

# **LPG Safety**

## **Guidelines for Good Safety Practice in the LPG Industry**

## Foreword

United Nations Environment Programme – Division of Technology, Industry and Economics

Major technological accidents have taught us that their effects often do not stop at the factory fence but affect people, property, and the environment outside the enterprise, sometimes at considerable distances. That is why safety is an essential part of good industrial *environmental* management.

'Prevention is better than cure' and effective safety promotion starts by getting things right within the factory, storage depot, or transport system. The importance of having an effective emergency management system in place should something go wrong has been recognised for a long time. International Standard ISO 14001, 'Environmental Management Systems – Specification with Guidance for Use' reinforces the point in paragraph 4.4.7:

*- The organisation shall establish and maintain procedures to identify potential for and respond to accidents and emergency situations, and to prevent and mitigate the environmental effects that may be associated with them.*

*- The organisation shall review and revise, where necessary, its emergency preparedness and response procedures, in particular after the occurrence of accidents or emergency situations.*

UNEP's Awareness and Preparedness for Emergencies at Local Level (APELL) programme was introduced in 1988 in co-operation with governments and the chemical industry. APELL responds to the growing need for better emergency preparedness planning in developing countries, and so helps prevent technological accidents while reducing the impacts of those that do occur. The APELL process has been introduced in over thirty countries throughout the world, and has the following aims:

*- Make industry, emergency response authorities, and the community at large aware of hazards within a community*

*- Develop a coordinated emergency response plan that can effectively handle accidents before these develop into major disasters*

*- Train residents of a community on what to do in the event of an emergency.*

Industry in all countries has an important role to play in preventing accidents and ensuring that sustainable development is not threatened by the effects of technological disasters. UNEP is pleased that the WLPGA is contributing to this world-wide effort by preparing and disseminating these Safety Guidelines. The Guidelines will help promote a stronger safety culture in the LPG industry, so lead to safer workplaces and communities throughout the world.

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## Introduction

LPG is an excellent, environmentally friendly fuel with hundreds of millions of satisfied consumers across all parts of the world.

Like all forms of energy, LPG is potentially hazardous if mishandled or misused. The promotion of safety is one of the key aims of the World LPG Association (WLPGA) and is included in its vision:

‘As the authoritative global voice for LPG, the WLPGA promotes the use of LPG worldwide to foster a safer, cleaner, healthier and more prosperous world’.

These Guidelines are intended for non-experts who may have responsibility for, or are otherwise concerned with, good safe practice in relation to LPG storage, handling, distribution and use.

The Guidelines were originally developed by the WLPGA to form the central part of a Safety Promotion Programme.

Although safety is an important issue, it should also be emphasised that LPG is an excellent, versatile and often preferred fuel for hundreds of applications. It is also recognised as an environmentally friendly fuel with many social and health related benefits.

As with all forms of energy, LPG can be hazardous if mishandled or misused. Care in the storage, handling, distribution and use of LPG will mitigate any incidents, accidents and their consequences. This is the key driver in the Safety Promotion Programme and with these guidelines.

There is a wealth of knowledge and expertise within the LPG industry which is used to enhance safety, and which is reflected in these guidelines. It is the policy of the WLPGA that the safety expertise available within the international LPG industry should be shared as widely as possible in the interest of participants, consumers and the community, providing of course it adheres to the Association’s anti-trust guidelines.

These guidelines are intended for policy makers, government officials, LPG industry managers at international, national and local levels, and anyone else who is concerned with good safety practice in relation to LPG storage, handling, distribution and use.

A hazard commonly associated with LPG is an uncontrolled release of product, followed by fire. These guidelines address this type of hazard, but they also take a more comprehensive view of LPG safety.

Since these guidelines were last updated the Internet of Things (IoT) has become an important subject for the LPG industry, not just for managing information but creating a powerful resource for managing safety. This will be discussed in Chapter Eleven (11.7).

These guidelines follow the LPG distribution chain from primary storage up to and including the point of use. Hazards are identified at each stage of the process and good safety practices are outlined. More detailed technical guidance references are provided in Appendix Three.

## CHAPTER ONE

# Key Responsibilities

The principal participants in the LPG industry – producers, suppliers, traders, marketers, equipment manufacturers, transporters and installers – all have responsibilities in the area of safety. They should collaborate to ensure the efficient discharge of their responsibilities.

National and local authorities should take advantage of the expertise within the LPG industry to ensure an informed and uniform approach to good safety practice.

Consumers should adhere to the safety instructions which are provided for them. There are many other stakeholders, and they all have a key role to play.



## **1.1 LPG Producer/Supplier/Marketer**

1.1.1 The LPG producer/supplier/marketer may be a producer, importer, a primary marketer or a distributor appointed by the marketer. It may be a state-owned, or a private-sector enterprise. Their responsibilities include all components of the distribution chain.

1.1.2 The producer/supplier/marketer will be responsible for the quality of LPG supplied, i.e. for conformity within a declared standard or specification, and for quantity, i.e. for conformity with a declared volume or weight.

- 1.1.3 The producer/supplier/marketer may retain ownership of the tanks and cylinders used to supply LPG. In this event conformity with prescribed or declared manufacturing standards, with specified periodic inspection or re-qualification procedures, must be maintained.
- