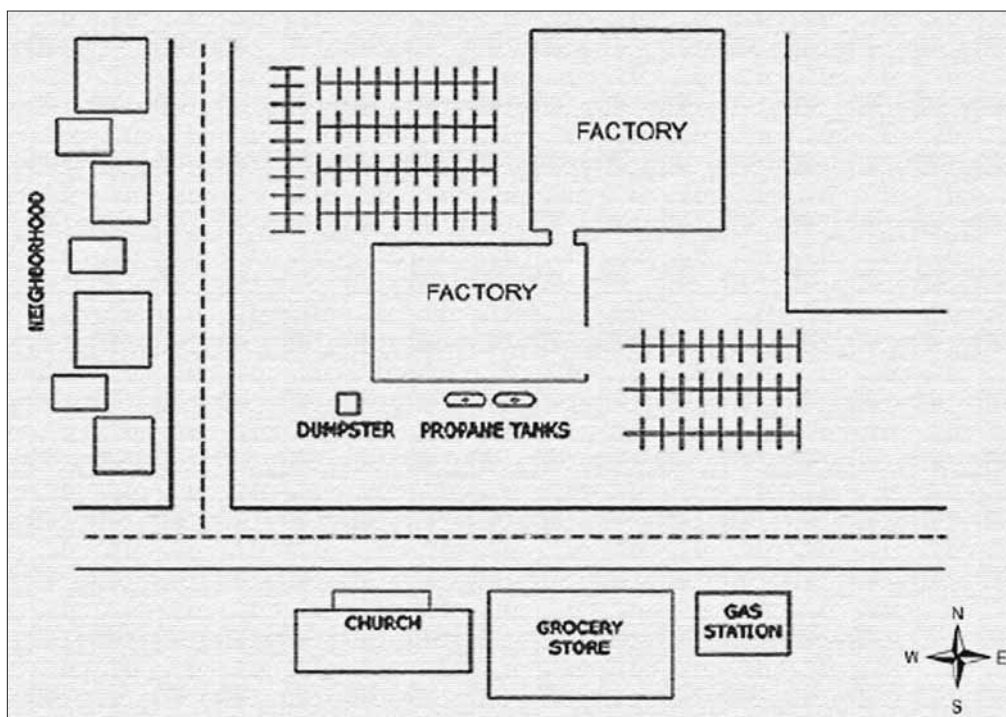


FIGURE 8-40

# SCENARIO # 12

## FIRE INVOLVING STATIONARY TANK



FIGURE 8-41

A carelessly discarded cigarette by a passing motorist has started a grass fire in the rear of Noll Manufacturing. The fire has spread along the highway and is now spreading to and under a 1,000 gallon ASME stationary aboveground storage tank. The propane tank is 25 feet away from the wall of the high school gymnasium. An adjacent 1,000 gallon storage tank is next to the burning tank but is not involved. A church, grocery store, and gasoline station are across the street. The fire has been burning for some time and several spectators are present. Shortly after the arrival of emergency responders, the pressure relief valve operates and ignites. The spectators inform the responders that the grass fire has been burning for about 25 minutes but only in the last few minutes has it reached the propane storage tank. There is discoloration on the burning tank and some of the paint is beginning to blister. There is no discoloration or blistering on the adjacent tank.

### SUMMARY OF CONSTRUCTION FEATURES

ASME stationary tanks can be found at homes and at commercial, industrial, and agricultural facilities. Stationary tanks can also be found at service stations for refilling recreational and motor fuel tanks. Stationary tanks are normally filled from a bobtail truck.

Most stationary tanks are built by welding two heads to a barrel. Their capacities typically range from 250 to 2,000 gallons, with most domestic tanks being less than 1,000 gallons. ASME stationary tanks are designed for different working pressures depending on their intended service. The normal working pressure for stationary

propane service is 250 psig. Fittings for valves less than 2,000 gallons capacity are normally threaded. Threaded appurtenances are commonly 1-1/4 inch male NPT or 2-1/2 inch female NPT for multiple valves with some special flanges for liquid level gauges. Openings are normally located on top of the tank.

The nature of pressure vessels and containment systems makes them vulnerable to external heating.

- A propane tank contains liquid and vapor. Any external fire creating direct flame impingement in the vapor space will heat the tanks shell. The fire will heat the tank shell in the vapor space more rapidly than in the area in contact with liquid.
- In most cases the tank's pressure relief valve (PRV) will function early in the fire. As the PRV functions gas escapes, lowering the liquid level inside the tank, even further, thus exposing a larger surface area of the tank in the vapor space.
- Firefighters should be aware that a functioning pressure relief valve on a burning propane tank is not a reliable indication that the tank is safe to approach or a reliable indicator of when or if a tank may fail. Likewise, containers may fail even if the pressure relief valve is not operating.
- Rapid application of cooling water on the outside of the tank above the liquid level can reduce the likelihood of container failure by lowering the external temperature of the shell of the exposed tank.
- Cooling water applied to the tank will not necessarily lower the temperature of the liquid inside the container. Basically, the liquid acts as a heat sink and protects itself. This is why failure of the tank in the liquid space is non-existent.
- Any decision to approach a propane tank showing direct flame impingement on its vapor space must be made on a case-by-case basis after evaluating the hazards and risks. How long fire has been impinging on the tank is a key risk factor.

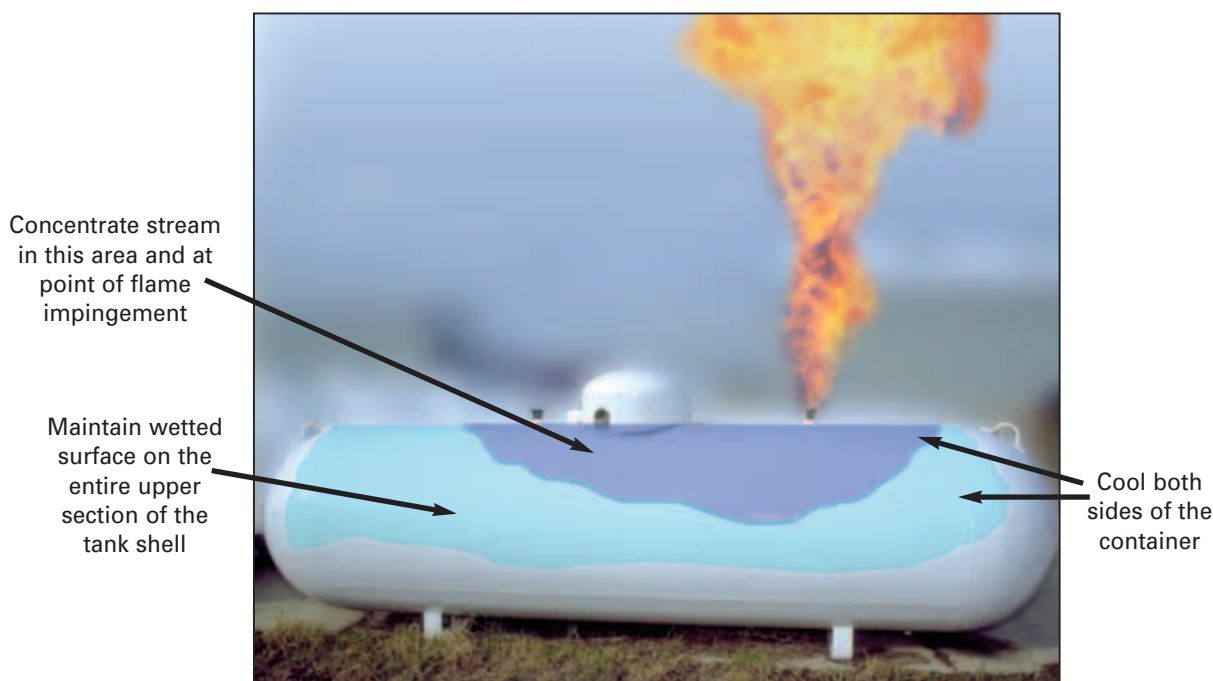


FIGURE 8-42

- Bulk storage tanks can fail within 20 to 30 minutes of direct flame impingement if containers are not adequately cooled.

## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

The primary objective is to cool the total surface area on the outside of both stationary tank shells and at the point of flame impingement so that the internal tank pressure of the burning tank drops to the point where the pressure relief valve closes and the tank valve can be manually closed.

Secondary objectives are to protect exposures, extinguish any ground or structural fires, and check for extension of the fire into the school gymnasium.

### METHODS FOR CONTROL IN THE EVENT OF FIRE

- 1 This 1,000 gallon propane tank requires a minimum continuous flow of 100 gpm on the entire tank surface to adequately cool the tank shell. This can be provided through a 1-1/2 or 1-3/4 inch attack line flowing 100 gpm or higher for each tank. Two handlines are recommended to attack and extinguish the fire. The first line should be placed in service as soon as possible and be played evenly on the burning tank shell to keep it cool while the second line is being deployed. The third line should be placed on the adjacent tank. A fourth line is recommended to protect the attack crews and protect exposures.
- 2 Crews should continue cooling the tank shell until the pressure relief valve closes and the tank shell does not produce steam. Once the pressure relief valve has closed and the tank shell is cooled both attack teams should simultaneously advance toward the burning tank from the side of the tank, under the protection of fog patterns. Nozzle patterns should be adjusted so that they overlap and provide the broadest possible protection as crews advance to close the tanks valve under the dome cover.
3. Cooling water must be applied at the point of flame impingement and on the entire upper half of the tank shell.
  - (a) Maintain a wetted surface on the entire upper section of the tank shell.
  - (b) Remember to cool both sides of the container.
  - (c) Continue to cool the tank until well after the fire has been extinguished. The initial application of water to the super heated steel will generate steam. When steam no longer appears it is an indication the situation is coming under control. The metal surface should be cool enough to touch.

Additional factors to consider for this operation include:

- If a fixed mounted master stream such as a deck gun on a pumper can be placed in service immediately, it should directed onto the burning tank until handlines are deployed.
- It is important that nozzles on handlines match so that there is a constant flow and nozzle patterns are compatible. If variable gallonage nozzles are being used and are being supplied from two different pumps, the driver/operators must ensure that they are maintaining a coordinated fire flow.



- The back-up handline should be supplied from a water supply which is independent of the primary attack line in case the primary handline loses its water supply.
- In rural water supply operations, it is important that pumpers be adequately supplied so that water supplies are not expended once the initial attack begins. Water supplies obtained from portable drafting basins and shuttle tankers must be able to meet the required fire flows.
- Heavier hose streams and fire flows may be required if the fire has communicated to the structure, e.g., in this scenario, the school is a primary exposure.
- The area around the tank and inside the adjacent structure should be monitored for flammable gas using a combustible gas indicator (CGI.)

## SCENARIO #12

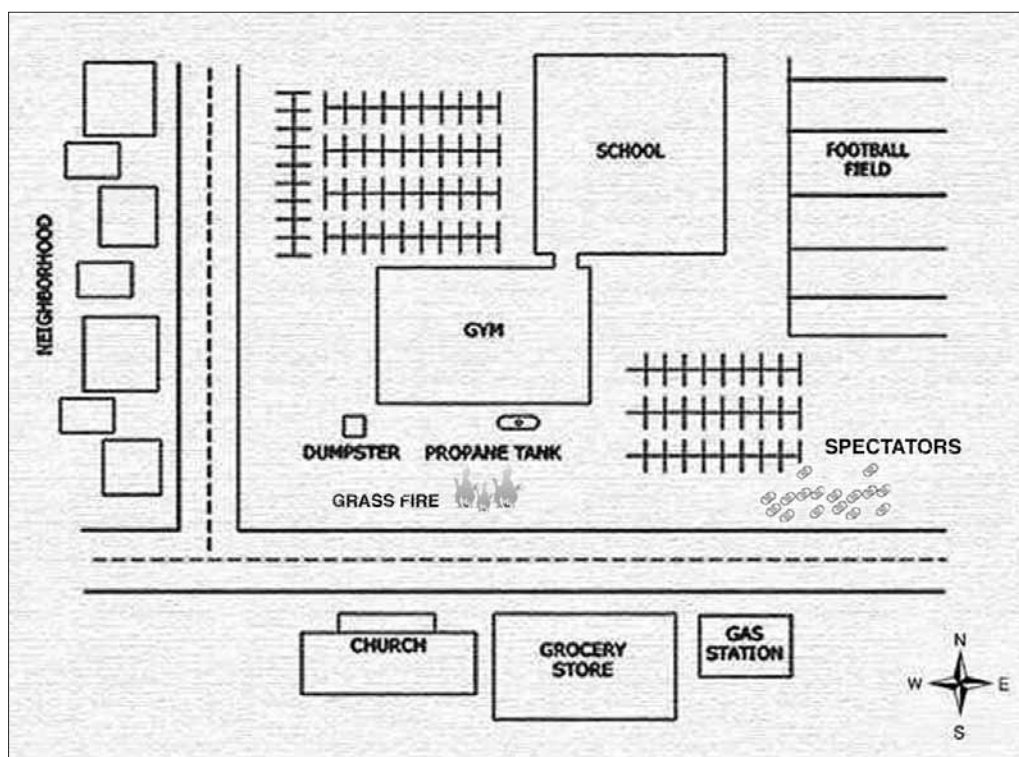


FIGURE 8-43

# SCENARIO # 13

## UNDERGROUND PROPANE TANK FIRE



Ray Enstine

FIGURE 8-44

A lawn service is cutting the grass in the yard of a new home using a riding lawn mower. The grass is high and the gardener fails to notice the exposed riser of a 500 gallon underground propane tank. The lawn mower runs over the riser and gets hung up on top of the shroud protecting the combination valve. The impact of the mower against the riser causes a crack to develop in the pipe at the point where it enters the underground tank two feet below grade. Propane gas is released through the crack in the pipe and escapes into the shroud surrounding the pipe. The leaking propane is ignited by the lawn mower. The gardener was able to escape the area without injury and called the fire department.

Upon arrival at the scene, the Incident Commander observes intense fire shooting up in the air. The gardener explains that he hit something with the lawn mower and then smelled gas. This is his first time cutting the lawn at this location and he was unaware that there was a propane tank buried in the yard. The owner is not at home.

Upon further investigation the Incident Commander notices that the synthetic siding on the home about 70 feet away is blistering. A crowd of spectators is standing on the sidewalk in the front yard. The wind is blowing towards the home at about 5 mph.

### SUMMARY OF CYLINDER CONSTRUCTION FEATURES

#### VALVE FITTINGS

Most underground tanks under 2,000 gallons w.c. have one opening in the top of the tank. The opening has a pipe attached to it called the riser. The top of the riser is threaded to a 2-1/2-inch male NPT. Usually, a large combination valve is installed

on the top of the riser. The combination valve contains a filler valve, vapor return valve, service valve, pressure relief valve, fixed maximum liquid level gauge, and an optional pressure gauge. A liquid withdrawal valve is usually in a separate location away from the combination valve and riser.

A shroud is used to protect the "riser" as well as the combination valve on the top of the riser. The riser length on a typical underground domestic tank is 14 to 28 inches. A shroud includes a hinged lid that surrounds the riser. This is a key identification feature for emergency responders.

## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

The primary tactical objectives are to protect the home and other exposures from radiant heat and remove bystanders from the immediate area. The secondary objective is to allow the underground tank to safely burn off the remaining propane. Technical assistance should be obtained from the local propane dealer.

### METHODS OF CONFINEMENT AND LEAK CONTROL

The first initial action by the Incident Commander should be to implement site management procedures, (e.g., isolate the area and deny entry, remove bystanders to a safe area, and establish Hazard Control Zones.)

A call for technical assistance from the local propane dealer should be made as soon as possible. The dealer should be briefed on the nature of the problem so that the proper personnel and resources are dispatched to the scene.

Firefighters in full protective clothing and SCBA should deploy hoselines to protect the home and other exposures. Two 1-3/4 inch hoselines flowing 100 gpm or higher are recommended. The home should be checked for fire extension to the interior.

The fire will remain above ground at the riser and will continue to burn until all the fuel has been consumed. Unlike aboveground tanks, there is no risk of explosion from an underground tank since the tank shell is protected by the soil surrounding the tank.

The propane fire should not be extinguished. The fire should be allowed to burn until technical assistance has been obtained from the propane dealer.

After the propane vapor has burned for some time, the fire often dies down giving the appearance that the propane has been consumed. This usually means that the tank has gone into a state of auto refrigeration. When an underground tank's riser is damaged and the pipe shears, there is an initial "blow-off" of the propane as the tank rapidly depressurizes. In some cases the initial release of propane rapidly dissipates and there is no ignition. Once this initial blow-off occurs, the tank will go into auto-refrigeration and the rate of release of flammable gas will slow down significantly. If the propane does ignite there will be a rapid burn off of propane until the tank reaches auto refrigeration. For a more detailed explanation of auto refrigeration see Scan Sheet 9-B, page 260.

Rapid vaporization of the propane will frost the underground tank shell and freeze the ground around the area where the tank is exposed. If the tank has gone into a state of refrigeration, repair crews can usually gain access to the opening in the top of the tank and the riser. A qualified product or container specialist with proper protective clothing and equipment can sometimes make emergency repairs by replacing either the damaged piece of pipe, the ball valve, or the entire assembly. The top of the riser is threaded to a 2-1/2-inch male NPT. A temporary ball valve can be

screwed into the pipe opening with propane vapor still flowing out. Note: The base of the riser is welded to the tank. If the riser has been sheared or damaged where it is connected to the tank, other techniques will have to be employed by container specialists.

All emergency repair operations must be done under the protection of wide-angle fog from a hoseline dedicated to the protection of the repair crew working on the pipe removal and replacement. Once the replacement parts are in place the area should be checked with a CGI before the hoselines can be shut down.

Often, the safest solution for an underground tank where the riser pipe has been damaged is to let it burn itself out while protecting the home and other exposures near the tank from possible ignition.

Additional factors to consider for this operation include:

- Damage to underground tanks risers are usually caused by heavy construction equipment, snowplows, or riding lawn mowers. When firefighters first arrive on the scene of an underground propane tank fire, this equipment will be burning along with the propane. Rubber tires and plastic parts give off heavy dark smoke which can obscure the area and make it difficult to determine that the source of the fire is actually propane burning at the underground tank riser.
- If possible, keep water away from the damaged riser. Water flooding the area can create mud and make repairs more difficult.
- Where possible, the back-up or standby hoseline should be supplied from a water supply which is independent of the primary hoselines dispersing flammable vapors in case the primary handline loses its water supply.
- During the course of the operation, and before leaving the scene, buildings and adjacent areas should be checked for flammable vapors using a combustible gas indicator (CGI).

### SCENARIO #13

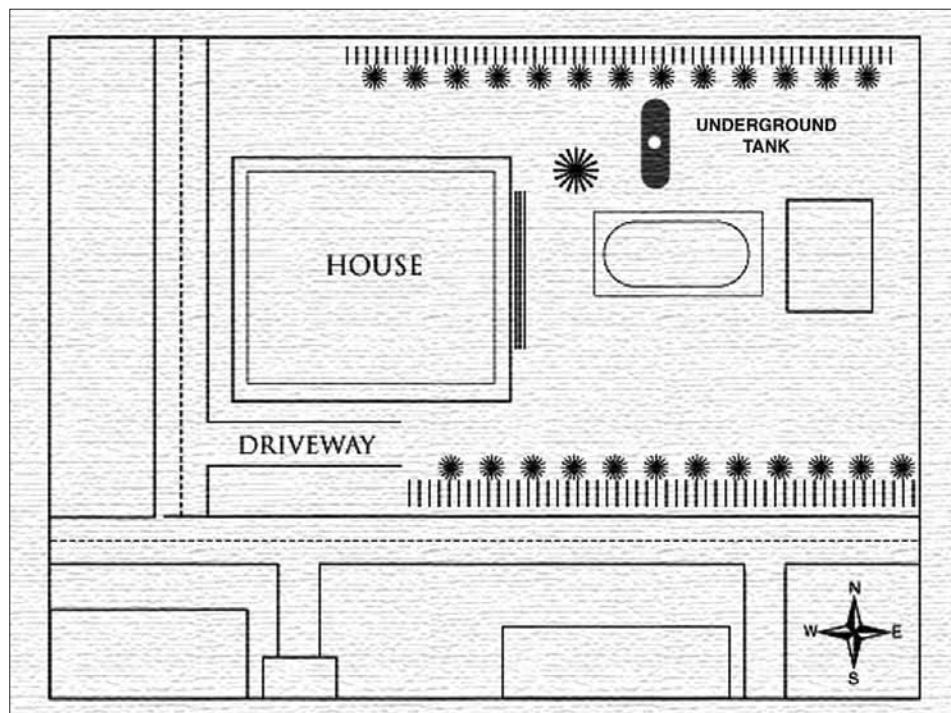


FIGURE 8-45



# SCENARIO #14

## BARBEQUE GRILL FIRE ON THIRD FLOOR BALCONY OF AN APARTMENT BUILDING



FIGURE 8-46

The resident of a four-story apartment building started a propane gas grill in preparation for cooking on his third floor balcony. As he waited for the grill to warm up, he received a phone call, and after five minutes, shut off the grill. When he returned 45 minutes later, he restarted the grill using a match when the grill's igniter did not work. Once the fire was going, he noticed flames near the neck of the propane cylinder. Although he immediately turned the burners off, the fire continued to burn at the cylinder.

The man called 911 to report the fire, then returned to the balcony to find the fire had spread to plastic furniture near the grill. The man tried to control the fire, but the flames continued to spread, so he closed the sliding glass door to the balcony and left the apartment. On the way out, he told occupants of the building that he met in the stairwell about the fire, and they activated the local fire alarm using a pull station. Residents began to evacuate the building.

Upon arrival at the scene the Incident Commander finds a four story wood frame (Type V) constructed building with fire showing from the balcony of the third floor of the building. About 50 people are in front of the building.

From the street level the Incident Commander can see that the balcony door has broken and fire is leaping upward and contacting the balcony above it. Plastic furniture on the fourth floor balcony above is catching fire. The 20 pound propane cylinder is venting forcefully and continuously.

## SUMMARY OF CYLINDER CONSTRUCTION FEATURES

Most propane barbecue gas grills utilize the standard portable 20 pound propane cylinder. They are typically refilled at cylinder filling stations and transported home and hooked up by the user.

The 20 pound class cylinder is usually of two piece welded steel construction. Cylinders generally have one fitting welded in the service end of the cylinder. The fitting is threaded to a female NPT coupling and is raised above the surface of the cylinder. One combination service valve and pressure relief valve is installed in the coupling.

## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

The primary tactical objectives are to: 1) Cool the propane cylinder from a safe location to prevent tank failure and, 2) Prevent extension of the fire from the third floor balcony to the interior of the third floor apartment and/or to the fourth floor balcony.

### METHODS OF EXTINGUISHMENT

A hoseline or deck gun should be immediately placed in service at the street level and directed onto the third floor balcony to cool the venting 20 pound propane cylinder. The objective is to cool the propane cylinder to prevent rupture, not to attack the main body of the fire. Caution must be used not to blow the fire into the interior of the apartment through the patio door.

Hoselines should be stretched to the interior of the building via the stairway. The fire should be attacked from inside the 3rd floor apartment. Crews should check for extension to the 4th floor and the loft area. The propane tank should continue to be cooled until after the fire is extinguished.

Additional factors to consider for this operation include:

- Obviously there are other ways to attack a similar fire based on actual fire conditions and building construction. Regardless of the method used, special caution must be exercised to minimize the exposure of firefighters making the attack.
- Several serious fires have occurred in apartment buildings of wooden construction involving propane gas grill fires where fire rapidly extended upward from balcony to balcony until it reached the roof. Most jurisdictions adopt NFPA 58, which prohibits propane or charcoal grills on wooden balconies. See page 18 of the July / August 2000 issue of *NFPA Fire Journal* for a case study.
- The propane cylinder should be removed from the building and properly disposed of by a propane dealer. Residual propane may still be in the damaged cylinder. The cylinder should be isolated outdoors until the fire investigation has been completed.

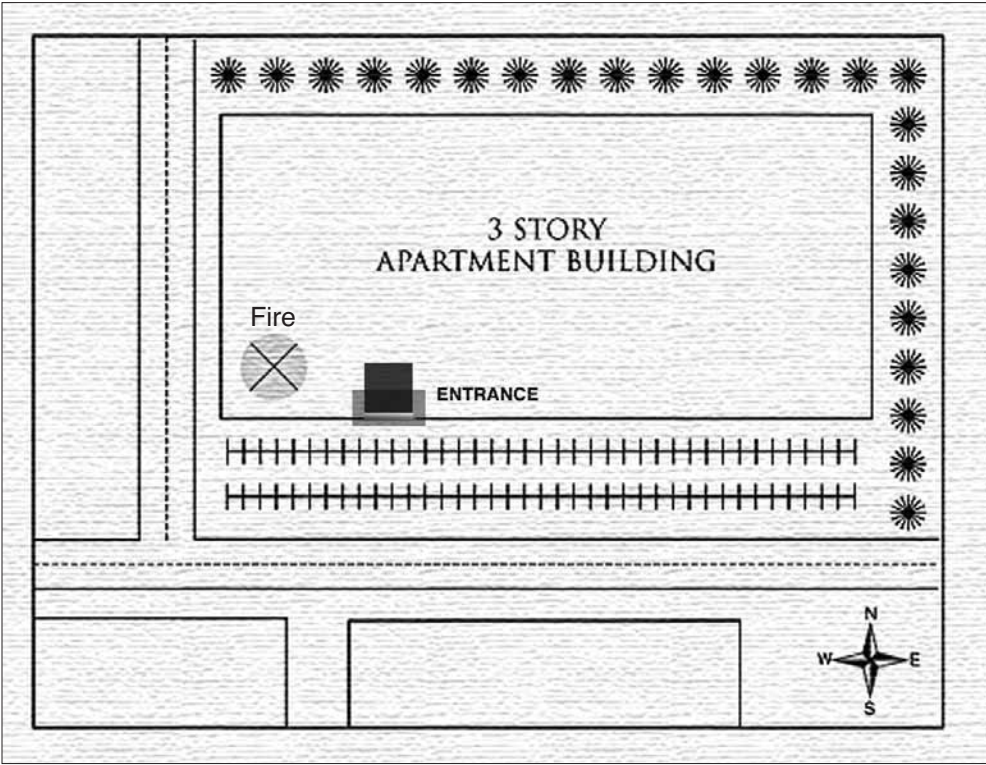


FIGURE 8-47

# SCENARIO # 15

## AUTOMOBILE LEAKING PROPANE IN PARKING GARAGE



FIGURE 8-48

A security officer on patrol on the ground level of a shopping mall parking garage smells a strong odor of gas. He investigates further and finds that the odor is strongest near the center of the garage. Several shoppers going to their cars have reported smelling the same odor. The security officer calls 911 and requests that the fire department respond. The fire department dispatches one engine company to investigate.

Upon arrival at the shopping mall, the company officer positions the fire apparatus on the south side of the garage and meets the security officer. The security officer draws a sketch for the company officer indicating where the odor is the strongest in the garage. It is a hot and humid day and there is very little air moving. The garage is open to the outside on all four sides.

The company officer sends two firefighters into the garage with a Combustible Gas Indicator (CGI) to investigate the source of the odor. The firefighters enter at the ground level on the south side and read 5% of the Lower Flammable Limit on the CGI. This information is relayed to the company officer, who requests that the security officer block off the entrance to the parking garage. He directs the firefighters to continue their investigation.

Using the CGI to survey the area, the firefighters discover that the highest reading is obtained near a white automobile. The car has a small black and white diamond shaped label on the rear of the vehicle with the word "Propane" on it. This information is relayed to the company officer.



## SUMMARY OF TANK CONSTRUCTION FEATURES

Motor vehicle propane fuel tanks are designed for installation in cars, vans, pickup trucks and buses. These tanks are built in a variety of shapes and sizes to accommodate different vehicle designs and space requirements. Their capacities range from 25 to 65 gallons water capacity.

All new motor vehicle fuel tanks for new vehicles must have a maximum working pressure of 312.5 psig.

Pressure Relief Valves (PRV) must be vented to the outside of the vehicle. All fittings must be vented to the outside of the vehicle if the tank is installed within a confined space within the vehicle, such as in the trunk or in a camper shell or shall be gas tight with respect to the driver or passenger compartments and to any space containing radio transmitters or other spark producing equipment.

### VALVE FITTINGS

Most motor vehicle fuel tanks usually have a maximum of 5 threaded openings. The number, size and location of valve fittings in mobile tanks will vary. These fittings usually include a pressure relief valve, a liquid and vapor fitting, a tank gauge (which reads full, half full, or empty) and a fixed maximum liquid level gauge. Most valve fittings are threaded and the sizes of the openings are limited to 1/4 inch, 3/4 inch, and 1-inch female NPT.

### VALVE PROTECTION

Mobile/motor fuel tanks have special hardware to protect tank valves. Typically, mobile tanks are equipped with a protective guard or collar which consists of a metal plate that partially surrounds the fittings and valves on the tank. This protective guard or collar may be welded directly to the tank or it may be bolted to brackets that are welded to the tank.

### MOUNTING HARDWARE

ASME tanks used in mobile service must be securely attached to the vehicle. All tank manufacturers install special hardware for mounting the tank to the vehicle. The location of the mounting hardware varies according to the type of vehicle on which the tank is being installed. Steel strips or brackets are usually drilled so that they can be bolted to the vehicle.

### LABELING

Vehicles powered by propane are required by NFPA 58 to be identified with a diamond shaped label, although this type of marking is not universal. The label should be located on an exterior surface on the lower right rear of the vehicle. The diamond shaped marking consists of a border and the letters "PROPANE" of silver or white reflective luminous material on a black background.

## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

The primary tactical objective for this operation is to isolate people from the problem, establish Hazard Control Zones, and control ignition sources. The secondary objective is to identify the source of the leaking propane and stop the leak.

## METHODS OF CONTROL

Locating the source of a gas leak in a large parking garage can be a frustrating and time consuming job. There are many different types of vehicles in a parking garage and the source of the odor could be a range of possible flammable liquid or gases, including a small 20 pound propane cylinder improperly stored inside of a van or a trunk or a natural gas or propane powered vehicle fuel tank. Both LPG and natural gas have odorants to make it easier to detect a leak.

The most effective way to identify the source of the leak is to use a Combustible Gas Indicator (CGI) to systematically survey the area and map out the concentrations of the flammable gas. The company officer should draw a sketch of the scene and record the CGI readings and note the time and location of each reading. This information will help identify safe, unsafe, and dangerous areas and may help narrow the search area to three or four vehicles.

Once the area has been surveyed using the CGI and the search area has been narrowed, individual vehicles should be inspected to determine the source of the leak. If the vehicle is an automobile, the fuel tank will usually be located inside the trunk. The trunk will need to be opened to gain access to the tanks valves and fittings. Special consideration should be given to the potential risk of ignition of flammable gas that has accumulated inside the automobile's trunk. The contact switch for the trunk light is a potential source of ignition. The risk to emergency responders can be reduced by opening the hood and disconnecting the 12 volt car battery before opening the trunk.

Once access to the trunk has been gained, a CGI reading should be taken to determine if the atmosphere is within safe limits. The protective guard or collar containing the fittings should be inspected to see if there is frost on the box. The lid to the box must be removed to access the valves and fittings. The most likely source of the leak will be the vapor or liquid valves or the fixed maximum liquid level gauge. The liquid outlet connection shall have a manual shutoff, excess flow and automatic closure features. The valve assembly shall prevent the flow of fuel when the engine is not in an operating mode, even if the ignition switch is in the "on" position. These valves should be checked for leaks and secured. Motor fuel tank shutoff valves are right-to-tight, left-to-loosen. Make sure you are turning the valve off, not on. Close valves hand tight.

If there is no frost on fittings or valves, a soap and water solution can be applied to the connections to determine if there is a small leak. The gauge on the fuel tank should be examined to determine if the tank is full or empty.

If the source of the leak is not in the trunk, the engine compartment should be checked. Leaks in engine compartments can be controlled by shutting off the supply valve on the fuel tank in the trunk. Remember, even though the supply valve has been shut off, the fuel line still contains propane. It will take a period of time for the leak to stop, depending on the size of the fuel line and leak. Note: Fires in engine compartments can be controlled in the same manner. First gain access to the trunk, and then close the supply valve.

Additional factors to consider for this operation include:

- Propane is odorized for safety and early detection of a leak. The most commonly used odorant for propane is ethyl mercaptan. The odor threshold of ethyl mercaptan is about 0.1 ppb. NOTE: The odor threshold is the lowest concentration of a material's vapor in air that is detectable by human smell.
- Propane can be smelled at a very low level. It is possible to initially over react to the situation before a complete size-up has been made. Evacuating

large areas (in this case a shopping mall) based on odor complaints from citizens can create additional safety problems. Using a Combustible Gas Indicator is the most effective way to evaluate the hazards and risks.

- The Lower Flammable Limit for propane is 2.15% (21,500 ppm) and the upper flammable limit is 9.60% (96,000 ppm). Concentrations of 10% (2,150 ppm) of the Lower Flammable Limit should be considered unsafe atmospheres in the flammable range (2.15 to 9.60%) are dangerous.
- At 10% LFL precautionary steps should be taken to control ignition sources and access of emergency response personnel and citizens to the area. [ $2.15\% \text{ LFL} \times 10,000 = 21,500 \text{ ppm} \times 10\% \text{ of the LFL} = 2,150 \text{ ppm}$ ]. Using 10% of the LFL for propane to determine unsafe areas provides a very good margin for firefighter safety. Personnel working in these areas must use full protective clothing and self-contained breathing apparatus.
- Contact the local propane marketer for technical assistance.

## SCENARIO #15

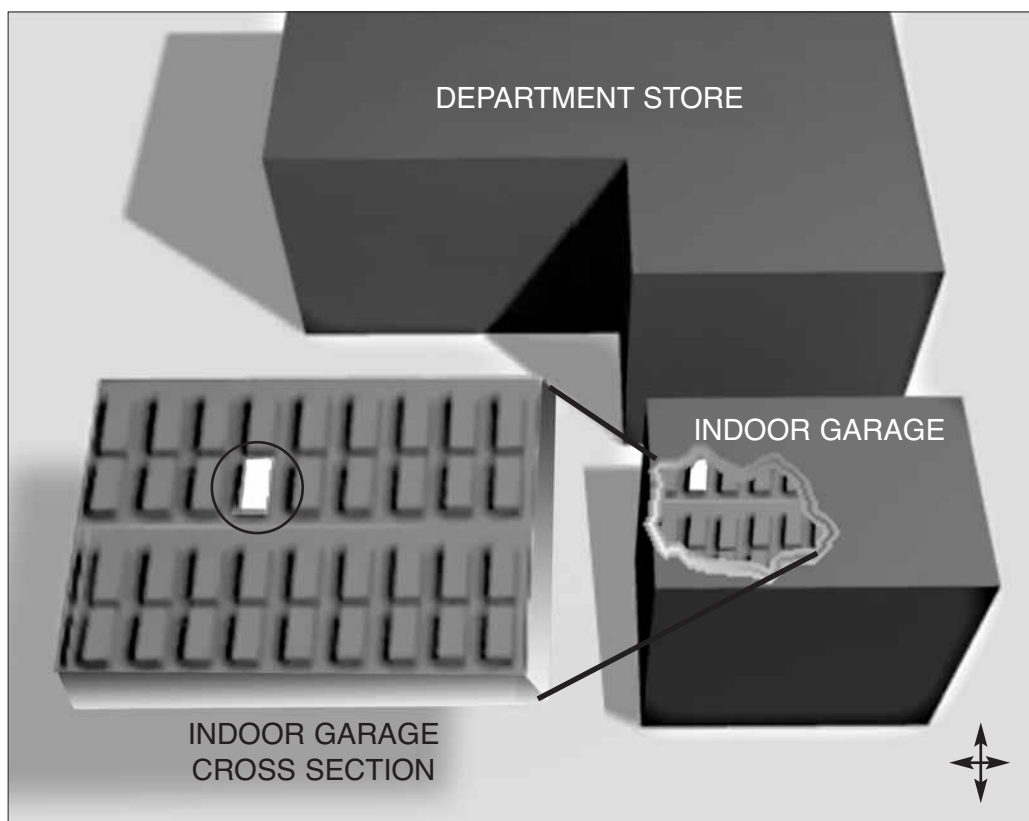


FIGURE 8-49

# SCENARIO # 16

## OVERTURNED MC-331 CARGO TANK TRUCK



Paul Bogan

FIGURE 8-50

While driving down a major interstate highway in a metropolitan area, an MC 331 cargo tank truck was cut off by an automobile making a quick lane change causing the tank truck driver to swerve sharply and lose control of the vehicle. The cargo tank truck overturned onto its left side, sliding along the concrete highway until it came to rest against a guard rail.

Upon arrival at the scene, the Incident Commander (IC) sizes up the situation. The driver has already extricated himself from the tractor, and an EMS unit has arrived on-scene and has begun treatment of the injured driver. There are no visible leaks or spills from the cargo tank.

Visual inspection of the damaged cargo tank truck reveals the truck is placarded "1075" (the correct placard for propane). The truck is also painted with the name of the propane transport company. EMS personnel inform the IC that the driver has reported that the product is propane, that the cargo tank is approximately 80% full, and that he was enroute to make several deliveries.

Under the protection of hoselines, the IC sends an entry team in to assess the damage to the container. Using a combustible gas indicator (CGI) the entry team determines that there is a small leak on the bottom liquid unloading valve (i.e., "belly valve"). They also report that there is a "street burn" that extends along the entire length of the cargo tank caused by the container sliding along the highway. There are no other obvious dents or gouges visible on the tank underside.



## SUMMARY OF TANK TRUCK CONSTRUCTION FEATURES

MC-331 propane cargo tanks have a maximum design pressure of 250 psig [49 CFR178.337-1(b).] MC-331's may be constructed to a design pressure not less than the vapor pressure of the commodity contained at 115°F. They are constructed from steel metal sheets that are formed into a cylindrical shape, and then welded along the seams. Hemispherical or elliptical tank heads are welded to the barrel to form the tank. See Figure 8-51.

All MC-331 cargo tanks have pressure relief valves; temperature, pressure and liquid level gauges; liquid and vapor transfer lines and valves; and remote emergency valve controls.

Openings for transferring propane liquid and vapor are located in the bottom of the tank, either in the underside of the shell and/or in bottom half of the rear head. Openings for the pressure relief valves are located in the top of the tank.

Most propane cargo tanks are uninsulated and have the upper two-thirds of the tank painted white, aluminum or a similar heat reflective color.



FIGURE 8-51

## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

The primary tactical objective for this operation is to control or stop the propane liquid from escaping the liquid belly valve on the MC-331 cargo tank truck. The secondary objective is to conduct a damage assessment and maintain site safety until the overturned tank truck is safely uprighted or until the propane in the damaged cargo tank truck can be transferred to another cargo tank truck.

### METHODS OF LEAK CONTROL

The first initial action by the Incident Commander should be to implement site management procedures, (e.g., isolate the area and deny entry, remove bystanders to a safe area, and establish Hazard Control Zones.)

A call for technical assistance from both the regional Hazardous Materials Response Team (HMRT) and the propane transport company or propane marketer

should be made as soon as possible. The transport company representative or marketer should be briefed on the nature of the problem so that the proper personnel and resources are dispatched to the scene.

Firefighters in full protective clothing and SCBA should deploy hoselines to disperse and dilute the flammable gas away from the container. Two 1-1/2 or 1-3/4-inch hoselines line flowing 100 gpm or higher are recommended; however, depending upon the rate of release larger hoselines or master streams may be necessary. A combustible gas indicator (CGI) should be used to monitor the hazard area and determine the effectiveness of hoselines in dispersing the gas. If temperatures are expected to rise, water for container cooling as well as vapor suppression should be provided.

With the cargo tank lying on its left side, all of the container valves and piping will be in the liquid product. Although the leak appears to be minor, some attempt should be made to slow down or stop the leaking propane on the damaged tank.

The Incident Commander has several very important tactical options for leak control:

- **Ensure that the liquid unloading valve is closed.** Remember, the problem may simply be that the valve has been partially opened as a result of the accident.
- **Fiberglass Wrap—A vapor leak** can be stopped with the use of a commercial fiberglass wrap material known as "Stop It". Field experience has shown that fiberglass wrap kits work successfully on most propane vapor leaks. The roll of Freeze Wrap is wetted and unwound around the damaged pipe or valve. When the wrap sets up it will stop a vapor leak up to 200 psig. However, if there is a liquid leak producing a vapor cloud that can be seen, these kits will not work
- **Freeze Wrap—A liquid leak** can sometimes be sealed off by the use of a freeze wrap which forms an ice patch over the leak area. A towel or fabric wrap is wetted, and then wrapped around the leaking valve or pipe. The wet cloth will freeze due to the propane liquids very low temperature. **CAUTION:** Firefighters must wear heavy neoprene gloves suitable for working with low temperatures to avoid frostbite. Cloth or leather gloves can absorb liquid propane and result in injury.

## DAMAGE ASSESSMENT

The nature of both the leak and the mechanical stress applied by the rollover will determine the path forward. Conducting a damage assessment will assist the IC in determining if the cargo tank must be off-loaded in a timely manner, or if the container can first be uprighted and then off-loaded. While there are general guidelines on uprighting versus off-loading, technical assistance should be obtained during the hazard and risk evaluation process.

Much of the available literature on damage assessment of pressurized containers is based upon testing and experience with railroad tank cars. It should be noted that design and construction standards for tank cars are significantly different than those for MC-331 cargo tank trucks.

Damage assessment should evaluate the following factors:

- Determine the type of container, material of construction and internal pressure.
- Determine the type of stress applied to the container (e.g., thermal, mechanical or a combination of stressors).

- Evaluate the stability of the container. Use caution when inspecting an unstable container as it may move or shift during the inspection process.
- Examine the surface of the container, paying attention to the types of damage and the radius (i.e., sharpness) of all dents.

In this scenario, the street burn is actually a long dent that is inherently flat. It is generally caused by a container overturning and sliding some distance along a cement or asphalt road. If there are no accompanying sharply curved dents or gouges, the cargo tank can often be safely uprighted providing a sufficient lifting capability is present.

Additional factors to consider for this operation include:

- Where possible, a back-up handline should be supplied from a water supply that is independent of the primary attack line in case the primary handline loses its water supply.
- When the ambient temperature is above 90°F hose water fog played on the top of the tank can be effective in keeping the tank shell cool.
- Combustible gas indicator (CGI) readings should be taken continually throughout the incident to ensure that hoselines are effective in discharging flammable vapors.
- Damage assessment is, at best, a qualitative process which will require input from product and container specialists who have experience in evaluating structural damage and the integrity of pressurized containers (e.g., propane industry representatives, cargo tank truck specialists).

Additional information on damage assessment can be referenced in Section 9—Product Removal, Transfer and Recovery Operations.

## SCENARIO #16

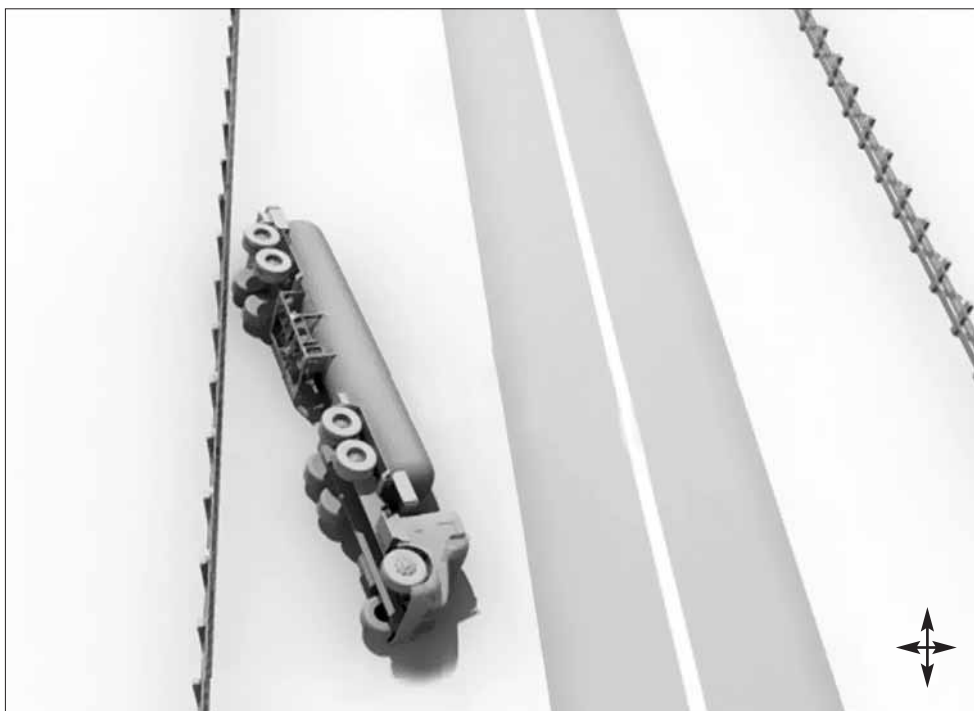


FIGURE 8-52

# SCENARIO #17

## MOTOR FUEL CYLINDER BURNING ON A FORKLIFT



FIGURE 8-53

A forklift operator driving a propane powered forklift was stacking wooden pallets in the rear of a warehouse loading dock when she smelled smoke. Upon investigation, she discovered that two battery cables on the forklift had come loose and contacted the engine's manifold starting a fire. The operator immediately shut down the forklift, turned off the battery switch, and told her co-worker to call the fire department.

The forklift operator ran to the loading dock and grabbed a dry chemical fire extinguisher. Meanwhile, a third employee ran to the forklift and attempted to remove the motor fuel cylinder from the rear of the forklift by using the quick disconnect on the fuel line connected to the service valve. The fuel line was disconnected, and propane flowed freely out of the service valve. It was immediately ignited by the engine fire, and the fire flashed back to the cylinder burning the employee.

After observing what had just occurred, the forklift operator ran back to the forklift and discharged the fire extinguisher onto the burning engine compartment. Realizing that the fire was not extinguished, she pulled the injured employee clear of the fire area and waited for the arrival of the fire department.



## FIRE DEPARTMENT SIZE-UP

Upon arrival at the warehouse, the first arriving engine company officer observes a bright orange and yellow fire burning horizontally from the rear of the forklift. The Pressure Relief Valve (PRV) on the propane cylinder is not functioning. Heavy black smoke is seen coming from the engine compartment.

The company officer also observes a stack of wooden pallets about 50 feet east of the burning forklift next to a brick building used as a maintenance shop. A steel frame loading dock is located approximately 50 feet north of the fire. The loading dock is attached to a metal deck on steel warehouse.

The warehouse manager advises the company officer that one of his employees is lying on the west end of the loading dock and has been badly burned and is in need of medical attention. He also advises that the warehouse stores auto parts and is not sprinklered.

## SUMMARY OF CYLINDER CONSTRUCTION FEATURES

### MOTOR FUEL SERVICE CYLINDERS

Motor fuel service cylinders are used as portable fuel tanks for forklifts. They are also used to power heavy-duty building maintenance equipment such as floor polishers and aisle sweepers. See Figure 8-54.

Motor fuel cylinders are usually configured to supply liquid propane to the engine rather than vapor. They can have as many as five openings in the service end of the cylinder. Fittings may be threaded or flanged. Each service valve opening is marked for either vapor or liquid service. The service valves are connected to dip tubes which run into the liquid or vapor space of the cylinder.

Motor fuel service cylinders are equipped with a Pressure Relief Valve (PRV) which is set to function at 375 psi.

## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

The primary tactical objectives for this operation are to: 1) Evacuate employees from the warehouse and the loading dock; 2) Rescue the injured employee from the loading dock and provide emergency medical treatment in a safe area; and (3) Control the fire on the forklift and prevent the fire from spreading to the wooden pallets and the warehouse.

### METHODS OF CONTROL

Two 1-1/2 inch or 1-3/4 inch hoselines should be placed in service as soon as possible. The first hoseline should be directed onto the motor fuel cylinder's outer shell to maintain its integrity while the propane is allowed to burn off under controlled conditions.

The second hoseline should be used to extinguish the engine compartment fire, and then be redirected to cool hot metal surfaces on the forklift. Hoselines should remain in position until the propane burns off and there is no evidence of steam.

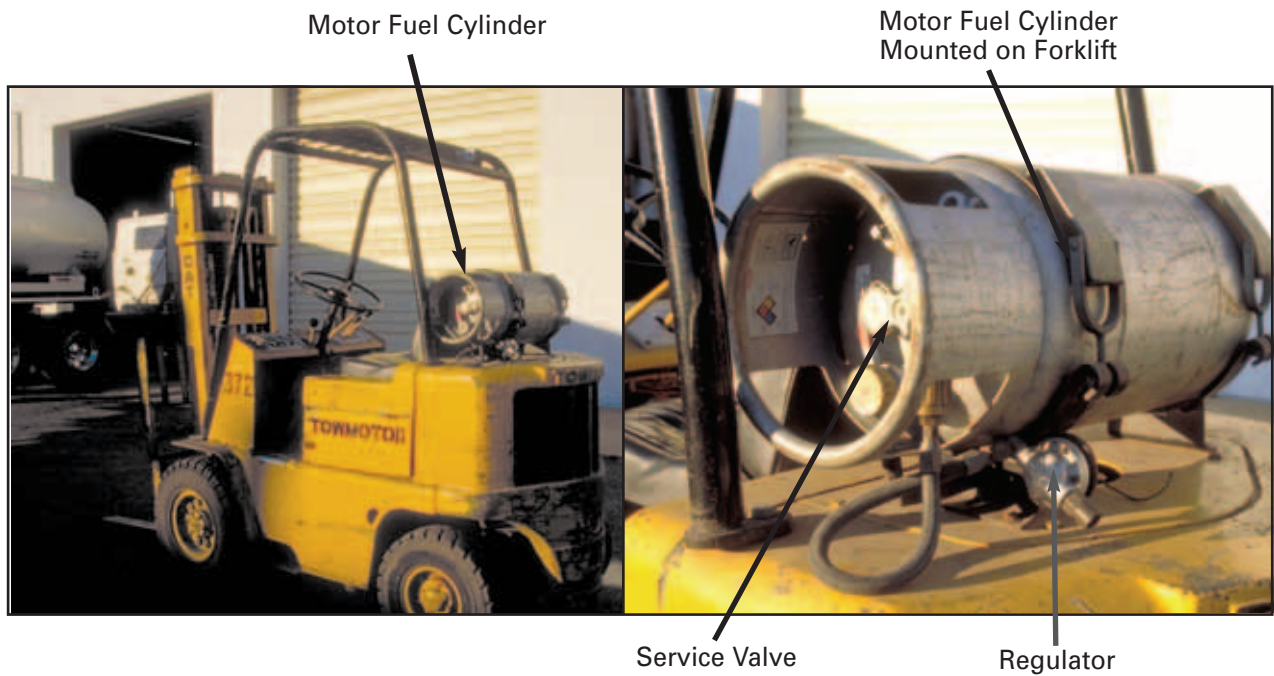


FIGURE 8-54

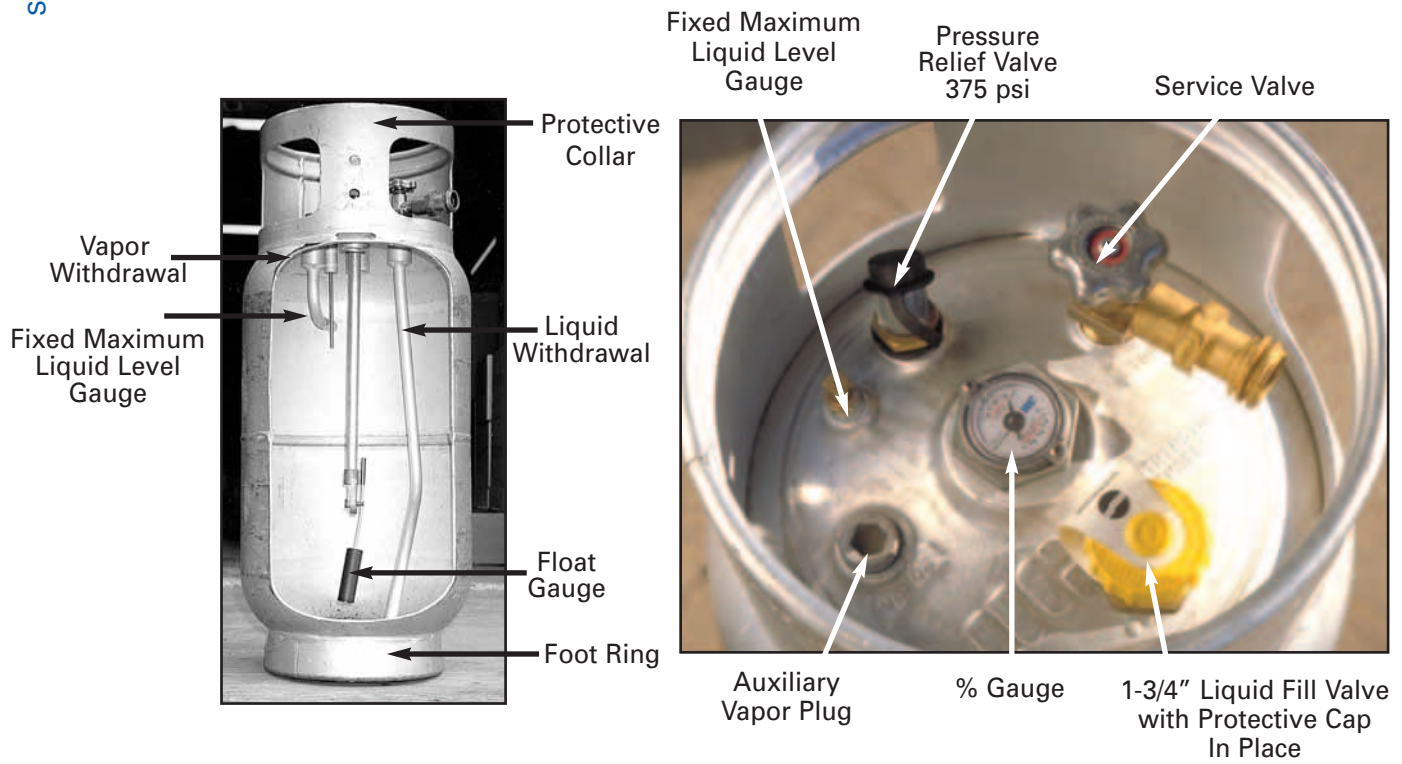


FIGURE 8-55

Additional factors to consider for this operation include:

- This scenario describes special life safety circumstances that may justify offensive tactics. These include: 1) An injured employee requires rescue and emergency medical treatment, 2) Employees need to be evacuated to a safer area, and 3) Fire is threatening to extend to a non-sprinklered warehouse. The Incident Commander must weigh the risk of intervention using offensive tactics against non-intervention; e.g., evacuate the area and let the forklift burn. For example, if there are no life safety issues involved and no exposures, why should firefighters assume a risk for a forklift that is basically a total loss when the fire department arrives?
- Motor fuel cylinders can rupture under fire conditions even if the Pressure Relief Valve (PRV) is not functioning. The fact that the cylinder is attached to the forklift with a mounting strap is not a guarantee that a ruptured cylinder will remain attached if the cylinder fails. Very few motor fuel cylinder fire results in a tank rupture. Normally the cylinder simply burns off.
- In this scenario, the liquid service valve is in the open position. Liquid propane is burning from the open service valve. Consequently the fire will be more intense than a vapor fire. Care should be used in applying cooling water to the service end of the cylinder's head so that the fire is not extinguished. If the fire is extinguished before all the fuel is consumed, liquid propane will leak from the cylinder and may reignite and flash back to the cylinder. The expansion ratio of propane is 1 to 270.
- If the fire is accidentally extinguished by hoselines, streams should switch to the power cone water fog pattern and be used to dissipate propane vapor. A Combustible Gas Indicator (CGI) should be used to check the area to determine if the atmosphere is flammable.
- Use maximum hose stream reach to place as much distance as possible between firefighters and the burning cylinder.
- Special attention should be given to rubber tire fires on the forklift. Tires contain lots of energy and can burn intensely. Note that the rear tires on the forklift are directly underneath the motor fuel cylinder. Dry chemical extinguishers used in combination of water fog from hoselines can be effective in extinguishing tire fires.
- Disconnecting a motor fuel cylinder from a burning vehicle is a dangerous practice even if the service valve is closed. Residual propane will remain trapped between the closed service valve and the fuel line and can ignite.
- Contact the local propane marketer for technical assistance in removing and disposing of the cylinder.

SCENARIO #17

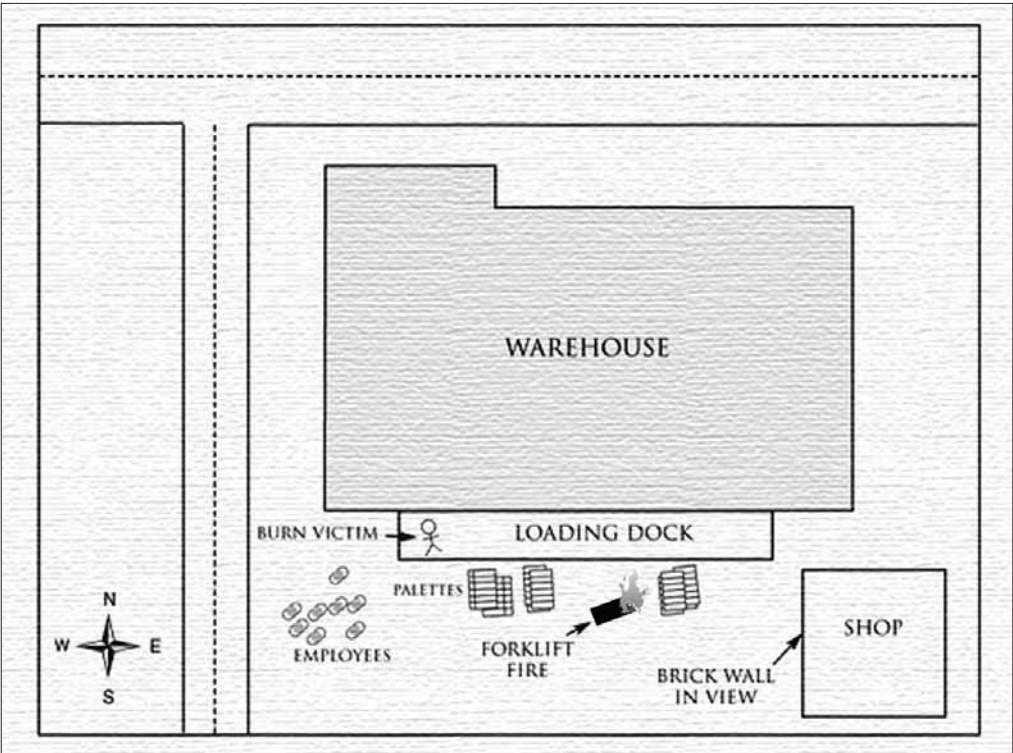


FIGURE 8-56



# SCENARIO #18

## LEAK ON INTERMODAL PRESSURE TANK CONTAINER



FIGURE 8-57

Your fire department responds to a marine terminal for a report of a gas leak involving an intermodal tank in a container yard. Upon arrival at the marine terminal, the Port Authority Police escorts you to the scene of the incident where you establish an Incident Command Post (ICP).

The senior police officer at the scene tells you that the container was off-loaded from a container ship about one hour ago. Dock workers smelled a strong odor of gas in the area of the tank and called the Port Police. The area has been isolated and a security perimeter has been established by the Port Authority Police. You cannot smell any gas from your location, which is about 50 yards from the intermodal container.

The Yard Master informs you that a container ship unloaded the propane container about 13:00 hrs and that neither the ships crew or the dock workers smelled gas. He advises you that the marine terminal must resume work as soon as possible so that the ship can meet its sailing schedule. A delay in the scheduled departure will cost thousands of dollars.

The Port Authority Safety Manager joins you at the ICP and explains that based on his experience with similar containers, it is likely that the Fixed Maximum Liquid Level Gauge may need to be secured so that it is not leaking liquid propane.

## SUMMARY OF TANK CONSTRUCTION FEATURES

Intermodal pressure tank containers are commonly known as DOT Spec. 51 Portable Tanks or International Maritime Organization (IMO) Type 5 (DOT Spec. 51/IMO Type 5) containers. Intermodal Containers are designed to be moved on one or more modes of transportation, e.g., from ship to trucks to rail cars. Consequently, they can be found almost anywhere within the transportation system. They may also be found at fixed facilities.

DOT Spec. 51/IMO Type 5 containers are pressurized containers designed to handle internal pressures ranging from 100 to 500 psig. They must be designed for product lading in excess of 1,000 pounds water capacity, and have a minimum shell thickness of .1875 inches.



Valve Compartment

**FIGURE 8-58** End view of Spec. 51 tank showing the container valve compartment.

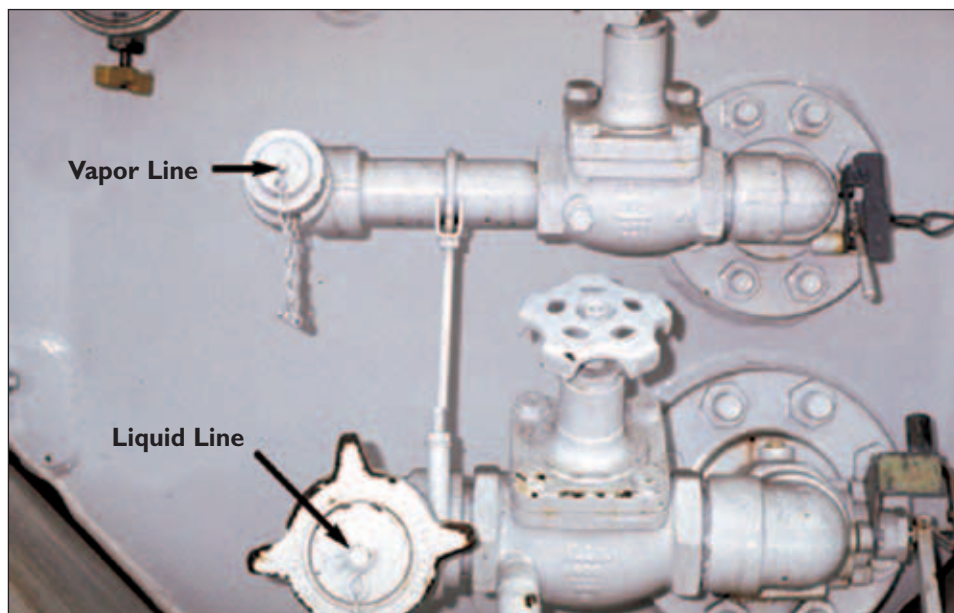


**FIGURE 8-59** Liquid and vapor valves on Spec. 51.



**FIGURE 8-60** Pressure relief device on Spec. 51.

DOT Spec. 51/IMO Type 5 containers used to transport propane will be in the range of 4,500 to 5,500 gallons. However, it is not uncommon to find DOT Spec. 51 tanks having other capacities, depending on customer and shipper requirements. The portable container is a 40 foot beam constructed unit with 10,610 gallons (40,160 liters) capacity.

### TANK CONTAINER FITTINGS

The following fittings can be found on DOT Spec. 51/IMO Type 5 tank containers to make them safe and functional. These fittings may be on the top, the end or the bottom. Generally, the fittings are enclosed with a cover or recessed to protect them from mechanical damage. The fittings on the tank shown in this scenario are on the end of the tank. The Pressure relief Valve is on the top of the tank.

**Loading/Unloading Valves**—Liquid and vapor valves are used for filling and emptying the tank. The liquid valve extends into the lading by means of an eductor pipe that may also be fitted with an excess flow check valve. Vapor valves, which also may have an excess flow check valve, are used to remove vapors from the tank, or to pressurize the tank for unloading.

All tank outlets must be marked to designate vapor or liquid discharge potential when the tank is filled to the maximum level permitted. They may be either threaded or flanged valves. However, unlike cargo tank trucks and railroad tank cars, valve threads may be British Standard Pipe (BSP) or metric threads.

**Gauging Devices**—Gauging devices may be installed to measure how much liquid is in the tank. Various types are found, including the rotary gauge, and open and closed gauging devices as found on some propane railroad tank cars.

**Thermometer Wells**—The thermometer well is used for measuring the lading temperature. Temperature readings can assist responders in determining if a product is expanding and increasing the internal tank pressure. If a thermometer well tube breaks inside the tank container, leaks can develop.

**Pressure Relief Devices**—Pressure relief devices are mounted on top of the container to protect the tank from over-pressure under abnormal conditions, such as over-pressure. These devices may be found inside of an unhinged compartment that protects them from the elements.

**Excess Flow Valves**—Excess flow valves may be found on both liquid and vapor piping. Mounted inside of the tank under the liquid and vapor valves, excess flow valves will stop the product flow if a valve is sheared off. Gravity or pressure differential operates excess flow valves.

**Fixed Maximum Liquid Level Gauge**—This device is used to determine when the propane liquid level has reached the maximum level for safe transportation. Propane tanks are normally filled to 80% capacity. During filling operations, the gauge is opened by a technician who observes the gauge while the container is being filled. When the tank reaches 80% capacity, a small amount of liquid escapes and signals the technician to stop the filling operation. The gauge is then closed and secured. Fixed Maximum Liquid Level Gauges can develop leaks at the handle or around the plugs. They may initially leak small amounts of liquid that will expand to vapor at a ratio of 1 to 270.

## INCIDENT ACTION PLAN

### TACTICAL OBJECTIVES

Maintain Site Management and control all ignition sources in the area. Combustible Gas Indicator (CGI) readings should be taken on all sides of the container and documented to determine if the atmosphere is Safe, Unsafe, or Dangerous.

All personnel working in the area must be in full structural firefighting protective clothing and self-contained breathing apparatus.

Hoselines or monitors using fog patterns should be placed so that the air entrained in the fog pattern can help dissipate the propane. NOTE: While propane is 1.5 times heavier than air, it will rapidly dissipate in air. The objective is to keep the propane atmosphere in the vicinity of the leak below the flammable range.

An aerial device should be used to gain access to the valve area to determine the source of the leak. Firefighters should be in full protective clothing and backed up by charged hoselines. Hose streams should continue to dissipate propane vapors but should not be directed onto the firefighters checking out the leak.

If the Fixed Maximum Liquid Level Gauge is leaking, an attempt should be made to close the valve by screwing the hexagonal nut closed (right-to-tight). CAUTION: Liquid propane can cause severe frostbite injuries. Neoprene gloves suitable for liquid propane may be needed to avoid injury. Seek assistance from your local propane dealer.

Additional factors to consider for this operation include:

- After a complete and careful evaluation of the hazards and risks present, it may be possible to use the marine terminal's overhead crane or a stacking crane to remove the container from the stack and place it on the ground where leak control work can be carried out safely without having firefighters working off of an aerial device.
- If the Fixed Maximum Liquid Level Gauge cannot be secured, it may be possible to wrap the gauge in a wet towel and direct a small amount of water fog onto the wrap to form a freeze patch. The cold liquid (-44°F) will freeze the towel on contact with water. This may stop the leak or reduce its size so



- that the container can be moved to a safe area where the container can be offloaded. Most container yards have a designated and isolated area within the marine terminal where damaged containers can be moved for repair or cargo transfer.
- There are many players involved at marine terminal emergencies including owners, operators, shippers, freight handlers, unions, etc. If the marine terminal is involved in loading or unloading operations there will be a great deal of pressure on all of the players to resolve the incident as soon as safely possible. The marine industry has many resources available to the Incident Commander to help resolve the incident.
  - Marine terminals are dangerous environments during loading/unloading operations. There are numerous hazards, including vehicle traffic, overhead crane and container movements and physical hazards. An Incident Safety Officer should be appointed as soon as possible to work with Port Authorities to ensure the safety of emergency responders.

### SCENARIO #18

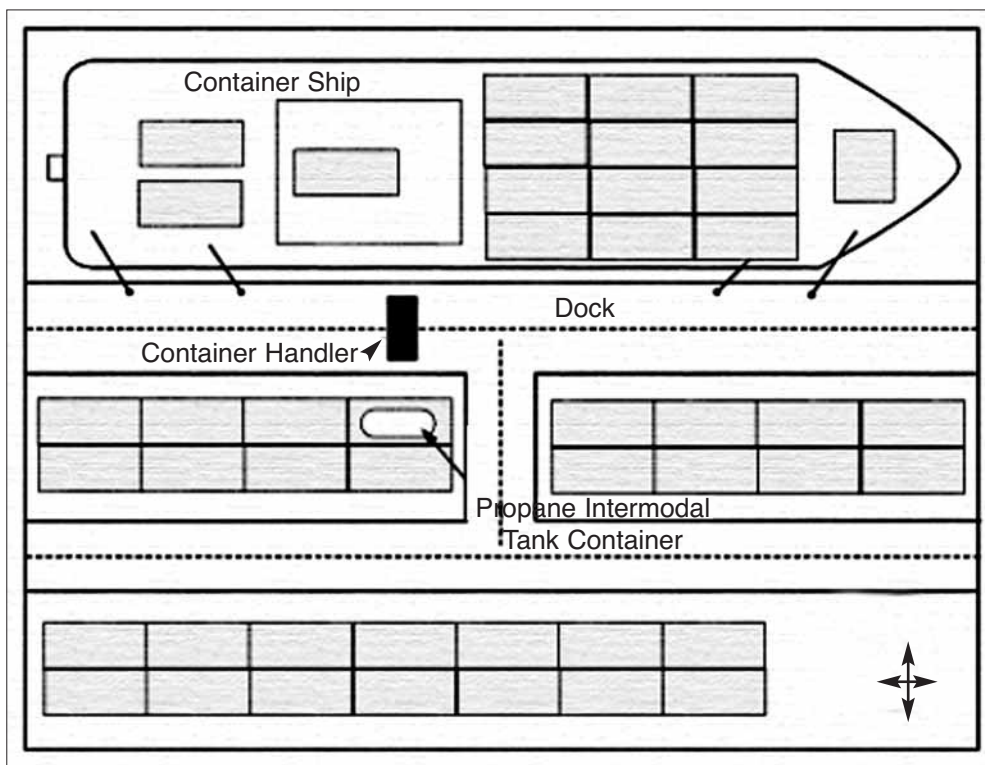


FIGURE 8-61

# SCENARIO # 19

## EMERGENCY PLANNING FOR A PROPANE BULK PLANT



FIGURE 8-62

You are the manager of a large propane bulk plant. You receive a call from the Sheriff's Department at 2:15 AM. There is a fire at your facility!

The Sheriff's Department Dispatcher informs you that one of your bulk stationary tanks is burning and the fire department is on-scene and is beginning operations to cool the tank. You are informed the Pressure Relief Valve (PRV) is operating. The fire department has ordered an evacuation of the area. The Fire Chief has requested that you report to the plant and meet him at the Incident Command Post (ICP).

As you drive towards the facility, your mind races with questions. Which tank are they talking about? How big is the fire? What has been done already? How many people have been evacuated? Was an evacuation really necessary? Who else has been notified? Have my operations people been called? These and a hundred more questions race through your mind but you have very few answers. You have only bits and pieces of information. About three miles from the plant your heart sinks when you see the bright orange glow of fire against the night sky.

### PLANNING FOR YOUR WORST DAY

Imagine you are faced with this emergency. Impossible you say? Improbable yes, Impossible No! Firefighters often cite a fire involving a large propane tank at a bulk plant as one of the most dynamic scenarios that they could encounter. Most firefighters will never respond to an event like the one described in this scenario because of effective safety programs. The limited possibility of a major fire at your plant is not enough of a reason not to prepare for a major emergency. An important question we must ask ourselves as propane marketers and dealers is are we prepared for the different types of emergencies that could occur? We cannot be sure

how we will respond when faced with a real emergency, but if we have a plan before the event, we will be better prepared to solve the problem.

Unfortunately, some propane facilities have not planned well for a major fire and rely totally on the local fire department to deal with potential fires at the plant. Most propane dealers support their local fire departments and rely on them for handling emergencies, but a well-trained and equipped fire department is not enough. An Emergency Response Plan is needed!

## WHERE DO WE START?

On June 5 1996, the National Response Team (NRT) issued a good planning aid for industrial facilities that want to plan for emergencies. This document is called the Integrated Contingency Planning Guidelines (ICP) and is commonly referred to in industry as the "One Plan". The ICP allows facilities to create new plans or revise their existing emergency plans to address the many different regulatory requirements of various federal agencies in one single plan. The National Response Team (NRT) consists of the primary federal agencies that have some type of emergency planning requirements for industry. These agencies include the Department of Homeland Security, U.S. Department of Transportation, Department of Interior, Environmental Protection Agency, and the Occupational Safety and Health Administration.

The unique characteristic about the Integrated Contingency Planning Guidelines is that they are simply guidelines and recommendations and not law. They are designed to help organizations write an effective Emergency Response Plan. If the ICP guidelines are followed in preparing your plan, the document will help you deal with any type of emergency including a propane release, fire, tornado, hurricane, or any contingency that may require emergency actions.

The concept of having "One Plan" instead of several different plans for various types of emergencies help minimize duplication and makes emergency planning cost effective. It also helps keeping the plan up to date easier.

## OVERVIEW OF THE ICP GUIDELINES

The Integrated Contingency Plan is divided into three primary sections. These include:

- 1) Introduction,
- 2) Core Plan and,
- 3) Annexes.

### INTRODUCTION SECTION

This section covers the preliminary details that are found in most plans such as the scope of the document, key names, addresses of contacts for an emergency, a description of processes, and the general facility hazards information. A sample outline for this section includes:

- 1) Table of Contents
- 2) Purpose and Scope of the Plan
- 3) Current Revision Dates
- 4) General Facility Identification Information
- 5) Facility Name

- 6) Owner / Operator
- 7) Physical Address of the Facility
- 8) Mailing Address
- 9) Other Identifying Information
- 10) Description of Facility Processes and Hazards

## CORE PLAN SECTION

This section is the heart of the plan. It describes how to alert and notify, those that will do what during the emergency, who responds, how the problem will be controlled, and how to terminate the incident. It is organized into four subsections. These include:

- 1) Introduction,
- 2) Core Plan and,
- 3) Annexes.
  - a) Discovery,
  - b) Initial Response,
  - c) Sustaining Actions and,
  - d) Termination and Follow Up Actions.

## DISCOVERY

This section describes the initial actions the person discovering an emergency would take to recognize the problem and sound the alarm. Topics should include recognition and basic assessment, quick action steps to control the emergency, and the initial notification procedure. Checklists can be developed for the telephone operator, security, plant personnel and plant supervisors.

## INITIAL RESPONSE

This section describes procedures for notifying the appropriate personnel of the emergency. This should address internal as well as external responders. The facility Incident Management System should be described and include a table of organization. It is important that employees understand who is in charge during an emergency.

This section should also include a set of procedures for preliminary assessment. In addition to the preliminary assessment, there must be a method of establishing response objectives.

The plan should describe what type of resources will be needed to handle an emergency and where they can be obtained. This could include your local fire department, industrial mutual aid organizations or environmental response contractors.

This section should also describe a 24-hour contact point with the names of the person(s) and alternates who will be called to the scene to represent your company. It should also include information for the person who makes the call and what critical information needs to be delivered. Usually in the form of a checklist.

## SUSTAINED ACTIONS

Sustained actions are those actions that would allow a transition between the initial response and longer sustained actions to accomplish mitigation. Sustained actions



would also address recovery actions that should progress under an Incident Management System. Section 9 addresses many of the issues that would be considered as sustained actions such as flaring the tank, repairing or righting an overturned transport vehicle and any necessary clean up operations.

## TERMINATION AND FOLLOW-UP ACTIONS

This section should briefly address methods that will aid people in charge of coordinating a successful conclusion of the incident. Follow-up activities may need to be addressed such as accident investigation, critique, reports and revisions of the existing plans. This information does not have to be developed in a vacuum. Facilities can use information already in the annexes that will be discussed in the next section.

## ANNEX SECTION

This is the portion of the plan where the detail is placed. Many plans get bogged down in too much detail in the main body of the plan. Maps, phone lists, prevention documents, training records, and a matrix that shows how the plan meets various regulatory requirements from federal and state agencies, go in this section. Remember this is the “One Plan”.

The basic annexes are:

### Annex 1—Facility and Locality Information

This annex includes the details of how to drive to the facility and detailed maps of the plant along with descriptions of the operation and layout of the plant in relationship to the community. It also includes the telephone numbers of the members of the community who need to be notified. This annex may also include detailed descriptions of vulnerable resources in the community and populations or organizations that may be at risk, such as schools, hospitals, transportation routes and another vital area or population that may be at risk in the event of an emergency at the facility. Information obtained from product release prevention and incident response reviews can be useful in preparing this annex, see Scan Sheet 6-A (page 120) for more information on a fire safety analysis.

### Annex 2—Notification

This annex includes detailed lists and contact information of individuals that must be notified of an emergency. This includes external organizations in the community and the appropriate federal representatives. The plan should describe who to call, when to call, and what information needs to be supplied. Information provided in the Core Plan does not need to be duplicated here.

### Annex 3—Response Management System

In any emergency there needs to be an Incident Management System. The facility must provide the details of the organizational system in place to manage an emergency. This should include organization charts, job descriptions, and information charts. In addition, there must be a designated commander or coordinator. Section 7 provides an overview of the Incident Management System as it may apply to a propane incident.

### Annex 4—Incident Documentation

Every incident needs to be documented. This annex includes the procedures, forms and details of what must be done after every incident. This should include procedures for conducting an investigation and coordination with outside agencies such as the fire marshal, state police and other local, state and federal investigators.

### Annex 5—Training and Exercise / Drills

Emergency response training and exercises should be documented in this section. This should include the description of the training, logs of who has been trained and when they were trained, and past, present and future schedules of training.

The details of the facility exercise program should be included in this section. Dates of the exercises and details of recommendations for changes and improvements should be detailed.

### Annex 6—Critique and Review

This annex explains the procedures for conducting an incident or training exercise critique. The annex should include a description of how to implement the lessons learned from the critique and any modifications that are required. In addition to the list of changes, the past changes and modifications should be documented along with the dates of the changes.

### Annex 7—Prevention

In order to be successful in emergency planning, prevention must be addressed. This annex allows facilities to describe their fire and accident prevention programs, inspection intervals and procedures, testing and inspection of detection devices, emergency shut offs, and excess flow valves.

### Annex 8—Regulatory Compliance and Cross-Reference Matrices

This last annex has two parts. Part One includes the signatory page and certifications while Part two addresses the information necessary for reviewers to determine compliance with specific regulatory requirements. This annex can contain cross-references for locating the specific item for other planning requirements. This plan allows the facility to meet the needs of several plans. For facilities interested in compliance with other agencies, the ICP guideline contains a series of matrices that can be used when emergency planners to the outline described in this scenario.

## SCENARIO #19

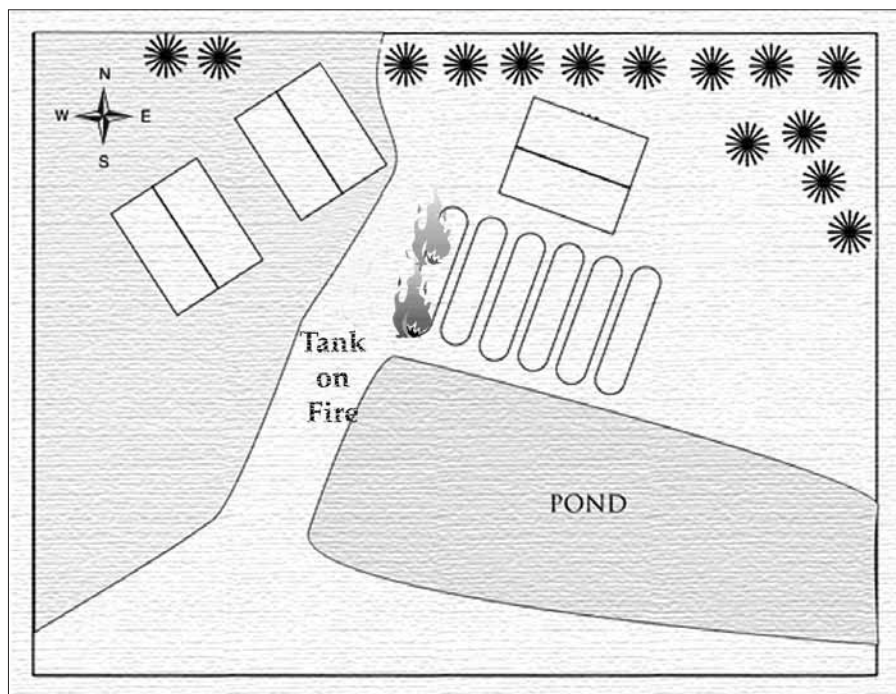


FIGURE 8-63

# SCENARIO #20

## DEVELOPING CREDIBLE SCENARIOS FOR EMERGENCY RESPONSE PLANNING



FIGURE 8-64

On a hot summer afternoon, a bulk plant is in the process of off-loading 33,000 gallons of propane from a railroad tank car. As the unloading process continues, a thunderstorm begins to develop and move in from the southeast. The decision is made to stop off-loading the rail car until the storm passes. Before the pump is shut down, the rail car unloading rack is hit with a direct lightening strike and a fire breaks out.

A technician at the pump house sees a small fire at the dome of the tank car. He immediately hits the Emergency Shutoff Valve (ESV) switch at the pump house and a controlled and safe shut down of the plant begins. The ESD automatically shuts down the propane liquid transfer pump, closes valves in the transfer system, and activates the plant's emergency alarm to alert other employees of the emergency. Within seconds, the system is completely isolated.

After activating the plant ESV, the operator calls the local fire department and returns to the loading rack where he activates a fixed fire monitor tied into the plant's domestic water system. A large fire stream from the 500 gallon per minute (gpm) monitor is directed onto the rail car's tank shell near the dome. By the time the fire department arrives the fire has already gone out.

## SCENARIO-BASED EMERGENCY PLANNING

What if this scenario occurred at your facility? If you have good engineering controls, trained personnel, and a well-thought out Emergency Response Plan it could happen this way. Fortunately, most emergencies in industrial facilities never develop into major events because the scenario was anticipated and planned for before the event actually occurred.

As an owner or operator, you understand the hazards of propane. But have you looked at possible emergency response scenarios within your plant? What are the probability and consequences of each scenario? This process is a critical benchmarking developing a facility Emergency Response Plan. Sometimes known as "scenario based emergency planning," this process assists you in (1) identifying likely emergency scenarios within your facility; (2) evaluating the hazards and potential risks of each event; and (3) determining the necessary procedures and/or resources to handle the event should it occur. The terms HAZARD and RISK are often used interchangeably but from an emergency planning perspective, they actually have very different meanings and represent two different activities in the planning process.

**Hazards**—Hazards are materials, processes, or locations within the plant that may pose some danger or peril. In emergency response operations, hazards generally refer to the physical and chemical properties of a material under certain conditions. For example, propane has very specific characteristics such as boiling point, vapor density, expansion ratio, and flammable limits, which determine how it and its container will behave under both normal and emergency conditions. The hazardous characteristics of propane remain constant. Propane will always be propane regardless of the size or type of storage container, location etc.

**Risks**—Risk is the probability that something will go wrong. Unlike hazards, which are constant and fairly easy to identify, risks are variable and may change. Within the fields of Process Safety Management and Safety Engineering, there are many risk evaluation tools used to help determine the probability that an event may occur and the consequences of that event. However, from an emergency planning perspective, the risk assessment process can be simplified by focusing on scenarios that represent the range of credible events that could happen.

## CREDIBLE EMERGENCY SITUATIONS

Experienced emergency planners develop Emergency Response Plans based on scenarios that are "credible". In simple terms, a Credible Scenario is believable and falls within the range of accepted probability. It may be based upon either actual experiences within the facility or historical experience or events within the gas industry at-large.

On one end of the spectrum are emergencies that have a very low probability of ever occurring, but for which the consequences would be severe. An example of this scenario would be a fully loaded passenger aircraft crashing into your bulk plant with all of the storage tanks filled to capacity. This scenario is not very likely, but it could happen. However, If you developed your Emergency Response Plan around this scenario your plan will not be very realistic in addressing the more likely and probable events.

At the other end of the spectrum are scenarios that have a very high probability of occurring, but the consequences will be minimal. An example of this type of scenario might be a trash dumpster on fire in the plant's parking lot. An Emergency Response Plan built around this scenario would also be deficient in addressing emergencies that may test your capabilities and operations.



If we listed all of the possible emergency scenarios and placed them on a scale with Low Probability/High Consequence events on one end and High Probability/Low Consequence events on the other end, the "credible" emergencies would fall would be somewhere in the middle.

Although selecting credible scenarios can be somewhat subjective, but there are some practical guidelines that can be used to determine what should be addressed in the Emergency Response Plan. These include:

- What types of hazards are in your facility that could be involved in an emergency? Identifying the real hazards within your facility is a key step in determining the types of credible emergencies that could occur. These should include both physical and chemical hazards, including fires, releases, and confined spaces.
- What type of storage systems and product transfer operations are found at your facility?

Fire and leak scenarios involving propane storage and loading/off-loading systems should be practical and take into consideration how the system is designed to function during an emergency. Although large quantities of liquid propane may be found in storage vessels, most emergency response events involve the transfer and handling of product.

- Are there any fixed or semi-fixed fire suppression and detection systems in-place? What are the capabilities of the firewater system? Depending upon local requirements, some facilities may have a range of engineered fire detection, fire suppression, and emergency shutdown systems in-place. In addition, the fire flow requirements and flow capabilities of the either the plant or local water system should be assessed.
- What types of exposures are around your facility that will need special attention if there is an emergency in your plant? What are potential off-site consequences of an event at your facility?

Exposures can include people, property, environmental or systems that could be impacted by an emergency in your plant. Systems can range from transportation systems (e.g., railroad, highway and air corridors) to impacts upon electrical and utility grids. For example, if you have a propane leak and there are special occupancies downwind (e.g., school, nursing home, etc.), what are the procedures for notifying these occupancies? If there is a vapor release involving your facility, will it potential impact the highway or railroad corridor that adjoins your facility? What types of hazards are off-site that could impact your facility and/or your employees and customers?

Neighboring facilities could also pose a threat to your facility if they have an emergency. For example, if the facility next door stores or uses certain liquefied gases such as chlorine or anhydrous ammonia, how will it effect your plant? Are there procedures in-place for notification of your facility?

NFPA 58, Liquefied Petroleum Gas Code requires a facility operator or owner to conduct a fire safety analysis for propane facilities having ASME containers of aggregate storage greater than 4,000 gallons water capacity. NFPA 58 requires planning for response to incidents including inadvertant release of LP gas, fire, or security breach. Planning requires consideration of the safety of emergency responders, workers, and the public.

SCENARIO #20

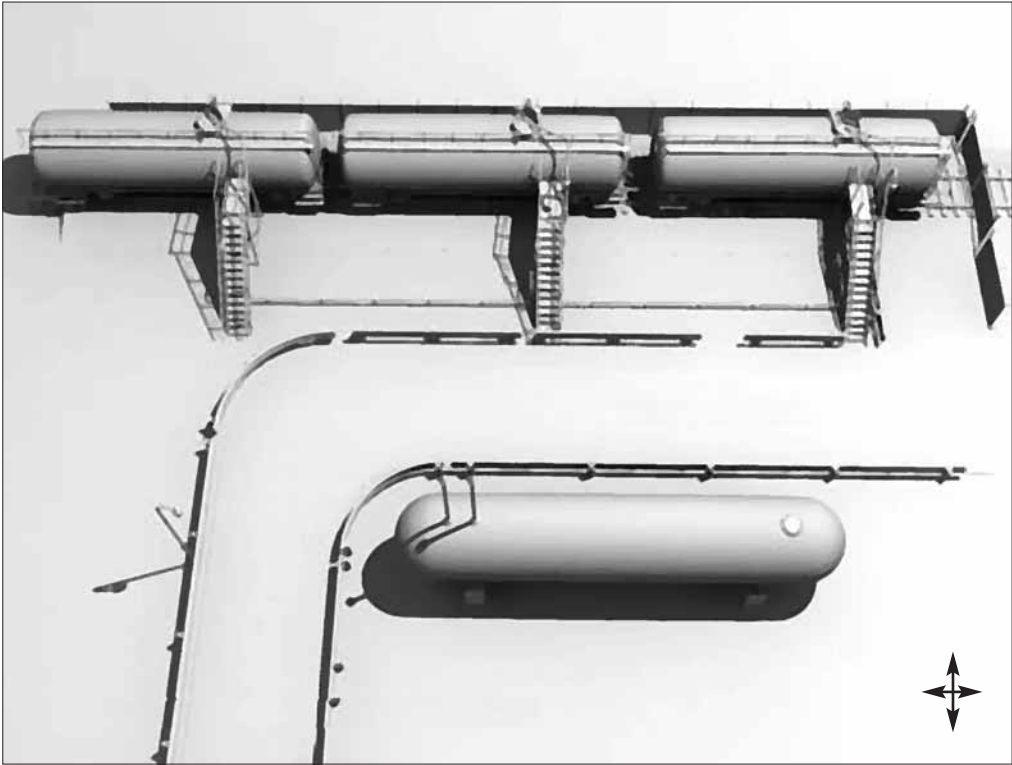


FIGURE 8-65

In order to understand the hazards and risks of different types of propane container emergencies, you must be familiar with both the physical properties and behavioral characteristics of propane, as well as the basic design and construction features of propane tanks.

Hazard and risk assessment is a definitive step taken by the Incident Commander to identify the hazards involved in the incident and evaluate the potential risks of each tactical option being considered. Hazard and risk assessment should be an ongoing process along the entire timeline of the incident. It begins upon arrival at the emergency scene and continues along the incident timeline until the problem has been safely resolved and the incident is terminated.

In normal circumstances, propane dissipates quickly in open air. The use of firehoses and master streams with nozzles on fog pattern (power cone) can rapidly disperse flammable propane gas in air under most conditions.

Most emergency responders are very familiar with the potential for violent closed container failure hazards associated with large bulk LPG containers like railroad tank cars. However, they often fail to see comparable hazards and the potential for violent container failure when dealing with smaller propane tanks and cylinders. Approaching a burning propane tank from the sides with flame impingement in the vapor space is not a guarantee that you will be safe from projectiles or missiles if the tank BLEVEs. For small containers, research shows that a minimum safe approach distance from the sides of a burning tank to avoid the majority of projectiles would be about 300 feet, but beware that ruptured cylinders and containers have traveled distances much further. Use distance and shielding to your tactical advantage. The larger the tank, the further away you should be. Remember, projectiles from BLEVEs are the major hazard to emergency responders.

Rapid application of cooling water on the outside of the tank above the liquid level can reduce the likelihood of container failure by lowering the external temperature of the shell of the exposed tank. Any decision to approach a propane tank showing direct flame impingement on its vapor space must be made on a case-by-case basis after evaluating the hazards and risks and determining if an adequate water supply is available to support firefighting operations. Bulk storage tanks can fail within 10 to 20 minutes of direct flame impingement if the containers are not adequately cooled.

Propane fires should not be extinguished unless the fuel source can be isolated. If the fuel source is not shut off and the fire is extinguished, the leaking gas can migrate away from the container and may find an ignition source.

Structural firefighting gear and SCBA can offer sufficient protection to the wearer engaged in propane firefighting and leak control if the user is fully aware of the hazards being encountered and the limitations of the protective clothing. Remember, PPE will provide only minimal protection against propane liquid burns.







# PRODUCT REMOVAL, TRANSFER AND RECOVERY OPERATIONS

**OBJECTIVES**

1. Identify three safety considerations for product transfer operations. [NFPA 472-6.4.3.7]
2. Identify three factors to be considered in conducting a damage assessment of a pressurized container.
3. Describe the following terms and their significance in the damage assessment process for pressurized containers:
  - Score
  - Gouge
  - Wheel burn
  - Dent
  - Rail burn
  - Street burn
  - Crack
4. Identify one method for determining the pressure in propane bulk transport containers. [NFPA 472-6.2.2(F)].
5. Identify one method for determining the amount of lading remaining in a damaged propane bulk transport container. [NFPA 472-6.2.2(G)].
6. Identify the types of damage that a pressure container, such as an MC-331 propane cargo tank truck, could incur. [NFPA 472-6.2.3.4].
7. Identify three factors to be considered when surveying an propane cargo tank truck prior to initiating transfer and/or uprighting operations.
8. Define the following terms and their application at a propane emergency:
  - Bonding
  - Grounding
9. Identify the common methods for product transfer from an MC-331 propane cargo tank truck. [NFPA 472-6.3.5(B)]
10. Describe three product and transfer considerations for dealing with an overturned MC-331 propane cargo tank truck. [NFPA 472-6.4.3.11]
11. Describe the application, advantages and limitations of flaring as a method of leak control.
12. Describe the process of auto-refrigeration and its significance when dealing with propane emergencies
13. Identify three factors to be considered in uprighting an overturned MC-331 propane cargo tank truck.

**ABBREVIATIONS AND ACRONYMS**

|      |                                      |
|------|--------------------------------------|
| DOT  | Department of Transportation         |
| IAP  | Incident Action Plan                 |
| EFV  | Excess Flow Valve                    |
| HMRT | Hazardous Materials Response Team    |
| ICP  | Incident Command Post                |
| MC   | Motor Carrier                        |
| NFPA | National Fire Protection Association |
| PTO  | Power Take-Off                       |

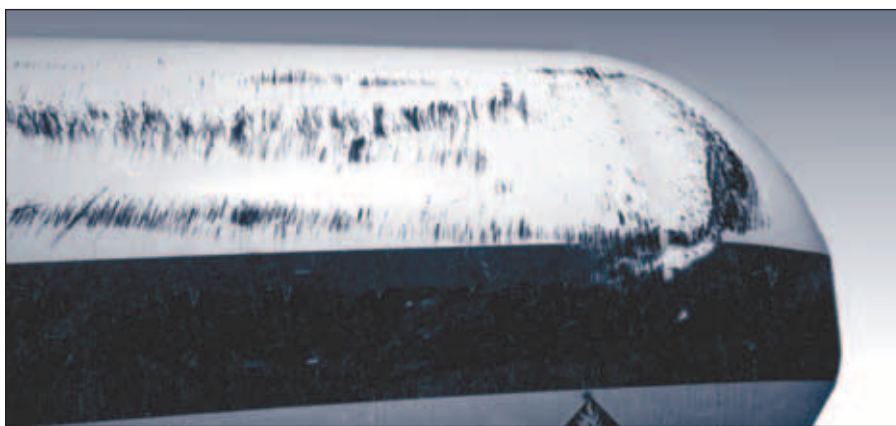
**PRODUCT AND CONTAINER RECOVERY ISSUES**

Most of the information in this section focuses upon propane cargo tank trucks, although a number of the basic product container and recovery principles also apply to other types of flammable and pressurized containers (e.g., rail cars).

Many bulk cargo tank truck accidents involving propane are the result of low-speed rollovers (e.g., the driver fails to judge the curve on an off-ramp and the vehicle slips onto a soft shoulder and overturns). Low-speed rollovers usually result in minor “cosmetic” damage to the tank and a survey of the container by cargo tank specialists often reveals no leaks or significant problems with structural integrity. In most of these situations, the vehicle is carefully uprighted without incident.

When significant structural damage to the tank is apparent, the best way to proceed requires both container assessment and risk analysis. How should an overturned vehicle be handled? For example, is it better to upright the tank truck fully loaded, or should it be initially off-loaded and then uprighted? What if you are unable to fully off-load the cargo? How does this change the fluid dynamics between the container and its contents?

Having a unified command structure where the key players participate is a critical element in working through these situations. In many respects, there is not always a right way or a wrong way. Rather, there are a range of options that should be evaluated based upon a number of tactical inputs, including the nature of the incident, its location, container damage assessment, and available resources.



KEITH HANCHETT

**FIGURE 9-1** Low-speed rollovers usually result in minor cosmetic damage to the tank.

Disagreements concerning the way to handle removal and recovery operations can generate issues that can potentially break down lines of communication between public safety agencies, carriers, propane marketers, and the recovery contractor. If handled poorly by any of the key players, the situation can jeopardize site safety and may have a negative and long-lasting effect on good working relationships after the incident is over.

The Incident Commander should strive to achieve a consensus amongst the key players within unified command. Differences of opinion concerning product or vehicle recovery and removal operations need to be addressed by one or more of the following situations:

- **Cargo tank or product specialists, or owners and operators must be integrated into the command structure.** It is critical that these individuals are in the communications loop and are part of the decision-making process concerning the best course of action. If an agency or organization works within the incident command structure, they become part of the solution.

If propane industry representatives work independently outside of the command structure, do not have a liaison at the Incident Command Post (ICP), or are excluded from participating by the Incident Commander, they can become part of the problem. Think about it...if you can't communicate with the decision-makers, how can you be part of the decision-making process?

- **All key players must have credibility with the other players.** Lack of credibility can be due to poor initial impressions reinforced by a perceived lack of training, sloppy dress and personal appearance, a demonstrated bad and unprofessional attitude, failure to show up with the right tools or improperly maintained and unsafe equipment, etc. Always remember—perceptions are reality.

Credibility at the emergency scene is built on the basis of trust. Positive first impressions, previously established good working relationships, your personal or organizational reputation for professionalism, and the way you handle yourself during meetings at the ICP all help lay the groundwork for credibility. Translation: If you want people to listen to your opinions and follow your recommendations, you must have credibility, and credibility in the emergency response business must be earned. Propane industry and emergency response personnel who have developed good working relationships prior to an incident have the advantage.

- **There must be a technical basis to support the proposed Incident Action Plan (IAP) or site safety practices.** It is important that decisions concerning product and container recovery be made from a solid technical basis. The Incident Commander must clearly understand the hazards and risks of each tactical option (e.g., uprighting versus off-loading). Product and container specialists are a critical resource in establishing the technical foundation upon which these decisions should be made.

A common mistake made by some product and container specialists is to recommend an IAP without taking the time to fully explain the technical basis for the proposed plan, as well as the associated advantages and limitations. Many emergency responders use a "risk-based" decision-making process when assessing tactical options at a hazardous materials incident. Product and container specialists must provide the Incident Commander with the risks and benefits associated with each tactical option, and should



include a discussion as to why some tactical options may not be technically viable. It is important that the IAP be “unified” and that the Incident Commander, owners/operators, product and container recovery specialists, etc. all be on the same page and in agreement on how transfer and/or uprighting operations will proceed.

## SITE SAFETY AND CONTROL ISSUES

Product removal and recovery operations should not begin until the incident site is stabilized and the area has been re-evaluated for hazards and risks. Stabilization means that all fires have been extinguished, ignition sources have been secured, and all product releases have been controlled.

As the excitement of the incident winds down, there is often a strong desire to “get this problem cleaned up and go home.” If site safety is not maintained, some responders and players may become less attentive and may attempt shortcuts in favor of speeding up the recovery operation. This is especially a concern when the weather is poor and the emergency extends over many hours. It is also the most likely period during the response when disagreements may arise over the safest and fastest way to recover the product from a damaged tank.

Specific site safety considerations that should be addressed during this phase of the incident include:

- Ensure that back-up crews are available and in place to protect all personnel involved in the off-loading and uprighting operation. It should be noted that in some tank truck rollovers, small incidental leaks may still be present.
- A minimum of two 1-1/2 or 1-3/4 inch fully charged handlines and at least two dry chemical fire extinguishers should be used. Master stream appliances should also be considered when dealing with rollovers involving transport tank trucks. All hoselines should be supported by a sustainable uninterrupted water supply.
- Always have an emergency signal and an escape pathway for personnel working in the immediate hazard area.
- Continuously monitor the hazard area with flammable gas monitoring equipment, as necessary.
- Maintain Hazard Control Zones throughout the off-loading process and enforce protective clothing requirements established by the Incident Commander.
- Ensure that all personnel remain alert. Frequent relief and rotation of personnel can usually minimize this problem.

## DAMAGE ASSESSMENT OF PRESSURIZED CONTAINERS

Responders can be confronted with a variety of pressurized propane containers, including cylinders, cargo tank trucks (MC-330/331), and railroad tank cars (e.g., DOT-105, 112, and 114 tank cars). Much of the available literature on damage assessment of pressurized bulk transport containers is based upon testing and experience with railroad tank cars. Responders should recognize that design and construction standards for tank cars are substantially greater than those for cylinders and cargo tanks and provide a greater margin of safety.

Over 35 years of accident experience have shown that many pressurized containers have sustained extensive damage in accidents and have not released their contents. This is especially the case with the MC-331 cargo tank trucks and DOT railroad tank cars equipped with head shields, shelf-couplers and thermal insulation. However, improper off-loading or uprighting techniques can cause mechanical failure of the container even if the outer shell shows no significant structural damage.

## CAUSES OF CONTAINER FAILURE

The violent rupture of pressurized containers can be triggered by two related conditions: (1) the thinning of the tank metal as a result of scores, gouges, and thermal stress, and (2) the presence of a crack in the tank metal associated with dents. Factors which can affect the severity of the container damage include the ductility of the container metal (i.e., ability of the metal to bend or stretch without cracking) and the internal pressure causing stress on the container metal.

Emergency response personnel should have a basic understanding of ductility. Ductility is the relative ability of a metal to bend or stretch without cracking. Ductile materials have a fine-grain structure and tend to bend but not crack. Brittle materials have a coarse-grain structure and tend to crack rather than bend. When a ductile steel container cracks, the crack tends to be small; in contrast, a crack in a brittle steel container tends to run linearly and cause the container to fail.

The ductility of a container metal is affected by the following:

1. **Specification of the steel**—particularly important in evaluating the integrity of damaged railroad tank cars, as different types of steel with different characteristics have been used over time.

When dealing with cargo tank trucks, responders will encounter quench tempered (QT) and non-quench tempered (NQT) tank metals. Differences can be summarized as follows:

- QT tank metals are heated to a high temperature, then rapidly cooled. This produces a metal that is quite hard and strong, but also can be somewhat brittle. The brittleness of a metal can become an issue if the cargo tank is subjected to extensive mechanical stress, such as when the tank is involved in a serious rollover or strikes a concrete abutment.
  - NQT tank metals are heated to specified temperature for a specified period of time, then slowly cooled through the use of some type of heated media (e.g., melted salt). This produces a metal that is hardened, but not as hard as QT metal. In addition, NQT metals are not as brittle as QT metals.
2. **Temperature of the steel**—the higher the temperature of the steel at the time of damage, the more ductile (less brittle) the steel will be and the less risk there is for failure. For many liquefied gases that are loaded cold, it will take time for the shell temperature to rise to ambient temperature levels.
  3. **Cold work**—deformation of steel when it is bent at ambient temperatures or results from an impact or static load. Cold work reduces the ductility of the metal.
  4. **Heat-affected zone**—area in the undisturbed tank metal next to the actual weld material. This area is less ductile than either the weld or the steel plate due to the effect of the heat of the welding process. This zone is most vulnerable to damage as cracks are likely to start there (see Figure 9-2).

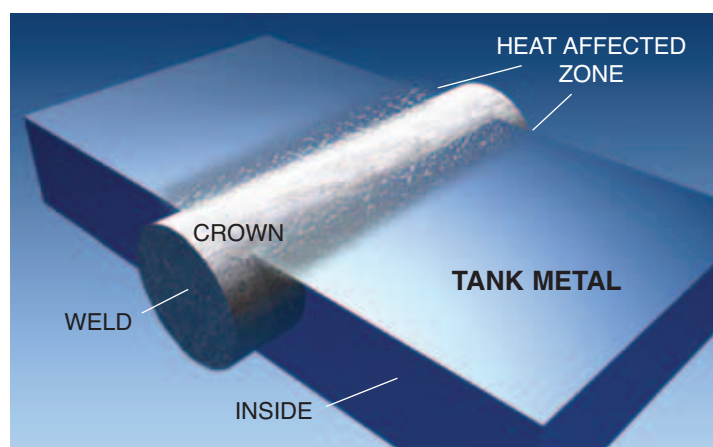


FIGURE 9-2 Heat-affected zone.

## DAMAGE ASSESSMENT

The process of conducting damage assessment of pressurized containers should incorporate the following factors:

- Determine the type of container (e.g., DOT specification number), material of construction, quantity of product and internal pressure. Methods for determining product quantity and internal pressure are outlined in Figure 9-3.
- Determine the type of stress applied to the container (e.g., thermal, mechanical, or a combination of stressors).
- Evaluate the stability of the container. Use caution when inspecting an unstable container as it may move or shift during the inspection process. It may be necessary first to stabilize the container with blocks, cribbing, air bags, or other means.
- Examine the surface of the container, paying attention to the types of damage and the radius (i.e., sharpness) of all dents. Railroad personnel may use a Tank Car Dent Gauge as a tool for comparing the radius of curvature of a tank car dent to accepted standards, and to assess the severity of damage. It should be stressed that the Tank Car Dent Gauge should not be used on cargo tank trucks due to the differences in shell thickness and construction.

Experience shows that the most dangerous situations will include the following:

- Sharply curved dents or abrupt dents in the cylindrical shell section that are parallel to the long axis of the container. The container should be off-loaded without moving it when a dent is considered critical, such as a dent accompanied with scores or gouges.
- Scores and gouges across a container's weld seam. If the score crosses a welded seam and removes no more than the weld reinforcement (i.e., that part of the heel which sticks above the base metal), the stress is considered non-critical. However, if the score removes enough of the base metal at the welded seam, the stress is considered critical.
- Cracks in the base metal of a tank or cracks in conjunction with a dent, score or gouge. If the crack is leaking the situation is very serious. These situations, as well as others, justify off-loading the container as soon as safely possible.

These guidelines can be used by emergency responders to make general decisions about uprighting versus off-loading. Always remember that there may also be parts of the container that may not be visible for assessment. Technical assistance from container specialists is critical and should be an integral part of the hazard and risk evaluation process. Container specialists may include railroad personnel, propane industry representatives, and cargo tank truck specialists.

**In summary, damage assessment is, at best, a qualitative assessment process that requires input from product and container specialists who have experience in evaluating structural damage and the integrity of pressurized containers (e.g., stable versus nonstable, go/no go, etc.).**

### **DETERMINING PRODUCT QUANTITY AND PRESSURE WITHIN PROPANE CONTAINERS**

An obvious question often asked by responders is “how much product and/or pressure is within a container?” Tools and techniques that can be used to answer this question include:

#### **Determining Amount of Product**

- Shipping papers and related documents—will show the type, number of, and weight of any hazmat containers. Examples include bills of lading, railroad consist or train list and dangerous cargo manifest. In many instances, the highway bill of lading will simply list “One Cargo Tank” as the amount of product being transported.
- Fixed gauging devices—can be found on liquid containers. Some examples include rotary and float type (magnatel) gauges commonly used on propane cargo tank trucks, and gauging rods located within the protective housing of DOT-112/114 pressurized railroad tank cars transporting propane and butane. Depending upon the position of the container, they may not be a reliable method as they are designed for use when the container is in its normal upright position.
- Weigh small non-bulk cylinders—can be used for some liquefied gases in non-bulk cylinders, such as 20 or 30 lb. propane cylinders.
- Infrared cameras—will detect the temperature difference between the liquid phase and the vapor phase, and clearly show the liquid level within the container.
- Visible frost line on a leaking propane container.

#### **Determining Container Pressure**

- Fixed pressure gauge—permanently attached to some non-bulk and bulk pressurized containers (e.g., MC-331 cargo tank trucks).
- Attach a pressure gauge to sample lines, gauging device, fittings, etc. of a pressurized container (e.g., railroad tank car).
- Determine the temperature of the product and use a vapor pressure/temperature conversion chart. Vapor pressure/temperature graphs are available from the *Compressed Gas Handbook*, as well as the shipper or manufacturer of the material.

**FIGURE 9-3** Determining product quantity and container pressure can be important factors in predicting container behaviors and outcomes.



## EXAMPLES OF PRESSURIZED CONTAINER DAMAGE

**Score**—Reduction in the thickness of the container metal. It is an indentation in the shell made by a relatively blunt object. A score is characterized by the reduction of the container or weld material so that the metal is pushed aside along the track or contact with the blunt object. See Figure 9-4.



FIGURE 9-4

**Gouge**—Reduction in the thickness of the tank shell. It is an indentation in the shell made by a sharp, chisel-like object. A gouge is characterized by the cutting and complete removal of the container or weld material along the track of contact. See Figure 9-5.



FIGURE 9-5

**Wheel burn**—Reduction in the thickness of a railroad tank metal. It is similar to a score, but is caused by prolonged contact with a turning rail car wheel. See Figure 9-6.

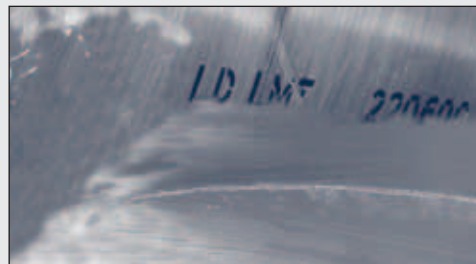


FIGURE 9-6

**Dent**—A deformation of the tank head or shell. It is caused from impact with a relatively blunt object. If the dent in the tank metal has a sharp radius, there is the possibility of cracking. NOTE: Jacketed rail cars sometimes reveal dents while the tank shell remains undamaged. See Figure 9-7.

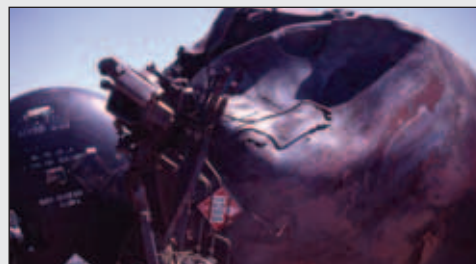


FIGURE 9-7

**Rail burn**—A deformation in the tank metal of a railroad tank car. It is actually a long dent with a gouge at the bottom of the inward dent. A rail burn can be oriented circumferentially or longitudinally in relation to the tank shell. The longitudinal rail burns are the more serious because they have a tendency to cross a weld. A rail burn is generally caused by the tank car passing over a stationary object, such as a wheel flange or rail. See Figure 9-8.



FIGURE 9-8

**Street burn**—A deformation in the shell of a highway cargo tank. It is actually a long dent that is inherently flat. A street burn is generally caused by a container overturning and sliding some distance along a cement or asphalt road. See Figure 9-9.



FIGURE 9-9

**Crack**—Narrow split or break in the tank metal which may penetrate through the container metal (may also be caused by fatigue). It is a major mechanism which could cause tank failure. Cracks are very difficult to determine in the field and typically require the use of x-ray or similar metallurgical testing equipment. See Figure 9-10.

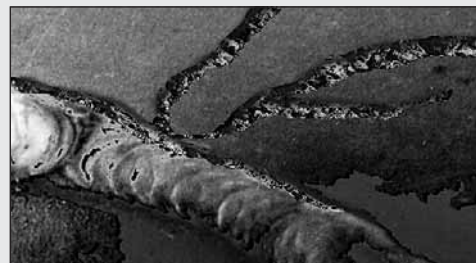


FIGURE 9-10

**NOTE:** Some of the information contained in this section was referenced from the Union Pacific Railroad Company manual written by Charles Wright, entitled, *Participants Manual: Tank Car Safety Course*.

## PRODUCT REMOVAL AND TRANSFER OPERATION

### SURVEYING THE CONTAINER

Product removal and transfer operations involve moving the contents from a damaged or overloaded tank(s) into an undamaged and compatible receiving tank(s), such as a tank car, cargo tank truck, intermodal tank or fixed tank.

Product transfer and removal procedures will vary based upon the type of container involved, container design and construction, container stress and actual or potential breach, and the position and location of the container. An effective damage assessment process must always be conducted to determine the appropriate tactical actions for off-loading and uprighting.

Experience in managing rollover scenarios has resulted in the following operational considerations:

- If a cargo tank is upright and not leaking, normal methods for unloading the product can be used.
- If a cargo tank or rail car is on its side, only 50% of the product may be off-loaded because the internal liquid and vapor valves will eventually be above the liquid level as the product is removed. In addition, excess flow valves may fall into place if the container is off 90°.
- If a cargo tank or rail car is upside down, it may still be unloaded by reversing the liquid and vapor valves / lines.

**When to Transfer Product.** Although bulk propane transportation containers are often uprighted while loaded, there are numerous scenarios and situations where that may not be possible. Product transfer operations may be required on highway or rail incidents when one or more of the following conditions exist:

- Site conditions prevent uprighting the damaged tank. For example, access is limited or the terrain does not permit the use of cranes (e.g., ground slope is too severe, ground is too soft for outriggers on cranes, etc.).
- The tank has been stressed by one or more stressors (e.g., mechanical, thermal, chemical, etc.). Off-loading can reduce the stress on a bulk transport container by reducing the overall weight of the package being lifted (i.e., the weight of the product plus the weight of the tank). Depending on the position of the tank and its stability, transferring product from a damaged tank may reduce the stress on the tank by reducing its weight. However, transferring product out of the tank will not significantly reduce the internal tank pressure since a gas exerts uniform pressure on all sides of the vessel regardless of quantity. Flaring may also be used to reduce the tank pressure.
- Leaking valves and fittings are damaged and cannot be repaired. Valves will continue to leak over time.
- The tank is structurally sound but cannot be safely moved because of its location (e.g., in a precarious position such as hanging over a bridge, embedded in a structure, etc.).
- Damage assessment determines that the container has been stressed and damaged to the point that it cannot be safely uprighted.

**Factors to Consider Before Determining Transfer Method.** Overturned bulk transport containers should initially be surveyed by a container specialist to determine the safest method of off-loading. Factors that should be considered by the Incident Commander before approving transfer operations include:

- *Stability of the vehicle and container.* Even when the unit appears stable, consideration must be given to shoring and bracing. This may be accomplished using cables and slings attached to cranes, come-alongs, heavy timber bracing, hydraulic or mechanical jacks, or mat jacks and air bags. A combination of these devices may be required to get the job done safely. **NOTE:** Do not use hydraulic rescue tools to lift or stabilize these vessels. Damage to the container may result.
- *Pitch and position of the container.* The position, location, and condition of piping and valves that will be used for product off-loading. Is the container partially buried making valves inaccessible, in a precarious and unstable position, or in an inaccessible or dangerous area? If a cargo tank truck or rail car is involved, the pitch and position of the container—front to back and left to right—are particularly important. It is possible that the container may move as product is pumped off and the product load shifts. A tank that shifts or slides during off-loading can cause product hoses or couplings to break, place extreme stress on the tank as the internal load shifts, or crush and trap workers involved in the transfer operation.
- *Ambient temperature.* Very high or low ambient temperatures will influence off-loading rates. This translates into the time it will take to off-load the product due to its vapor pressure. Consideration must also be given to changes in day versus night ambient temperatures, and their impact upon product temperature, pressure and transfer rates. Given that the ambient

conditions may adversely impact off-loading, uprighting or flaring may be a better alternative.

- *Availability of qualified personnel and equipment.* Qualified specialists and equipment must be on scene to perform the safe transfer of the product and container uprighting operations. Experienced emergency responders often seek out third party opinions from product or container specialists who are not on the scene to validate a plan of action. This is a good practice, but ultimately someone experienced in the hands-on aspects of the operation must be on the scene to supervise the operation.



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**FIGURE 9-11** Transfer operations as a result of a MC-331 transport rollover.

## GROUNDING AND BONDING

In recent years, there has been some confusion within both the propane industry and the emergency response community as to whether bonding and grounding of propane cargo tank trucks and rail cars is necessary during off-loading operations involving damaged tanks. For example, Chapter 6.20.1.3 of *NFPA 58—The LP-Gas Code*, states “grounding and bonding shall not be required on LP-Gas Systems.” The rationale behind this provision is that since liquefied petroleum gas is contained in a closed system of piping and equipment, the system need not be electrically conductive or electrically bonded for protection against static electricity.

However, it should be noted that NFPA 58, Chapter 6.20 applies to LP-Gas systems installed and operated in accordance with the Code. It is not intended to apply to emergency operations involving damaged cargo tank trucks or rail cars. In addition, the *NFPA 58 Handbook*, Chapter 6.20.1.3 notes that if liquid LP-Gas is released at a high velocity, creating a mixture of liquid drops, then vapor, air and water drops (due to condensation of water vapor in the air from refrigerating effect of vaporizing liquid) can generate an electrostatic charge.

Emergency operations involve many unknowns, and experience shows that even with the best equipment and planning, conditions can change rapidly and deteriorate. Consequently, it is common practice among Hazardous Materials Response



Teams (HMRTs) to plan for the worst-case scenario and to take tactical actions to minimize the level of risk, especially in the event of a problem during transfer operations. Bonding and grounding is typically required by HMRTs when transferring flammable liquids and gases in a response scenario. These special precautions are usually taken even though they may be considered by some as unnecessary and “overkill.”

The foundation and justification for bonding and grounding when flammable liquids and gases are involved is well established in *NFPA 472—Standard for Professional Competence for Responders to Hazardous Materials Incidents*. NFPA 472 emphasizes the importance of grounding and bonding in both Chapters 13 and 14 of the Standard. Chapter 13, “Competencies for the Technician with a Tank Car Specialty,” states that the railroad tank car specialist must be able to, “Demonstrate [competency in] bonding and grounding procedures for the transfer of flammable and combustible products from tank cars, or other products that can give off flammable gases or vapors when heated or contaminated.” Chapter 14, “Competencies for the Technician with a Cargo Tank Specialty,” contains identical language, and specifically addresses the MC-331 cargo tank truck.

In summary, while bonding and grounding is not required for normal transfer operations involving properly installed fixed tanks and systems, bonding and grounding is a widely accepted practice by public safety Hazardous Materials Response Teams for off-loading propane cargo tank trucks and rail cars during emergency operations. Ultimately, the decisions concerning whether to bond and ground a damaged cargo tank truck or rail car should be made on a case-by-case basis by the Incident Commander in conjunction with the technical advice of safety, hazardous materials, product, and container specialists. Factors such as poor soil conditions, frozen ground, etc., may make bonding and grounding impractical even where the parties involved agree that bonding and grounding is necessary.

## PRODUCT TRANSFER METHODS

Product transfer and removal operations are normally performed by industry emergency responders, product specialists and container specialists serving as contractors to the owner/operator. However, public safety responders will have overall command of the incident scene, and will ultimately be responsible for site safety and oversight of product transfer and removal operations.

The following information provides an overview of the range of options available for off-loading. Decisions to use one method over another must be made on a case-by-case basis in consultation with product and container specialists.

### PUMPS

Pumps can be used for transferring product from an overturned propane tank truck. They are often mounted on the receiving vehicle and are powered through a PTO-drive. Portable pumps provided by contractors or propane industry representatives may also be used. The most common types of pumps are of a centrifugal and rotary design.

Operational considerations when using pumps for transfer operations include:

- Temperature and elevation of the overturned container to the receiving container can influence the transfer rate.
- Having sufficient hoses of the same size and connections may create operational problems in safely positioning the transfer vehicles in proximity to the overturned container.

- If a cargo tank or rail car is on its side, only 50% of the product may be off-loaded because the internal liquid and vapor valves will eventually be above the liquid level as the product is removed.
- Heat transfer and product vaporization should be considered when transferring product during high ambient temperature conditions.
- A vapor return line is required to equalize container pressures and facilitate product movement.
- Excess flow valves (EFV) can affect the transfer operation, depending upon flows, hose sizes and hose lengths.

See Figure 9-12 for a diagram of a pumping system.

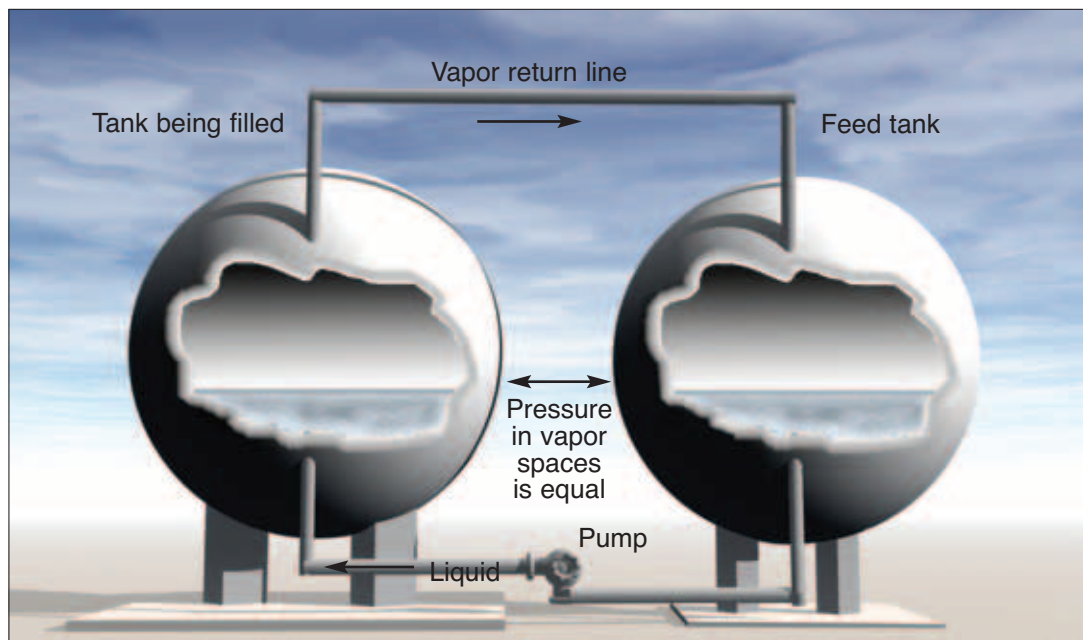


**FIGURE 9-12** Pumping system with vapor return line.

## VAPOR COMPRESSOR

Vapor compressors are the most common method of off-loading cargo tank trucks and rail cars. LP Gas compressors are of a reciprocating compressor design. Under this design, propane vapors are pulled into a cylinder through a suction valve by drawing back a piston to create a low-pressure area in the cylinder. The vapors are then pressurized by pushing the piston back up into the cylinder, thereby squeezing out the vapors through the discharge valve. A single stage or two-stage compressor may be found, depending upon the application.

A compressor is used to move the contents from the damaged container into a receiving tank. The vapor compressor pulls the vapors from the receiving tank, compresses them, and forces them into the damaged cargo tank. The higher pressure in the tank being off-loaded then pushes the liquefied propane into the receiving tank.

Operational considerations when using vapor compressors for transfer operations include:

- The use of the vapor compressor will cause an increase in pressure in the container being off-loaded and should only be used when the pressure increase can be handled safely.
- Small amounts of liquid in a compressor can result in major damage to the unit. A liquid trap may be incorporated into the compressor to remove entrained liquids.
- A compressor can be used when both the liquid and vapor lines are in the liquid space in an overturn scenario (aka Emergency Liquid Transfer). Once a line goes “liquid empty,” the pressure differential between the overturn and receiving tanks will drop. Depending upon the position of the overturned tank, there may be as much as 50% liquid remaining. While a compressor can continue to remove product in this scenario, a pump would no longer be effective. See Figure 9-13.
- A compressor can be used to transfer product by “boiling off” the remaining liquid product, thereby reducing the overall vehicle weight and product loss during the recovery operation (aka Emergency Vapor Recovery). This boil off process can be extremely slow, depending upon the liquid level and ambient conditions. The colder the product, the longer the transfer time. The internal pressure drop will also decrease during the product boil off. See Figure 9-14. For example, a 10,500 gallon propane transport at the 50% liquid level at an ambient temperature of 70°F. and being off-loaded with a 36 cfm compressor will take approximately 6.25 hours to complete a “boil off” operation.
- A vapor compressor will remove the “heel” from a container by reducing the internal pressure in the overturned container.

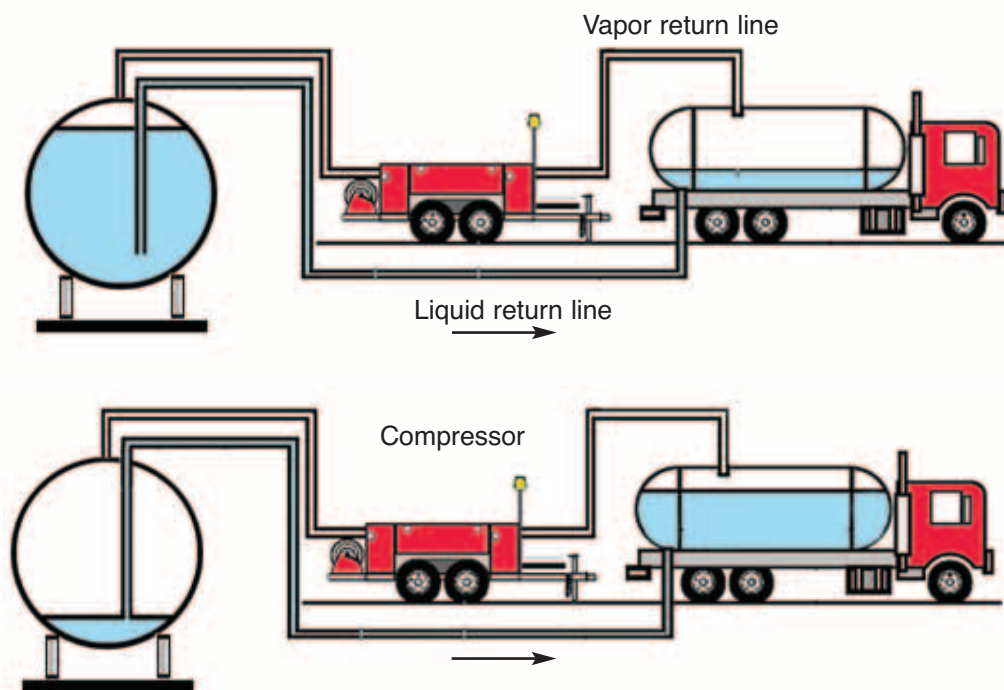


FIGURE 9-13 Typical liquid transfer, using a compressor.

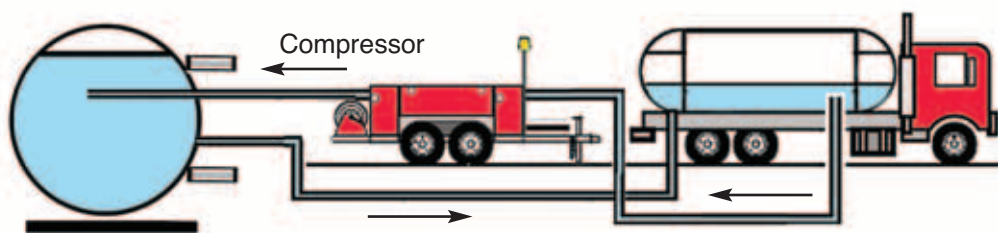


**FIGURE 9-14** Overturn emergency liquid transfer using a compressor.

### VAPOR COMPRESSOR WITH A LIQUID PUMP

Overturn scenarios with significant elevation changes or access to only 2-inch or less liquid lines can create challenges for product removal operations. In these situations, a booster pump may be used in conjunction with a vapor compressor to move the product from the off-loaded tank to the receiving tank.

The vapor compressor is used to accelerate the rate of transfer by withdrawing vapors from the receiving tank, compressing them, and forcing them into the tank being off-loaded. The higher pressure in the tank being off-loaded then pushes the liquefied gas into the pump, which then flows into the receiving tank. See Figure 9-15.

Operational considerations when using vapor compressors for transfer operations include:

- If the diameter of the liquid line is reduced, the rate of product transfer will be reduced.
- This method is commonly used when the receiving tank is a great distance (approximately 50 to 60 ft.) from the tank being off-loaded.
- If the booster pumps or compressors are electric, they must be rated to operate in Class 1 atmospheres (See NFPA 70). The distance from possible leak sources will determine whether the equipment must be rated for a Division 1 or 2 atmosphere.
- The use of the vapor compressor will result in a slight pressure increase inside the damaged tank.
- In scenarios where there is a concern of building pressure on the overturned tank, a smaller receiving tank can be used. Since the tank volume is smaller, it is less likely to build up pressure in the larger tank. The smaller tank can also be used as a nurse tank, whereby a larger transport will then pull of the product from the nurse tank.

### VAPOR PRESSURE DIFFERENTIAL

This method uses the material's own vapor pressure to move the contents of the tank being off-loaded to a receiving tank. As temperature inside the tank increases due to an exterior increase in ambient air temperature, the pressure on the inside of



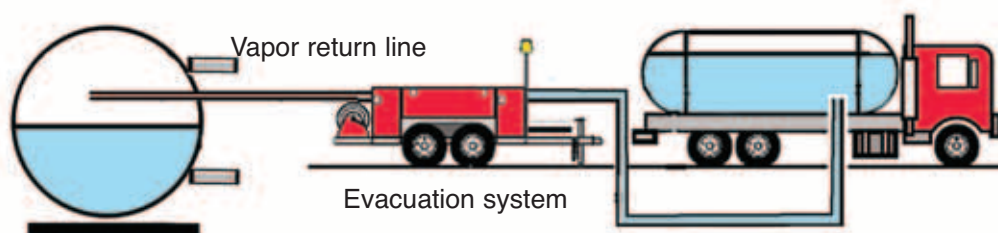


**FIGURE 9-15** Vapor compressor with a liquid pump.

the tank increases correspondingly. The gas inside the tank will seek the path of least resistance and naturally flow from high-pressure to low-pressure areas.

This technique is usually used in combination with a vapor flare that is connected to the receiving tank. As vapors are safely burned off at the outlet of the flare on the receiving tank, the pressure on the receiving tank is maintained as low as possible, and vapor follows the least path of resistance and steadily flows out of the tank being off-loaded.

## VAPOR AND LIQUID FLARING

Flaring is the controlled burning of propane vapors or liquid to reduce or control pressure inside the tank, dispose of residual vapors, and/or to dispose of a product when transfer operations may be impractical. Although the emergency response community refers to flaring as the process of burning off either liquid or vapor product, the propane industry refers to flaring as the process of burning off vapors and liquid burning as the process of burning off liquid propane. Units that are designed for burning off liquid are commonly referred to as a liquid burner, and are specifically designed and engineered for that purpose. We will use the generic term “flaring” in this textbook.

Flaring is commonly used in the propane industry to safely burn off product in cylinders, trucks, and rail cars when they have been severely damaged or access to the accident site is impractical for off-loading to another vehicle.

Operational considerations when evaluating the use of flaring include the following:

- Flaring operations should be performed by qualified and experienced personnel who have specialized training in flaring.
- Flares can be attached to either a vertical or horizontal pipe, and are designed to burn either liquid or vapor product. Most flares found in emergency response applications are attached to vertical pipes. When dealing with bulk propane containers, liquid flares are often preferred due to the exceptionally long burn-off times of a vapor flare. See Figure 9-16.
- If a hose is being used to move product to the flare, the last section that is closest to the flare should be metal pipe (e.g., Schedule 80) in case of a wind change, liquid carryover, etc.

- Flaring will emit significant amounts of radiant heat and can act as an ignition source. The flare should be positioned in a safe location upwind of the involved container and away from any exposures. Hoselines should be positioned for exposure protection.
- Flaring may not be a tactical option in very dry environmental or drought conditions where exposure risks are high.
- Flaring requires substantial time to burn off the product. If the IC decides to go with a flaring option, the time required to accomplish the task must be weighed against other factors such as safety, disruption of transportation systems and businesses, and the safety and speed that other options may present.
- Flaring operations involving flammable liquefied gases, including propane, must consider the impact of auto-refrigeration upon the process. See Scan Sheet 9-B for additional information.
- In some states, a vapor emissions permit may be required to perform emergency flaring.

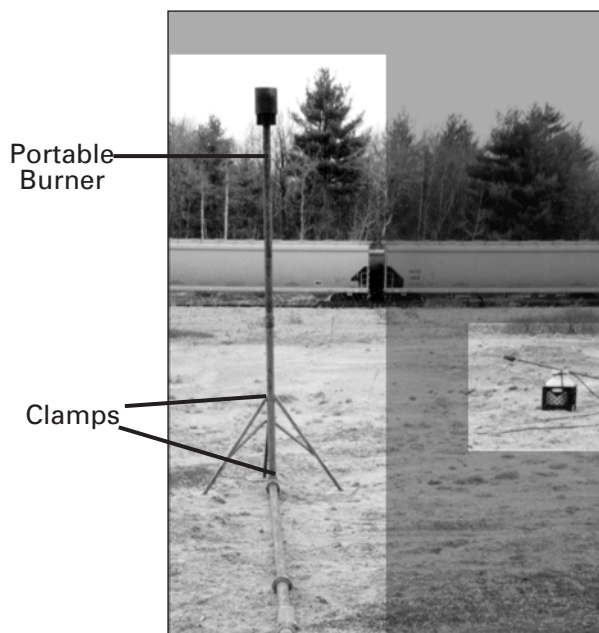
It should be emphasized that the flaring of bulk transport propane containers is normally considered after ruling out other possible transfer options. Flaring should be viewed as a tactical option that might be applicable when other transfer methods are not immediately available or not possible due to access. For example, if the damaged propane container is off a hard-surfaced road, it may take several hours or days to construct a road that will provide access for off-loading and transfer equipment. Flaring may also buy time when the ambient temperature is expected to rise and off-loading options are available. Starting flaring operations early in the process may save valuable time in the recovery process.



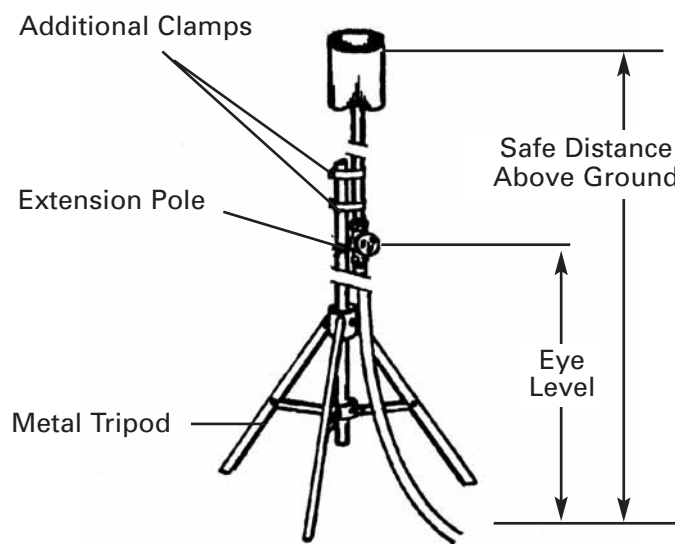
R.C. Powell

FIGURE 9-16 Flaring operation.

## TRIPOD ASSEMBLY



## TRIPOD AND EXTENSION



CETP PLANT OPERATIONS MANUAL

**FIGURE 9-17** Flaring burner support.

# SCAN SHEET 9-B

## AUTO-REFRIGERATION AND FLARING OPERATIONS

### FLARING

Flaring of propane vapor is routinely and safely performed for tank and equipment maintenance in the propane industry. It is also a safe option for emergency situations.

Flaring operations under emergency conditions are usually employed when:

- 1. A cargo tank truck or rail car has sustained significant damage.
- 2. The tank is in a location where off-loading cannot be performed due to inaccessible and rough terrain. While flaring is an acceptable alternative for small containers, it is usually not the best option for dealing with large containers (e.g., 3,000 to 30,000 gallons) because it is a time consuming. For example, using a 2 inch-diameter hose, 150 feet in length, it would take approximately 177 hours to flare off 30,000 gallons of propane, 54 hours to burn off 11,500 gallons, and 14 hours to burn off, 3,000 gallons (assuming the temperature of propane was 0° F. See Table 9-1, which shows the time required to flare off 30,000 gallons of propane using 1 and 2 inch-diameter hoses.

| FLARING RATES FOR 1-INCH DIAMETER HOSE     |                            |                        |                        |                                                      |
|--------------------------------------------|----------------------------|------------------------|------------------------|------------------------------------------------------|
| Flow Rates for 1-Inch Diameter Rubber Hose |                            |                        |                        |                                                      |
| Temperature<br>Propane, F                  | Flow Rate,<br>gallons/hour | Flow Rate,<br>lb./hour | Flow Rate,<br>Btu/hour | Time to Empty<br>30,000 gallons of<br>Propane, hours |
| 0                                          | 169                        | 710                    | 15435277               | 177.5                                                |
| 10                                         | 215                        | 903                    | 19636595               | 139.5                                                |
| 20                                         | 258                        | 1084                   | 23563914               | 116.3                                                |
| 30                                         | 312                        | 1310                   | 28495896               | 96.2                                                 |
| 40                                         | 364                        | 1529                   | 33245212               | 82.4                                                 |
| 50                                         | 420                        | 1764                   | 38359860               | 71.4                                                 |
| 60                                         | 501                        | 2104                   | 45757833               | 59.9                                                 |
| 70                                         | 541                        | 2272                   | 49411153               | 55.5                                                 |
| 80                                         | 701                        | 2944                   | 64024433               | 42.8                                                 |
| 90                                         | 775                        | 3255                   | 70783075               | 38.7                                                 |
| 100                                        | 825                        | 3465                   | 75349725               | 36.4                                                 |
| 110                                        | 957                        | 4019                   | 87405681               | 31.3                                                 |

TABLE 9-1



| FLARING RATES FOR 2-INCH DIAMETER HOSE     |                            |                        |                        |                                                      |
|--------------------------------------------|----------------------------|------------------------|------------------------|------------------------------------------------------|
| Flow Rates for 2-Inch Diameter Rubber Hose |                            |                        |                        |                                                      |
| Temperature<br>Propane, F                  | Flow Rate,<br>gallons/hour | Flow Rate,<br>lb./hour | Flow Rate,<br>Btu/hour | Time to Empty<br>30,000 gallons of<br>Propane, hours |
| 0                                          | 1050                       | 4410                   | 95,899,650             | 28.6                                                 |
| 10                                         | 1336                       | 5611                   | 122,020,888            | 22.5                                                 |
| 20                                         | 1601                       | 6724                   | 146,224,133            | 18.7                                                 |
| 30                                         | 1937                       | 8135                   | 176,912,021            | 15.5                                                 |
| 40                                         | 2264                       | 9509                   | 206,777,912            | 13.3                                                 |
| 50                                         | 2607                       | 10949                  | 238,105,131            | 11.5                                                 |
| 60                                         | 3116                       | 13087                  | 284,593,628            | 9.6                                                  |
| 70                                         | 3360                       | 14112                  | 306,878,880            | 8.9                                                  |
| 80                                         | 4355                       | 18291                  | 397,755,215            | 6.9                                                  |
| 90                                         | 4814                       | 20219                  | 439,677,062            | 6.2                                                  |
| 100                                        | 5127                       | 21533                  | 468,264,291            | 5.9                                                  |
| 110                                        | 5947                       | 24977                  | 543,157,351            | 5.0                                                  |

TABLE 9-1 continued

Source: NPGA

## REVIEW OF PROPANE'S PHYSICAL CHARACTERISTICS

In Section 2 we went into a lot of detail about propane's physical characteristics. Before we get into the issue of refrigeration, let's review some important material from Section 2 and learn more about how propane's low boiling point and high vapor pressure will allow it to be refrigerated easily.

Propane is stored and transported as a liquid in pressure vessels. At a given temperature (of the liquid) a corresponding vapor pressure will be created in the container. At temperatures above -44° F the liquid will boil off into a vapor until the vapor pressure in the container is equal to the pressure of the surrounding atmosphere. In a closed container, boiling (vaporization) will stop when this equalization is achieved.

When the container valve is opened and the vapor is allowed to escape, the pressure in the container will drop. The result is that the surface pressure of the liquid will exceed the vapor pressure in the container and vaporization (boiling) of the liquid propane will resume. The boiling will continue until the container again reaches equilibrium.

In order for the propane to change from a liquid to a gas, significant amounts of energy are required. Energy in the form of heat is drawn from the liquid. The liquid replaces this heat by drawing energy from the matter surrounding it. Mainly, it comes from the air outside the container. The heat is transferred through the container walls of the container to the LIQUID propane. (Very little heat is transferred through the container walls to the vapor space.)

## REFRIGERATION

As propane vaporizes, it gets its energy directly from the liquid. The loss of heat is made up by conduction through the container walls. When this capacity is exceeded, the temperature of the liquid begins to drop as energy is drawn from it. The propane actually cools itself and goes into a state known as “auto-refrigeration.” Under auto-refrigeration conditions, the temperature of the liquid can cool as low as  $-44^{\circ}\text{F}$ .

**SPECIAL NOTE:** Auto-refrigeration occurs when a valve is sheared from a container, and large amounts of vapor escape at a high rate. (See Section 8, Scenario #4.) In producing this vapor the liquid will rapidly cool and refrigerate to as low as  $-44^{\circ}\text{F}$  (propane’s boiling point). At this point in the process, the vaporization will stop and it will appear that there is no more propane in the container. This may not be the case! There still may be a quantity of super-cooled liquid in the cylinder. This is sometimes evidenced by a frost line part of the way down the container. This can provide emergency responders with an unexpected surprise. These types of incidents are potentially dangerous and must be handled with extreme care.

## FLARING

Auto-refrigeration of propane may come into play during flaring operations. As we have seen in the above explanation and examples, if enough propane vapor is removed from the container by burning it off from a flare, the liquid will cool and the internal pressure in the container will drop or stabilize.

Occasionally a situation will present itself where it is necessary to burn off liquid propane by flaring. This might occur when other methods of removing product are not practical and vapor flaring is either not practical or too slow. The practice of flaring liquid is used more frequently for railroad incidents. Because of the large volume of fire and radiant heat levels involved in liquid flaring, it is usually reserved for isolated and rural areas where life safety exposure is minimal. It should be noted that flaring liquid will not refrigerate the container. Liquid flaring will also not have the effect of reducing vapor pressure in the container.

The decision to off-load or upright a loaded, overturned and damaged propane rail car or cargo tank truck requires careful consideration and input from a variety of specialists. These should include product and container specialists, safety specialists from the propane industry, and heavy equipment specialists who will perform the actual lifting operation. All of these specialists should be consulted by the Incident Commander before a plan of action is implemented.

Experience has shown that both the MC-330/331 cargo tank truck and the DOT-112 / 114 railroad tank car are well-designed and constructed pressure vessels that can sustain heavy damage without losing their integrity. See Figure 9-18. These containers can often be uprighted while full providing that damage assessment has been carried out and sufficient lifting capacity is available.



KEITH HANCHETT

**FIGURE 9-18** The MC-331 can sustain heavy damage without losing the container's integrity.

## FACTORS FOR APPROVING LIFTING

The Incident Commander must be satisfied that the people doing the work are in fact "specialists" who are trained, qualified and properly equipped to perform the lifting operation. While there are many first-rate riggers in the business, there are also plenty of well-meaning tow truck operators and salvage companies who

simply do not have the necessary resources or expertise to perform the lifting operation. Make sure that people and equipment are qualified for the job.

Factors for the Incident Commander to consider before approving a lifting or uprighting operation include:

1. A complete damage assessment must be made of the exterior tank shell before moving or lifting the tank. Special attention should be given to dents, gouges and scores, especially those close to or over a weld.
2. Damage assessment is, at best, a qualitative assessment process which requires input from product and container specialists who have experience in evaluating structural damage. Riggers and crane operators should have access to damage assessment information through the Incident Commander. Critical factors include is the tank stable versus non-stable? What are the go/no go criteria and have they been fully evaluated, etc.?
3. Qualified and experienced cargo tank lifting and rigging specialists must be available to supervise and perform the uprighting or lifting operation. There are many highly qualified and equipped uprighting and rigging companies that exist throughout the United States—get to know those who operate in your area of operations.
4. Operating hoisting equipment can be a very complex and dangerous process, especially under emergency conditions. A qualified recovery specialist should know a wide range of specialized information, including knowledge of:
  - What can go wrong and how to deal with situations when they go bad. Recovery specialist must understand the changing conditions of the job and how these conditions will affect the overall safety of the operation. Examples include a change in wind direction, changes in temperature, formation of ice on the ground or lifting surface, etc.
  - Whether the load is properly rigged. A qualified recovery specialist must be able to read a load chart. A load chart shows lifting capacities for various crane operations.
  - Cables, chains, ropes, and slings. The recovery specialist must have a thorough knowledge of the rigging used to lift and stabilize the load and have the basic training to inspect rigging for problems. Rigging is critical since it forms the interface between the hoisting equipment and the load. The main hazards of rigging are failure due to excessive overloading, deterioration or wear, and improper rigging techniques. Load capacity charts are available for materials handling equipment and rigging. Slings are the preferred medium for lifting pressurized cargo tank trucks and cables should not come in contact with the container shell.
  - Safe lifting operations. An recovery specialist must have the ability to evaluate the site for safe lifting operations. For example, for a safe lift with a mobile crane, at least seven items of information are needed:
    - Is the vehicle level?
    - Are outriggers properly extended or retracted?
    - Are extended outriggers supported by stable ground?
    - What is the angle of the boom?
    - What is the boom and jib length?
    - What positions will the boom be in during the lift?
    - How much does the load weigh?



## WRECKERS AND CRANES: TYPES AND TERMINOLOGY

Wreckers and cranes can be divided into categories, based upon their lifting capacity, operational features and operational requirements. In addition, individual states may also have specific categories based upon state regulations. The following categories focus upon the use of wreckers for cargo tank truck operations.

### Light Duty Wreckers

- Rated winch capacity less than 10 tons
- Single boom and winch capability
- Used for the removal of cars, light trucks or vehicles weighing 10,000 pounds gross vehicle weight (GVW).
- Should not be used for uprighting bobtail units unless used in conjunction with a medium duty wrecker.



### Medium Duty Wreckers

- Rated winch capacity of 10 to 25 tons
- Usually 6 to 8 wheeled vehicle.
- Single boom and twin winch capability. May have an extension boom.
- Used for the removal of medium duty trucks or vehicles weighing 26,000 pounds gross vehicle weight (GVW).
- May be used for uprighting bobtail vehicles or in conjunction with other medium and heavy-duty wreckers for transport uprighting operations.



### Heavy Duty Wreckers

- Rated winch capacity greater than 25 tons
- 10 – 14 wheel, tandem axle vehicle
- Single boom and twin winches. May have an extension boom and rotating boom capability.
- Some new generation wreckers have remote control operational capability
- Required for uprighting operations involving transport tank trucks.



# SCAN SHEET 9-D

## BASIC STEPS FOR UPRIGHTING AN MC-331 BOBTAIL TRUCK

1. Assess the situation and ensure you have sufficient lifting capacity. Experience shows that in most rollover scenarios the bobtail truck will roll over on its side. In this position, as little as 40% of the product can be removed because the liquid and vapor valves will eventually be in the vapor space as product is removed.

If the bobtail comes to rest on its top or on its wheels, the tank can be unloaded. If a compressor is used to unload, only a 10 psi differential is needed to unload the tank.

A 3,000-gallon bobtail weighs approximately 31,000 pounds fully loaded. Medium wreckers used for uprighting must have lifting capability and the ability to both lift and twist the unit.



2. Stabilize the vehicle. If the bobtail is in an unstable position where it could shift and injure workers or slide further off a roadway, shoulder, bridge, etc., take time to stabilize the entire rig using cables, cribbing, etc.

Jack up the rig to install the lifting sling. "Mat Jacks" can usually be used to raise the tank a few inches so that the lifting sling can be placed under the tank. Mat Jacks are inflatable pillow-shaped air bags, usually rated for up to 40 tons of lift per bag. They can usually be inflated from the wrecker's air tanks. **NOTE:** Do not use hydraulic rescue tools to lift the vessel. These tools can damage the container.



3. Raise the bobtail using wreckers. The number of wreckers will be dependent upon the lifting capacity of the vehicles. If medium duty wreckers, two rigs should be used. One rig will serve as the "lift" unit, while the second vehicle will be the "holding or catch" unit to prevent the bobtail from tipping over in the other direction as it is lifted.



William Hand

## BASIC STEPS FOR UPRIGHTING AN MC-331 PUP TRAILER

1. Assess the situation and ensure you have sufficient lifting capacity. One major issue is whether the pup is connected to the tractor or has broken free. Experience shows that in most rollover scenarios the pup will roll over on its side.

A loaded 6,000 gallon pup trailer weighs approximately 26,000 lbs. while a fully-loaded 8,000 gallon pup will weigh approximately 32,000 lbs. The wrecker used for uprighting must have lifting capability and be able to both lift and twist.



2. Stabilize the pup trailer. If the truck is in an unstable position where it could shift and injure workers or slide further off a roadway, shoulder, bridge, etc., take time to stabilize the pup using cables, cribbing, etc.



3. Try to get the axles straight. When a pup tips over, the front tongue and front axle usually rotate at an angle away from the tank. A chain should be attached to the axle and connected to the wrecker's hoist. The hoist is then used to pull the axle or tractor back in line with the tank. If the pup has both a front and rear axle, the axles should be chained together to keep them parallel. Even if the tires are flat, a trailer unit can usually be carefully towed a short distance where it can be safely off-loaded.



If necessary, jack up the rig to install the lifting sling. **NOTE:** Do not use hydraulic rescue tools to lift the vessel. These tools can damage the container.

4. Raise the pup trailer using a heavy wrecker with a two hoist capability for both "lifting" and "holding" the pup.





# SCAN SHEET 9-F

## BASIC STEPS FOR UPRIGHTING AN MC-331 TRANSPORT VEHICLE

1. Assess the situation and ensure you have sufficient lifting capacity. Experience shows that in most rollover scenarios the transport vehicle will roll over on its side. In this position, as little as 40% of the product can be removed because the liquid and vapor valves will eventually be in the vapor space as product is removed.

An MC-330/331 transport trailer weighs up to 80,000 pounds when fully loaded. Given this weight factor, a combination of at least two heavy wreckers is normally required for uprighting operations.

2. Stabilize the vehicle. If the truck is in an unstable position where it could shift and injure workers or slide further off a roadway, shoulder, bridge, etc., take time to stabilize the entire rig using cables, cribbing, etc.
3. Tractor and trailer combinations should be lifted as a single unit; separating the trailer from the tractor could contribute to instability. If the tractor has become separated during the rollover, it may be necessary to use a fifth-wheel dolly to support the trailer during uprighting.
4. If necessary, jack up the rig to install the lifting slings. "Mat Jacks" can usually be used to raise the tank a few inches so that the lifting sling can be placed under the tank. Mat Jacks are inflatable pillow-shaped air bags, usually rated for up to 40 tons of lift per bag. They can usually be inflated from the wrecker's air tanks. **NOTE:** Do not use hydraulic rescue tools to lift the vessel. These tools can damage the container.
5. Raise the rig using a combination of medium and heavy wreckers, as available. Location of the incident and the capabilities of wrecker equipment will ultimately determine the exact process and procedures. However, in virtually all instances, an integrated lifting, rolling and holding procedure will be used.

Once the vehicle is uprighted, the unit may be towed a short distance, even if the tires are flat, where it can be safely off-loaded.





## USE OF AIR BAGS

Actual field experience using air bags to upright fully or partially loaded bulk cargo tank trucks like the MC-330/331 has been generally unsuccessful. Air bags may have the heavy duty lifting capacity needed, but the size and shape of the air bag are not compatible with the size and shape of the cargo tank being lifted (e.g., the round against round geometry causes slipping). However, mat jacks and air bags can be useful tools for assisting in both stabilizing an overturned truck and facilitating the initial set-up of the lifting operation. See Figure 9-19.



**FIGURE 9-19** Air bags are usually not effective for uprighting bobtails and MC-330/331 containers.

## SUMMARY

Product removal and recovery operations usually begin after the emergency has run its course (e.g., all leaks have been controlled). Product removal and recovery operations should not begin until after the incident site is stabilized and the area has been re-evaluated for hazards and risks. Stabilization means that all fires have been extinguished, ignition sources have been secured, and all product releases have been controlled. It should be noted that in many truck rollovers, small incidental leaks may still be present when it is time to upright.

Responders can be confronted with a variety of pressurized containers, including cylinders, cargo tank trucks (MC-330/331), and railroad tank cars (e.g., DOT-105, 112, and 114 tank cars). Over 35 years of accident experience show that many pressurized containers have sustained extensive damage in accidents and have not released their contents. This is especially the case with the MC-330/331 cargo tank truck and railroad tank cars equipped with head shields, shelf-couplers and thermal insulation.

Product transfer and removal procedures will vary based upon the type of container involved, container design and construction, container stress and actual or potential breach, and the position and location of the container. Most highway and railroad incidents involving propane do not require off-loading before uprighting. This is primarily due to the inherent structural strength of the container and its ability to withstand significant damage without breaching.

Product transfer and removal are typically performed by propane industry responders, product specialists or container specialists who are hired as contractors by the owner/operator. However, public safety responders will often continue to be responsible for site safety and will oversee the implementation of all product transfer and removal operations.

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## GLOSSARY OF TERMS

### A

**American Chemistry Council.** The parent organization that operates CHEMTREC.

**American Conference of Governmental Industrial Hygienists (ACGIH).** A professional society of individuals responsible for full-time industrial hygiene programs, who are employed by official governmental units. Its primary function is to encourage the interchange of experience among governmental industrial hygienist and to collect and make information available of value to them. ACGIH promotes standards and techniques in industrial hygiene and coordinates governmental activities with community agencies.

**American National Standards Institute (ANSI).** Serves as a clearinghouse for nationally coordinated voluntary safety, engineering, and industrial consensus standards developed by trade associations, industrial firms, technical societies, consumer organizations, and government agencies.

**American Petroleum Institute (API).** Professional trade association of the United States petroleum industry. Publishes technical standards and information for all areas of the industry, including exploration, production, refining, marketing, transportation, and fire and safety.

**API-ASME Container (or Tank).** A container constructed in accordance with the pressure vessel code jointly developed by the American Petroleum Institute and the American Society of Mechanical Engineers.

**Appurtenances.** Items connected to a container opening needed to make a container gas tight. These include pressure relief devices, shut-off, backflow, excess flow, internal valves, liquid level gauging devices, pressure gauges, and plugs.

**Association of American Railroads (AAR).** Professional trade association which coordinates technical information and research within the United States railroad industry. Publisher of emergency response guidebooks.

**ASME Code.** The Boiler and Pressure Vessel Code (Section VIII, "Rules for the Construction of Unfired Pressure Vessels") of the American Society of Mechanical Engineers.

**Authority Having Jurisdiction (AHJ).** An organization, office or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation or a procedure.

**Auto-Refrigeration.** When a container valve or breach occurs, large amounts of vapor escape at a high rate. In producing this vapor the propane liquid will rapidly cool and refrigerate to as low as -44° F (propane's boiling point). At this point, the vaporization will stop and the product will go into a state known as "auto refrigeration." This condition may be evidenced by a frost line part of the way down the container indicating the liquid level.

**Awareness Level Personnel.** Those persons who, in the course of their normal duties, could encounter an emergency involving hazardous materials and who are expected to recognize the

presence of the hazardous materials, protect themselves, call for trained personnel, and secure the scene. Under 29 CFR 1910.120, this person is identified as the First Responder at the Awareness Level) These are individuals who, in the course of their normal duties, may be the first on scene of an emergency involving hazmats. They are expected to recognize hazmat presence, protect themselves, call for trained personnel, and secure the area.

## B

**Bobtail Vehicle.** Common name given to vehicles used to transport and deliver LP-Gas to customers who use containers that are filled on-site. Capacities range from 750 to 6,500 gallons, and cargo tanks are constructed to the MC-330 / MC-331 specification. DOT permits the use of non-specification bobtail cargo tanks in some instances.

**Boiling Liquid Expanding Vapor Explosion (BLEVE).** A container failure with a release of energy, often rapidly and violently, which is accompanied by a release of gas to the atmosphere and propulsion of the container or container pieces due to an overpressure rupture.

**Boiling Point.** The temperature at which a liquid changes its phase to a vapor or gas. The temperature where the vapor pressure of the liquid equals atmospheric pressure. Significant property for evaluating the flammability of a liquid, as flash point and boiling point are directly related. A liquid with a low flash point will also have a low boiling point, which translates into a large amount of vapors being given off.

**Buddy System.** A system of organizing employees into work groups in such a manner that each employee of the work group is designated to be observed by at least one other employee in the work group [per OSHA 1910.120 (a)(3)].

**Bulk Plant or Terminal.** A facility with the primary purpose of distribution of gas that receives propane by tank car, tank truck, or piping, and distributes this gas to the end user by portable container delivery, by tank truck, or through gas piping. Such plants have bulk storage of at least 2,000 gallons (7.6 m<sup>3</sup>) water capacity or more and have container filling and truck loading facilities on the premises.

**Bulk Packaging.** Bulk packaging has an internal volume greater than 119 gallons (450 liters) for liquids, a capacity greater than 882 pounds (400 kg) for solids, or a water capacity greater than 1,000 pounds (453.6 kg) for gases. It can be an integral part of a transport vehicle (e.g., cargo tank truck, railroad tank car, and barges), packaging placed on or in a transport vehicle (e.g., portable tanks, intermodal portable tanks, ton containers), or fixed or processing containers.

## C

**Cargo Tanks.** A container that is used to transport LP-Gas as liquid cargo and is either mounted on a conventional truck chassis or is an integral part of a cargo transporting vehicle. Includes both bobtails and transport vehicles which are constructed to the MC-330 / MC-331 specifications.

**Chemical Protective Clothing (CPC).** Single or multipiece garment constructed of chemical protective clothing materials designed and configured to protect the wearer's torso, head, arms, legs, hands, and feet. Can be constructed as a single or multipiece garment. The garment may completely enclose the wearer either by itself or in combination with the wearer's respiratory protection, attached or detachable hood, gloves, and boots.



**Chemical Safety and Hazard Investigation Board.** An independent Federal Agency charged with responsibility for investigating serious accidents and emergencies involving chemical emergencies.

**Chemical Transportation Emergency Center (CHEMTREC™).** The Chemical Transportation Center, operated by the American Chemistry Council (ACC) can provide information and technical assistance to emergency responders. Phone number: 1-800-424-9300.

**Classes.** As used in *NFPA 70—The National Electric Code*, used to describe the type of flammable materials that produce the hazardous atmosphere. There are three classes:

*Class I Locations*—Flammable gases or vapors may be present in quantities sufficient to produce explosive or ignitable mixtures.

*Class II Locations*—Concentrations of combustible dusts may be present (e.g., coal or grain dust).

*Class III Locations*—Areas concerned with the presence of easily ignitable fibers or flyings (e.g., cotton milling).

**Clean Air Act (CAA).** Federal legislation which resulted in EPA regulations and standards governing airborne emissions, ambient air quality, and risk management programs.

**Closed Container.** A container as herein defined, so sealed by means of a lid or other device that neither liquid nor vapor will escape from it at ordinary temperatures. The container is not allowed to have any vents, either automatic, fixed, or pressure operated.

**Code of Federal Regulations (CFR).** A collection of regulations established by federal law. Contact with the agency that issues the regulation is recommended for both details and interpretation.

**Cold Zone.** The control zone of a hazmat incident that contains the command post and other support functions as are deemed necessary to control the incident. This zone may also be referred to as the clean zone or the support zone.

**Combustion Ratio.** The range of flammable gas/air mixtures that will support efficient combustion. May also be referred to as the ideal combustion ratio. The ideal combustion ratio for propane is 24 parts of air (96%) to 1 part of propane (4%).

**Command.** The act of directing, ordering, and/or controlling resources by virtue of explicit legal, agency, or delegated authority.

**Command Staff.** Within NIMS, the command staff consists of the Public Information Officer, the Safety Officer, and the Liaison Officer, who report directly to the Incident Commander.

**Community Awareness and Emergency Response (CAER).** A program developed by the Chemical Manufacturers Association (CMA) to provide guidance for chemical plant managers to assist them in developing integrated hazmat emergency response plans between the plant and the community.

**Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).** Known as CERCLA or SUPERFUND, it addresses hazardous substance releases into the environment and the clean-up of inactive hazardous waste sites. It also requires those who release hazardous substances, as defined by the Environmental Protection Agency (EPA), above certain levels (known as “reportable quantities”) to notify the National Response Center.

**Compressed Gas.** Any material or mixture having an absolute pressure exceeding 40 psi (276 kPa) in the container at 70° F (21.1° C), having an absolute pressure exceeding 104 psi (717 lPa) at 130° F (54.4° C).

**Confined Space.** A space that (1) is large enough and so configured that an employee can bodily enter and perform assigned work; (2) has limited or restricted means for entry or exit (e.g., tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and (3) is not designed for continuous employee occupancy.

**Confined Space (Permit Required).** Has one or more of the following characteristics:

- 1) Contains or has the potential to contain a hazardous atmosphere. A hazardous atmosphere would be created by any of the following, including:
  - a) Vapors exceed 10% of the lower explosive limit (LEL).
  - b) Airborne combustible dust exceeds its LEL.
  - c) Atmospheric oxygen concentrations below 19.5% or above 23.5%.
  - d) Atmospheric concentration of any substance for which a dose or PEL is published and which could result in employee exposure in excess of these values.
  - e) Any other atmospheric condition which is immediately dangerous to life or health (IDLH).
- 2) Contains a material that has the potential for engulfing an entrant.
- 3) Has an internal configuration such that a person could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross section; or
- 4) Contains any other recognized serious safety or health hazard.

**Confinement.** Procedures taken to keep a material in a defined or localized area once released.

**Container.** Any vessel, including cylinders, tanks, and portable tanks, used for transporting, or storing of LP-Gases. A container may be either a DOT cylinder or an ASME tank.

**Controlled Burn.** Defensive or nonintervention tactical objective by which a fire is allowed to burn with no effort to extinguish the fire.

**Crack.** Narrow split or break in the container metal which may penetrate through the container metal (may also be caused by fatigue). It is a major mechanism which could cause catastrophic failure. Cracks are very difficult to determine in the field and typically require the use of x-ray or similar metallurgical testing equipment.

**Critical Temperature and Pressure.** Critical temperature is the minimum temperature at which a gas can be liquefied no matter how much pressure is applied. Critical pressure is the pressure that must be applied to bring a gas to its liquid state. Both terms relate to the process of liquefying gases. A gas cannot be liquefied above its critical temperature. The lower the critical temperature, the less pressure required to bring a gas to its liquid state.

**Critique.** An element of incident termination which examines the overall effectiveness of the emergency response effort and develops recommendations for improving the organization's emergency response system.

**Cylinder.** A container constructed in accordance with U.S. Department of Transportation specifications under Title 49 CFR.

**Damage Assessment.** The process of gathering and evaluating container damage.

**Debriefing.** An element of incident termination which focuses on the following factors:

- 1) Informing responders exactly what hazmats they were (possibly) exposed to, and the signs and symptoms of exposure.
- 2) Identifying damaged equipment requiring replacement or repair.
- 3) Identify equipment or supplies requiring specialized decontamination or disposal.
- 4) Identify unsafe work conditions.
- 5) Assign information-gathering responsibilities for a post-incident analysis.

**Decon.** Popular abbreviation referring to the process of decontamination.

**Decontamination.** The physical and/or chemical process of reducing and preventing the spread of contamination from persons and equipment used at a hazardous materials incident. OSHA 1910.120 defines decontamination as the removal of hazardous substances from employees and their equipment to the extent necessary to preclude foreseeable health effects.

**Defensive Tactics.** These are less aggressive spill and fire control tactics where certain areas may be “conceded” to the emergency, with response efforts directed toward limiting the overall size or spread of the problem. As a general rule, defensive operations expose responders to less risk than offensive operations.

**Degree of Solubility.** An indication of the solubility and/or miscibility of the material.

- Negligible—less than 0.1 percent
- Slight—0.1 to 1.0 percent
- Moderate—1 to 10 percent
- Appreciable—greater than 10 percent
- Complete—soluble at all proportions.

**Dent.** Deformation of the tank head or shell. It is caused from impact with a relatively blunt object (e.g., railroad coupler, vehicle). If the dent has a sharp radius, there is the possibility of cracking.

**Dilution.** Application of water to water-miscible flammable liquids to reduce to safe levels the hazard they represent. It can increase the total volume of liquid which will have to be disposed of. In decon applications, it is the use of water to flush a hazmat from protective clothing and equipment and the most common method of decon.

**Divisions.** As used in *NFPA 70—The National Electric Code*, describe the types of location that may generate or release a flammable material. There are two divisions:

*Division I*—Location where the vapors, dusts or fibers are continuously generated and released. The only element necessary for a hazardous situation is a source of ignition.

*Division II*—Location where the vapors, dusts or fibers are generated and released as a result of an emergency or a failure in the containment system.

**Divisions.** As used within the Incident Command System, are the organizational level having responsibility for operations within a *defined geographic area*. A building floor, plant location, or process area may be designated as a division, such as the Division 4 (i.e., 4th floor area) or the Alky Division (i.e., Alkylation Process Unit).

**Dome.** Circular fixture on the top of a pressurized railroad tank car containing valves, pressure relief valve, and gauging devices.

## E

**Eight Step Process®.** A widely used general Standard Operating Procedure (SOP) that has been adopted by many public safety and industrial Emergency Response Teams for managing hazardous materials emergencies. Serves as a general framework for systematically resolving a propane emergency.

**Emergency Medical Services (EMS).** Functions as required to provide emergency medical care for ill or injured persons by trained providers.

**Emergency Operations Center (EOC).** The secured site where government or facility officials exercise centralized direction and control in an emergency. The EOC serves as a resource center and coordination point for additional field assistance. It also provides executive directives to and liaison for government and other external representatives, and considers and mandates protective actions.

**Emergency Response.** Response to any occurrence that has or could result in a release of a hazardous substance.

**Emergency Response Organization.** An organization that utilizes personnel trained in emergency response. This would include fire, law enforcement, EMS, and industrial emergency response teams.

**Emergency Response Personnel.** Personnel assigned to organizations that have the responsibility for responding to different types of emergency situations.

**Emergency Response Plan (ERP).** A plan that establishes guidelines for handling hazmat incidents as required by regulations such as SARA, Title III and HAZWOPER (29 CFR 1910.120).

**Emergency Response Team (ERT).** Crews of specially trained personnel used within industrial facilities for the control and mitigation of emergency situations. May consist of both shift personnel with ERT responsibilities as part of their job assignment (e.g., plant operators) or volunteer members. ERTs may be responsible for both fire, hazmat, medical, and technical rescue emergencies, depending upon the size and operation of the facility.

**Emergency Shut-Off Valve.** A shut-off valve incorporating thermal and manual means of closing that also provides for remote means of closing.

**Environmental Protection Agency (EPA).** The purpose of the EPA is to protect and enhance our environment today and for future generations to the fullest extent possible under the laws enacted by Congress. The Agency's mission is to control and abate pollution in the areas of water, air, solid waste, pesticides, noise, and radiation. EPA's mandate is to mount an integrated, coordinated attack on environmental pollution in cooperation with state and local governments.

**EPA.** (See Environmental Protection Agency.)

**Evacuation.** A public protective option which results in the removal of fixed facility personnel and the public from a threatened area to a safer location. It is typically regarded as the controlled relo-



cation of people from an area of known danger or unacceptable risk to a safer area, or one in which the risk is considered to be acceptable.

**Expansion Ratio.** The amount of gas produced by the evaporation of one volume of liquid at a given temperature. Significant property when evaluating liquid and vapor releases of liquefied gases and cryogenic materials. The greater the expansion ratio, the more gas that is produced and the larger the hazard area. The expansion ratio of propane is 1 to 270.

**Explosion-Proof Construction.** Encases the electrical equipment in a rigidly built container so that (1) it withstands the internal explosion of a flammable mixture, and (2) it prevents propagation to the surrounding flammable atmosphere. Used in Class I, Division 1 atmospheres at fixed installations.

**Excess Flow Valve (Excess-Flow Check Valve).** A device designed to close when the liquid or vapor passing through it exceeds a prescribed flow rate as determined by pressure drop.

**Excess Flow Valve (Internal).** An excess flow valve constructed and installed so that the seat remains in the container so that damage to the valve parts exterior to the container will not prevent effective seating to the valve.

## F

**Failure of Container Attachments.** Attachments which open up or break off the container, such as pressure relief valves, frangible discs, fusible plugs, discharge valves, or other related appliances.

**Fire Entry Suits.** Suits which offer complete, effective protection for short-duration entry into a total flame environment. Designed to withstand exposures to radiant heat levels up to 2,000° F. Entry suits consist of a coat, pants, and separate hood assembly. They are constructed of several layers of flame-retardant materials, with the outer layer often aluminized.

**First Responder.** The first trained person(s) to arrive at the scene of a hazardous materials incident. May be from the public or private sector of emergency services.

**Flammable (Explosive) Range.** The range of gas or vapor concentration (percentage by volume in air) that will burn or explode if an ignition source is present. Limiting concentrations are commonly called the “lower flammable (explosive) limit” and the “upper flammable (explosive) limit.” Below the lower flammable limit, the mixture is too lean to burn; above the upper flammable limit, the mixture is too rich to burn. If the gas or vapor is released into an oxygen enriched atmosphere, the flammable range will expand. Likewise, if the gas or vapor is released into an oxygen deficient atmosphere, the flammable range will contract.

**Flaring.** Controlled burning of a high vapor pressure liquid or compressed gas in order to reduce or control the pressure and/or dispose of the product when transfer operations may be impractical.

**Flash Point.** Minimum temperature at which a liquid gives off enough vapors that will ignite and flash-over but will not continue to burn without the addition of more heat. Significant in determining the temperature at which the vapors from a flammable liquid are readily available and may ignite.

**Form.** Refers to the physical form of a material—solid, liquid or gas. Significant factor in evaluat-

ing both the hazards of a material and tactics for controlling a release. In general, gases and vapor releases cause the greatest problems for emergency responders.

**Full Protective Clothing.** Protective clothing worn primarily by fire fighters which includes helmet, fire retardant hood, coat, pants, boots, gloves, PASS device, and self-contained breathing apparatus designed for structural fire fighting. It does not provide specialized chemical splash or vapor protection.

## G

**Gauge / Gauging Device.** A device used to determine the amount of LP-Gas liquid remaining within a tank or container. There are various types of gauges, including fixed liquid level gauge, fixed maximum liquid level gauge, float gauge, magnetic gauge, rotary gauge, and slip tube gauge.

**Gouge.** Reduction in the thickness of the tank shell. It is an indentation in the shell made by a sharp, chisel-like object. A gouge is characterized by the cutting and complete removal of the container or weld material along the track of contact.

**Grounding.** A method of controlling ignition hazards from static electricity. The process of connecting one or more conductive objects to the ground; it is done to minimize potential differences between objects and the ground.

**Groups.** As used in *NFPA 70—The National Electric Code*, are products within a Class. Class I is divided into four groups (Group A–D) on the basis of similar flammability characteristics. Class II is divided into three groups (Groups E–G). There are no groups for Class III materials.

**Groups.** As used within NIMS, are the organizational level responsible for a *specified functional assignment* at an incident. Hazmat units may operate as a Hazmat Group. Groups are under the direction of a Supervisor and may move between divisions at an incident.

## H

**Hazard.** Refers to danger or peril. In hazmat operations, the term usually refers to the physical or chemical properties of a material.

**Hazard Analysis.** Part of the planning process, it is the analysis of hazmats present in a facility or community. Elements include hazards identification, vulnerability analysis, risk analysis, and evaluation of emergency response resources. Hazards analysis methods used as part of Process Safety Management (PSM) include HAZOP Studies, Fault Tree Analysis, and What If Analysis.

**Hazard and Risk Evaluation.** Evaluation of hazard information and the assessment of the relative risks of a hazmat incident. Evaluation process leads to the development of Incident Action Plan.

**Hazard Class.** The hazard class designation for the material as found in the Department of Transportation regulations, 49 CFR. There are currently 9 DOT hazard classes which are divided into 22 divisions.

**Hazard Communication (HAZCOM).** OSHA regulation (29 CFR 1910.1200) which requires hazmat manufacturers to develop MSDS's on specific types of hazardous chemicals, and provide hazmat health information to both employees and emergency responders.

**Hazard Control Zones.** The designation of areas at a hazardous materials incident based upon safety and the degree of hazard. Many terms are used to describe these hazard control zones; however, for the purposes of this text, these zones are defined as the hot, warm and cold zones.

**Hazardous Chemicals.** Any chemical that would be a risk to employees if exposed in the workplace (U.S. Occupational Safety and Health Administration, 29 CFR 1910).

**Hazardous Materials.** Any substance or material in any form or quantity capable of posing an unreasonable risk to safety and health and property when transported in commerce (U.S. Department of Transportation, 40 CFR 171).

**Hazardous Materials Specialists.** Individuals who respond and provide support to Hazardous Materials Technicians. While their duties parallel those of the Technician, they require a more detailed or specific knowledge of the various substances they may be called upon to contain. Would also act as a liaison with federal, state, local and other governmental authorities in regard to site activities.

**Hazardous Materials Technician.** Those persons who respond to hazardous materials incidents using a risk based response process with the ability to analyze a problem involving hazardous materials, select appropriate decontamination procedures, and control a release using specialized protective clothing and control equipment. These persons may have additional competencies that are specific to their response mission, expected tasks, and equipment and training as determined by the authority having jurisdiction. An HMRT may be a separate component of a fire brigade or a fire department or other appropriately trained and equipped units from public or private agencies.

**Hazardous Materials Technician with Specialty Area.** Under NFPA 472, these are a Hazardous Materials Technician with specific knowledge and skill competencies on a specific container or product area. Specialty areas that may apply to the LP-Gas industry include Tank Car Specialty, Cargo Tank Specialty, Intermodal Tank Specialty, and Flammable Gas Bulk Storage Specialty.

**Hazardous Substances.** Any substance designed under the Clean Water Act and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) as posing a threat to waterways and the environment when released (U.S. Environmental Protection Agency, 40 CFR 302). Hazardous substances as used within OSHA 1910.120 refer to every chemical regulated by EPA as a hazardous substance and by DOT as a hazardous material.

**Hazmat.** Acronym used for Hazardous Materials.

**Hazardous Waste Operations and Emergency Response.** Also known as HAZWOPER, this federal regulation was issued under the authority of SARA, Title I. The regulation establishes health, safety and training requirements for both industry and public safety organizations that respond to hazmat or hazardous waste emergencies. This includes firefighters, law enforcement and EMS personnel, hazmat responders, and industrial Emergency Response Team (ERT) members.

**Heat-Affected Zone.** Area in the undisturbed tank metal next to the actual weld material. This area is less ductile than either the weld or the steel plate due to the effect of the heat of the welding process. This zone is most vulnerable to damage as cracks are likely to start here.

**Heat Value.** The amount of heat produced by per cubic foot of propane, as expressed in BTU's per cubic foot of gas or in BTU's per gallon. According to NFPA 58, the heat value for propane (vapor) is 2,488 BTU/ft<sup>3</sup>.

**High-Temperature Protective Clothing.** Protective clothing designed to protect the wearer against short-term high-temperature exposures. Includes both proximity suits and fire entry suits. This type of clothing is usually of limited use in dealing with chemical exposures.

**Hot Tapping.** An offensive technique used by highly qualified specialists for welding on and cutting holes through liquid and/or compressed gas vessels and piping for the purposes of relieving the internal pressure and/or removing the product. Hot tapping is not performed on MC-330 / MC-331 cargo tank trucks.

**Hot Zone.** At a hazardous materials incident, the control zone immediately surrounding the hazard that presents the highest level of risk and extends far enough to minimize the adverse effects to unprotected personnel outside the zone. This zone is also referred to as the exclusion zone or the restricted area in other documents.

**Hydrocarbons.** Compounds primarily made up of hydrogen and carbon. Examples include LPG, gasoline, and fuel oils.

## I

**IAP.** (See Incident Action Plan).

**ICS.** (See Incident Command System).

**ICS Command Staff.** Those individuals appointed by and directly reporting to the Incident Commander. These include the Safety Officer, the Liaison Officer, and the Public Information Officer (PIO).

**ICS General Staff - Section Chiefs** are members of the Incident Commander's general staff, and responsible for the broad response functions of Operations, Planning, Logistics, and Finance/Administration.

**Ignition (Autoignition) Temperature.** Minimum temperature required to ignite gas or vapor without a spark or flame being present. Significant in evaluating the ease with which a flammable material may ignite.

**Immediately Dangerous to Life or Health (IDLH).** An atmospheric concentration of any toxic, corrosive or asphyxiant substance that poses an immediate threat to life or would cause irreversible or delayed adverse health effects or would interfere with an individual's ability to escape from a dangerous atmosphere.

**Impingement Event.** As the hazmat and/or its container engulf an area, they will impinge on, or come in contact with exposures. They may also impinge upon other hazmat containers, producing additional problems.

**Incident.** A release or potential release of a hazardous material from its container into the environment.

**Incident Action Plan (IAP).** The strategic goals, tactical objectives, and support requirements for the incident. All incidents require an action plan. For simple incidents the action plan is not usually in written form. Large or complex incidents will require that the action plan be documented in writing.



**Incident Command Post (ICP).** The location from which all incident operations in the field are directed and planning functions are performed. The communications center is often incorporated into the incident command post.

**Incident Commander (IC).** The individual responsible for all incident activities, including the development of strategies and tactics and the ordering and the release of resources. The IC has overall authority and responsibility for conducting incident operations and is responsible for the management of all incident operations at the incident site. May also be referred to as the On-Scene Incident Commander as defined in 29 CFR. 1910.120.

**Incident Command System (ICS).** An organized system of roles, responsibilities, and standard operating procedures used to manage and direct emergency operations.

**Industrial Occupancy.** Includes factories that manufacture products of all kinds and properties devoted to operations such as processing, assembling, mixing, packaging, finishing or decorating, and repairing.

**Industrial Plant.** An industrial facility that utilizes gas incidental to plant operations, with LPG-Gas storage of 2,000 gallons (7.6 m<sup>3</sup>) water capacity or more that receives gas by means of tank car, truck transport, or truck lot.

**Inhalation.** The introduction of a chemical or toxic products of combustion into the body by way of the respiratory system. Inhalation is the most common exposure route and often the most damaging. Toxins may be absorbed into the bloodstream and carried to other internal organs, or they may affect the upper and/or lower respiratory tract. Resulting respiratory injuries include pulmonary edema and respiratory congestion.

**Intermodal Tank Containers.** Specific class of portable tanks specifically designed for international intermodal use. Most common types used for the transportation of LP-Gases are DOT Spec. 51 portable tanks or International (IMO) Type 5 containers.

**Internal Valve.** A container's primary shut-off valve where the seat and seat disc remain inside the container so that damage to the parts exterior to the container or mating flange will not prevent effective seating of the valve. An internal valve closes when flow through the valve exceeds its rated excess-flow capacity or when pump actuation differential pressure drops to a predetermined point.

**Intrinsically Safe Construction.** Equipment or wiring is incapable of releasing sufficient electrical energy under both normal and abnormal conditions to cause the ignition of a flammable mixture. Commonly used in portable direct-reading instruments for operations in Class I, Division 2 hazardous locations.

**Isolating the Scene.** The process of preventing persons and equipment from becoming exposed to a actual or potential hazmat release. Includes establishing isolation perimeter and control zones.

**Isolation Perimeter.** The designated crowd control line surrounding the Hazard Control Zones. The isolation perimeter is always the line between the general public and the Cold Zone.

## J

**Jacket.** Outer metal covering of a railroad tank car that protects the tank's insulation and keeps it in-place.

**L**

**Labels.** Approximately 4-inch (100 mm) square markings required under DOT regulations and applied to individual hazardous materials packages. They are generally placed or printed near the contents names or are printed on the manufacturing label. When labels cannot be applied directly to the container because of its nonadhesive surface, they are placed on tags or cards attached to the package. The proper label(s) are determined by the product's hazard class.

**Leak.** The uncontrolled release of a hazardous material which could pose a threat to health, safety, and/or the environment.

**Liaison Officer.** Serves as a coordination point between the Incident Commander and any assisting or coordinating agencies who have responded to the incident, but who are not part of unified command or are represented at the Incident Command Post. Member of the Command Staff.

**Liquefied Petroleum Gas (LP-Gas).** Any material having a vapor pressure not exceeding that allowed for commercial propane composed predominantly of the following hydrocarbons, either by themselves or as mixtures: propane, propylene, butane (normal butane or isobutane), or butylenes.

**Local Emergency Planning Committee (LEPC).** A committee appointed by a State Emergency Response Commission, as required by SARA Title III, to formulate a comprehensive emergency plan for its region.

**M**

**Material Safety Data Sheet.** A document which contains information regarding the chemical composition, physical and chemical properties, health and safety hazards, emergency response, and waste disposal of the material as required by 29 CFR 1910.1200.

**Maximum Allowable Working Pressure (MAWP).** The maximum pressure at which a pressure vessel is to operate.

**Mechanical Harm Events.** Those harm events resulting from direct contact with fragments scattered because of a container failure, explosion, or shock wave.

**Mechanical Stress.** The result of a transfer of energy when one object physically contacts or collides with another. Indicators include punctures, gouges, breaks, or tears in the container.

**Mitigation.** Any offensive or defensive action to contain, control, reduce, or eliminate the harmful effects of a hazardous materials release.

**Mobile Containers.** Containers that are permanently mounted on a vehicle and are connected for uses other than engine fuel. Examples include recreational and catering vehicles.

**Monitoring.** The act of systematically checking to determine contaminant levels and atmospheric conditions.

**Monitoring Instruments.** Monitoring and detection instruments used to detect the presence and/or concentration of contaminants within an environment.

*Combustible Gas Indicator (CGI)*: Measures the concentration of a combustible gas or vapor in air.

*Oxygen Monitor*: Measures the percentage of oxygen in air.

*Colorimetric Indicator Tubes*: Measures the concentration of specific gases and vapors in air.

*Specific Chemical Monitors*: Designed to detect a large group of chemicals or a specific chemical. Most common examples include carbon monoxide and hydrogen sulfide.

*Flame Ionization Detector (FID)*: A device used to determine the presence of organic vapors and gases in air. Operates in two modes—survey mode and gas chromatograph.

*Gas Chromatograph*: An instrument used for identifying and analyzing specific organics compounds.

*Photoionization Detector (PID)*: A device used to determine the total concentration of many organic and some inorganic gases and vapors in air.

*Radiation Monitors*: An instrument used to measure accumulated radiation exposure. Include both alpha, beta and gamma survey detectors.

*Radiation Dosimeter Detector*: An instrument which measures the amount of radiation to which a person has been exposed.

*Corrosivity (pH) Detector*: A meter, paper or strip that indicates the relative acidity or alkalinity of a substance, generally using an international scale of 0 (acid) through 14 (alkali-caustic). (See pH.)

*Indicator Papers*: Special chemical indicating papers which test for the presence of specific hazards, such as oxidizers, organic peroxides and hydrogen sulfide. Are usually part of a hazmat identification system.

**Mounded Container.** An ASME container designed for underground service installed above the minimum depth required for underground service and covered with at least 1 ft. of earth, sand, or other material, or an ASME container designed for aboveground service installed above grade and covered with at least 1 ft. of earth, sand, or other material.

**MSDS.** (See Material Safety Data Sheet.)

## N

**National Fire Protection Association (NFPA).** An international voluntary membership organization to promote improved fire protection and prevention, establish safeguards against loss of life and property by fire, and write and publish national voluntary consensus standards (e.g., *NFPA 472—Professional Competence of Responders to Hazardous Materials Incidents*).

**National Institute for Occupational Safety and Health (NIOSH).** A Federal agency which, among other activities, tests and certifies respiratory protective devices, and air sampling detector tubes, and recommends occupational exposure limits for various substances.

**National Incident Management System (NIMS).** A national standardized system for organizing roles and responsibilities at any emergency. Serves as the national template to enable all government, private sector, and nongovernmental organizations (NGOs) to work together during domestic incidents.

**National Propane Gas Association (NPGA).** The national trade association for the liquefied petroleum gas industry. NPGA members include producers of LP-Gas, wholesale and retail marketers, gas appliance and equipment manufacturers and distributors, tank and cylinder fabricators, transport firms and others.

**National Response Center (NRC).** Communications center operated by the U.S. Coast Guard in Washington, D.C. It provides information on suggested technical emergency actions and is the federal spill notification point. The NRC must be notified within 24 hours of any spill of a reportable quantity of a hazardous substance by the spiller. Can be contacted at (800) 424-8802.

**National Transportation Safety Board (NTSB).** Independent federal agency charged with responsibility for investigating serious accidents and emergencies involving the various modes of transportation (e.g., highway, pipeline, air), as well as hazardous materials. Issues investigation reports and nonbinding recommendations for action.

**Nonbulk Packaging.** Any packaging having a capacity meeting one of the following criteria:

Liquid—internal volume of 119 gallons (450 L.) or less;

Solid—capacity of 882 lb. (400 kg) or less; and

Compressed Gas—water capacity of 1,001 lb. (454 kg) or less.

Nonbulk packaging may consist of single packaging (e.g., drum, carboy, cylinder) or combination packaging—one or more inner packages inside of an outer packaging (e.g., glass bottles inside a fiberboard box, infectious disease sample containers).

**Nonintervention Tactics.** Essentially taking no action other than isolating the area. It is useful at certain fire emergencies where the potential costs of action far exceed any benefits (e.g., BLEVE scenario or waiting for a propane container to burn off). May be implemented until sufficient resources arrive on-scene and an offensive attack can be implemented.

**Normal Physical State.** The physical state or form (solid, liquid, gas) of a material at normal temperatures [68° F (20° C) to 77° F (25° C)]. Determining the physical state of a material can allow responders to assess potential harm.

## O

**Occupational Safety and Health Administration (OSHA).** Component of the United States Department of Labor; an agency with safety and health regulatory and enforcement authorities for most United States industries, businesses, and states.

**Odor Threshold (TLVOdor).** The lowest concentration of a material's vapor in air that is detectable by odor. If the TLVOdor is below the TLV/TWA, odor may provide a warning as to the presence of a material.

**Offensive Tactics.** Aggressive leak, vapor control, and fire control tactics designed to quickly control or mitigate the problem. Although offensive operations can increase the risk to emergency responders, they may be justified if rescue operations can be quickly achieved, if the leak can be rapidly confined or contained, or if the fire can be quickly extinguished.

**On-Scene Incident Commander.** (See Incident Commander.)

**Operations Level Responders—** Those persons who respond to hazardous materials incidents for the purpose of protecting nearby persons, the environment, or property from the effects of the release. These persons may have additional competencies that are specific to their response mission, expected tasks, and equipment and training as determined by the authority having jurisdiction. Under 29 CFR 1910.120 this person is identified as a First Responder at the Operations Level.



These are individuals who respond to releases or potential releases of hazmats as part of the initial response to the incident for the purpose of protecting nearby persons, the environment or property from the effects of the release. They shall be trained to respond in a defensive fashion to control the release from a safe distance and keep it from spreading.

**Operations Section.** Responsible for all tactical operations at the incident within the Incident Command System. At a propane emergency, normally consists of fire, law enforcement, EMS and industry personnel directly involved in managing the tactical problem in the field.

**Overfill Prevention Device (OPD).** A safety device that is designed to provide an automatic means to prevent the filling of a container in excess of the maximum permitted filling limit.

**Overpressure Shut-Off Device.** A device that shuts off the flow of LP-Gas vapor when the outlet pressure of the regulator reaches a predetermined maximum allowable pressure.

**Oxygen-Deficient Atmosphere.** An atmosphere that contains an oxygen content less than 19.5% by volume at sea level.

**Oxygen-Enriched Atmosphere.** An atmosphere that contains an oxygen content greater than 23.5% by volume at sea level.

## P

**Packaging.** Any container that holds a material (hazardous and non-hazardous). Packaging for hazardous materials includes non-bulk and bulk packaging.

**Permissible Exposure Limit (PEL).** The maximum time-weighted concentration at which 95% of exposed, healthy adults suffer no adverse effects over a 40-hour work week and are comparable to ACGIH's TLV / TWA. PELs are used by OSHA and are based on an eight-hour, time-weighted average concentration.

**Personal Protective Equipment (PPE).** Equipment provided to shield or isolate a person from the chemical, physical, and thermal hazards that may be encountered at a hazardous materials incident. Adequate personal protective equipment should protect the respiratory system, skin, eyes, face, hands, feet, head, body, and hearing. Personal protective equipment includes: personal protective clothing, self-contained positive pressure breathing apparatus, and air purifying respirators.

**Physical State.** The physical state or form (solid, liquid, gas) of the material at normal ambient temperatures (68° F to 77° F).

**Planning Section.** Within NIMS, responsible for the collection, evaluation, dissemination and use of information about the development of the incident and the status of resources. Includes the Situation Status, Resource Status, Documentation, and Demobilization Units as well as Technical Specialists.

**Plume.** A vapor, liquid, dust, or gaseous cloud formation which has shape and buoyancy.

**Portable Container.** A container designed to be moved readily, as distinguished from containers designed for stationary installations. Portable containers, designed for transportation, filled to their

maximum filling limit, include cylinders, cargo tanks, and portable tanks, all three of which are defined separately under NFPA 58. Containers which are designed to be “readily” moved from one usage to another, but substantially empty of product, are defined under NFPA 58 as portable storage containers.

**Portable Storage Container.** A container similar to but distinct from those designed and constructed for stationary installation, designed so that it can be moved readily over the highways, substantially empty of liquid, from one usage to another. Such containers either have legs or other supports attached, or are mounted on running gear (such as a trailer or semitrailer chassis) with suitable supports of the fold-down type, allowing them to be placed or parked in a stable position on a reasonably firm and level surface. For large volume, limited duration product usage (such as construction sites and on site normally 12 months or less), portable storage containers function in lieu of permanently installed stationary containers.

**Post-Emergency Response Operations.** That portion of an emergency response performed after the immediate threat of a release has been stabilized or eliminated, and the clean-up of the site has begun.

**Pressure Relief Valve.** A device designed to open and prevent a rise of internal pressure in excess of a specified value due to emergency or abnormal conditions. Pressure relief valves are divided into the following types: External Pressure Relief Valve, Flush Type Full Internal Pressure Relief Valve, Full Internal Pressure Relief Valve, Internal Spring-Type Pressure Relief Valve, and Sump-Type Full Internal Pressure Relief Valve.

**Process Safety Management (PSM).** The application of management principles, methods and practices to prevent and control releases of hazardous chemicals or energy. Focus of both OSHA 1910.119—Process Safety Management of Highly Hazardous Chemicals, Explosives and Blasting Agents and EPA Part 68—Risk Management Programs for Chemical Accidental Release Prevention.

**Product Release Prevention and Incident Preparedness Review.** Under NFPA 58, propane installations with an aggregate water capacity of more than 4,000 gallons of LP-Gas develop a written Product Release Prevention and Incident Preparedness Review. The written review shall be submitted by the bulk plant owner, operator or designee to the authority having jurisdiction (AHJ) and local emergency responders, and shall include the following:

- Product control measures.
- Exposure hazards within the LP-Gas facility.
- External exposure hazards outside of the LP-Gas facility, including neighboring properties that present high life safety challenges.
- Capabilities of the local fire department
- Water supply requirements, including the availability, adequacy and reliability of the local water supply.

**Protective Clothing.** Equipment designed to protect the wearer from heat and/or hazardous materials contacting the skin or eyes. Protective clothing is divided into four types:

- Structural fire fighting protective clothing
- Liquid splash chemical protective clothing
- Vapor chemical protective clothing
- High temperature protective clothing

**Public Protective Actions.** The strategy used by the Incident Commander to protect unexposed people from the hazardous materials release by evacuating or protecting-in-place. This strategy is usually implemented after the IC has established an isolation perimeter and defined the Hazard Control Zones for emergency responders.

**Purging.** The process of venting undesirable gases from a tank.

## R

**Rail Burn.** Deformation in the shell of a railroad tank car. It is actually a long dent with a gouge at the bottom of the inward dent. A rail burn can be oriented circumferentially or longitudinally in relation to the tank shell. The longitudinal rail burns are the more serious because they have a tendency to cross a weld. A rail burn is generally caused by the tank car passing over a stationary object, such as a wheel flange or rail.

**Redundant Fail-Safe Product Control Measures (RFPCM).** Control measures required at LP-Gas cargo tank truck and railroad tank car transfer points to minimize any product release. Examples of RFPCM include:

- Vehicle pull away protection
- Automatic shutdown system for all primary valves in the event of a hose pull-away or thermal actuation
- Installation of additional isolation valves on liquid and vapor openings
- Use of backflow check valves
- Remote shutdown capability with stations within 15 ft. of the transfer point and 25 to 100 ft. away from the transfer point,

**Regulator.** A device designed to regulate pressure from the LP-Gas cylinder to an appliance or unit. There are various types of regulators available, depending upon the types of use.

**Reporting Marks and Number.** A unique set of initials and a number stenciled on both sides and both ends of railroad cars. Newer railcars may also have the reporting marks stenciled on the top of the railcar to aid in the identification process if the car is derailed and is lying on its side. These markings can be used to obtain information on the contents of the car from either the railroad or the shipper.

**Respiratory Protection.** Equipment designed to protect the wearer from the inhalation of contaminants. Respiratory protection is divided into three types: positive pressure self-contained breathing apparatus (SCBA), positive pressure airline respirators (SARs), and air purifying respirators.

**Risk Analysis.** A process to analyze the probability that harm may occur to life, property, and the environment and to note the risks to be taken to identify the incident objectives.

**Risk Management Programs.** Required under the EPA 40 CFR Part 68, risk management programs consist of three elements: (1) hazard assessment of the facility; (2) prevention program; and (3) emergency response considerations.

**Risks.** The probability of suffering a harm or loss. Risks are variable and change with every incident.

**Runaway Cracking.** Cracking occurring in closed containers under pressure, such as liquid drums or pressure vessels. A small crack in a closed container suddenly develops into a rapidly growing crack which circles the container. As a result, the container will generally break into two or more pieces.

## S

**Safely.** To perform the assigned tasks without injury to self or others, to the environment, or to property.

**Safety Officer.** Responsible for the safety of all personnel, including monitoring and assessing safety hazards, unsafe situations, and developing measures for ensuring personnel safety. The Incident Safety Officer (ISO) has the authority to terminate any unsafe actions or operations, and is a required function based upon the requirements of OSHA 1910.120 (q).

**Saturated Hydrocarbons.** A hydrocarbon possessing only single covalent bonds. All of the carbon atoms are saturated with hydrogen. Examples include methane (CH<sub>4</sub>), propane (C<sub>3</sub>H<sub>8</sub>), and butane (C<sub>4</sub>H<sub>10</sub>).

**SCBA.** (See Self-Contained Breathing Apparatus.)

**Score.** Reduction in the thickness of the container shell. It is an indentation in the shell made by a relatively blunt object. A score is characterized by the reduction of the container or weld material so that the metal is pushed aside along the track of contact with the blunt object.

**Section.** That organization level within the Incident Command System having functional responsibility for primary segments of incident operations, such as Operations, Planning, Logistics and Administration/Finance. The section level is organizationally between the branch and the Incident Commander.

**Self-Contained Breathing Apparatus (SCBA).** A positive pressure, self-contained breathing apparatus (SCBA) or combination SCBA/supplied air breathing apparatus certified by the National Institute for Occupational Safety and Health (NIOSH) and the Mine Safety and Health Administration (MSHA) or the appropriate approval agency for use in atmospheres that are immediately dangerous to life or health (IDLH).

**Shipping Documents/Papers.** Generic term used to refer to documents that must accompany all shipments of goods for transportation. These include Hazardous Waste Manifest, Bill of Lading, and Consists, etc. Shipping documents should provide the following:

- Proper shipping name.
- Hazard classification.
- Four digit identification number(s), as required.
- Number of packages or containers.
- Type of packages.
- Total quantity by weight, volume, and/or packaging.

**Shipping Name.** The proper shipping name or other common name for the material; also any synonyms for the material.



**Site Management and Control.** The management and control of the physical site of a hazmat incident. Includes initially establishing command, approach and positioning, staging, establishing initial perimeter and hazard control zones, and public protective actions.

**Size-Up.** The rapid yet deliberate consideration of all critical scene factors.

**Skilled Support Personnel.** Personnel who are skilled in the operation of certain equipment, such as cranes and hoisting equipment, and who are needed temporarily to perform immediate emergency support work that cannot reasonably be performed in a timely fashion by emergency response personnel.

**Solubility.** The ability of a solid, liquid, gas, or vapor to dissolve in water or other specified medium. The ability of one material to blend uniformly with another, as in a solid in liquid, liquid in liquid, gas in liquid, or gas in gas. Significant property in evaluating the selection of control and extinguishing agents, including the use of water and firefighting foams.

**Specialist Employee.** These are individuals who, in the course of their regular job duties, work with or are trained in the hazards of specific materials and/or containers. In response to incidents involving chemicals, they may be called upon to provide technical advice or assistance to the Incident Commander relative to their area of specialization.

**Special Protection.** As defined by NFPA 58, a means of limiting the temperature of an LP-Gas container for purposes of minimizing the possibility of failure of the container as a result of fire exposure. Special protection may consist of one of the following:

- Applied insulating coating
- Mounding
- Burial
- Water spray fixed system
- Fixed monitor nozzles
- Any means listed for this purpose

**Specific Gravity.** The weight of the liquid as compared with the weight of an equal volume of water. If the specific gravity is less than one, the material is lighter than water and will float. If the specific gravity is greater than one, the material is heavier than water and will sink. Most insoluble hydrocarbons are lighter than water and will float on the surface. Significant property for determining spill control and clean-up procedures for water-borne releases.

**Specification Marking.** Found in various locations on railroad tank cars, intermodal portable tanks, and cargo tank trucks, it indicates the standards to which the container was built.

**Stabilization.** The point in an incident at which the adverse behavior of the hazardous materials is controlled.

**Staging.** The management of committed and uncommitted emergency response resources (personnel and apparatus) to provide orderly deployment.

**Staging Area.** The safe area established for temporary location of available resources closer to the incident site to reduce response time.

**Standard Transportation Commodity Code (STCC).** A number which will be found on all shipping documents accompanying rail shipments of hazmats. A seven-digit number assigned to a specific material or group of materials and used in determination of rates. For a hazardous material, the STCC number will begin with the digits "49." Hazardous wastes may also be found with the first two digits being "48." The STCC will also be found when intermodal containers are changed from rail to highway movement.

**Strategic Goals.** The overall plan that will be used to control an incident. Strategic goals are broad in nature and are achieved by the completion of tactical objectives. Examples include rescue, spill control, leak control, fire control and recovery.

**Street Burn.** Deformation in the shell of a highway cargo tank. It is actually a long dent that is inherently flat. A street burn is generally caused by a container overturning and sliding some distance along a cement or asphalt road.

**Strength.** The degree to which a corrosive ionizes in water. Those that form the greatest number of hydrogen ions are the strongest acids (e.g.,  $\text{pH} < 2$ ), while those that form the hydroxide ion are the strongest bases ( $\text{pH} > 12$ ).

**Stress Event.** An applied force or system of forces that tend to either strain or deform a container (external action) or trigger a change in the condition of the contents (internal action). Types of stress include thermal, mechanical, and chemical.

**Structural Firefighting Protective Clothing.** Protective clothing normally worn by firefighters during structural firefighting operations. It includes a helmet, coat, pants, boots, gloves, PASS device, and a hood to cover parts of the head not protected by the helmet. Structural firefighting clothing provides limited protection from heat but may not provide adequate protection from harmful liquids, gases, vapors, or dusts encountered during hazmat incidents. May also be referred to as turnout or bunker clothing.

**Superfund Amendments & Reauthorization Act (SARA).** Created for the purpose of establishing Federal statutes for right-to-know standards and emergency response to hazardous materials incidents, reauthorized the Federal Superfund program and mandated states to implement equivalent regulations/requirements.

## T

**Tactical Objectives.** The specific operations that must be accomplished to achieve strategic goals. Tactical objectives must be both specific and measurable.

**Tasks.** The specific activities that accomplish a tactical objective.

**Technical Information Centers.** Private and public sector hazardous materials emergency "hot-lines" that (1) provide immediate chemical hazard information; (2) access secondary forms of expertise for additional action and information; and (3) act as a clearinghouse for spill notifications. Include both public (e.g., CHEMTREC) and subscription-based systems.

**Technical Information Specialists.** Individuals who provide specific expertise to the Incident Commander or the HMRT either in person, by telephone, or through other electronic means. They may represent the shipper, manufacturer or be otherwise familiar with the hazmats or problems involved. Commonly referred to as product or container specialists.

**Termination.** That portion of incident management where personnel are involved in documenting safety procedures, site operations, hazards faced, and lessons learned from the incident. Termination is divided into three phases: debriefing, postincident analysis, and critique.

**Thermal Stress.** Hazmat container stress generally indicated by temperature extremes, both hot and cold. Examples include fire, sparks, friction or electricity, and ambient temperature changes. Extreme or intense cold, such as that found with cryogenic materials, may also act as a stressor. Clues of thermal stress include the operation of pressure relief devices or the bulging of containers.

**Threshold Limit Value/Time-Weighted Average (TLV/TWA).** The airborne concentration of a material to which an average, healthy person may be exposed repeatedly for 8 hours each day, 40 hours per week, without suffering adverse effects. The young, old, ill, and naturally susceptible will have lower tolerances and will need to take additional precautions. TLVs are based upon current available information and are adjusted on an annual basis by organizations such as the American Conference of Governmental Industrial Hygienists (ACGIH). As TLVs are time-weighted averages over an eight-hour exposure, they are difficult to correlate to emergency response operations. The lower the value, the more toxic the substance.

**Toxic Products of Combustion.** The toxic by-products of the combustion process. Depending upon the materials burning, higher levels of personal protective clothing and equipment may be required.

**Toxicity.** The ability of a substance to cause injury to a biologic tissue. Refers to the ability of a chemical to harm the body once contact has occurred.

**Transfer.** The process of physically moving a liquid, gas or some forms of solids either manually, by pump or by pressure transfer, from a leaking or damaged container. The transfer pump, hoses, fittings and container must be compatible with the hazardous materials involved.

**Transport Vehicle.** Common name given to vehicles used to transport LP-Gas to bulk plants, marketing facilities, and large LP-Gas users. May be found in as a single unit or as tandem cargo tank trucks or “pups,” and are constructed to the MC-330 / MC-331 specification. Capacities can be as large as 17,000 gallons depending upon state vehicle weight regulations.

## U

**Unified Command.** The process of determining overall incident strategies and tactical objectives by having all agencies, organizations or individuals who have jurisdictional responsibility, and in some cases those who have functional responsibility at the incident, participate in the decision-making process.

**Unified Commanders (UC).** Command level representatives from each of the primary responding agencies who present their agency’s interests as a member of a unified command team. Depending upon the scenario and incident timeline, they may be the “lead” Incident Commander or play a supporting role within the command function. The unified commanders manage their own agency’s actions and make sure all efforts are coordinated through the unified command process.

**UN/NA Identification Number.** The four-digit identification number assigned to a hazardous material by the Department of Transportation; on shipping documents may be found with the prefix “UN” (United Nations) or “NA” (North American). The ID numbers are not unique and more than one material may have the same ID number.

**Universal Cylinder.** A cylinder constructed and fitted with appurtenances in such a manner that it can be connected for service with its longitudinal axis in either the vertical or the horizontal position, and so that its fixed maximum liquid level gauge, pressure relief device(s), and withdrawal appurtenance will function properly in either position.

## V

**Vapor.** An air dispersion of molecules in a substance that is normally a liquid or solid at standard temperature and pressure.

**Vapor Density.** The weight of a pure vapor or gas compared with the weight of an equal volume of dry air at the same temperature and pressure. The molecular weight of air is 29. If the vapor density of a gas is less than one, the material is lighter than air and may rise. If the vapor density is greater than one, the material is heavier than air and will collect in low or enclosed areas. Significant property for evaluating exposures and where hazmat gas and vapor will travel.

**Vapor Dispersion.** Use of water spray to disperse or move vapors away from certain areas or materials. Note that reducing the concentration of a material through the use of a water spray may bring the material into its flammable range.

**Vapor Pressure.** The pressure exerted by the vapor within the container against the sides of a container. This pressure is temperature dependent; as the temperature increases, so does the vapor pressure. Consider the following three points:

- 1) The vapor pressure of a substance at 100°F. is always higher than the vapor pressure at 68°F.
- 2) Vapor pressures reported in millimeters of mercury (mm Hg) are usually very low pressures. 760 mm Hg. is equivalent to 14.7 psi. or 1 atmosphere. Materials with vapor pressures greater than 760 mm Hg. are usually found as gases.
- 3) The lower the boiling point of a liquid, the greater vapor pressure at a given temperature.

**Vent and Burn.** The use of shaped explosive charges to vent the high pressure at the the top of a pressurized container and then, with additional explosive charges, release and burn the remaining liquid in the container in a controlled fashion. This is a highly sophisticated technique that is only used under very controlled conditions.

**Venting.** The controlled release of a liquid or compressed gas to reduce the pressure and diminish the probability of an explosion. The method of venting will depend upon the nature of the hazmat.

**Violent Rupture.** Associated with chemical reactions having a release rate of less than one second (i.e., deflagration). There is no time to react in this scenario. This behavior is commonly associated with runaway cracking and overpressure of closed containers.

**Volatility.** The ease with which a liquid or solid can pass into the vapor state. The higher a material's volatility, the greater its rate of evaporation. Significant property in that volatile materials will readily disperse and increase the hazard area.



**Warm Zone.** The control zone at a hazardous materials incident where personnel and equipment decontamination and hot zone support takes place. It includes control points for the decontamination corridor, thus helping reduce the spread of contamination. This is also referred to as the “decontamination,” “contamination reduction,” “yellow zone,” or “limited access zone” in other documents.

**Water Capacity (w.c.).** The amount of water at 60°F (16° C) required to fill a container. It is expressed in pounds for cylinders and gallons for ASME containers. The water capacity, in pounds, is the weight of water needed to fill an ASME container completely, while the maximum permitted filling capacity allowed for propane is 80% full. The maximum propane capacity in pounds is 42% in weight of the water capacity. For example, a cylinder marked as being 48 lb. would have a propane capacity of 42% of 48 lb., or about 20 lbs.

**Wheel Burn.** Reduction in the thickness of a railroad tank shell. It is similar to a score, but is caused by prolonged contact with a turning rail car wheel.

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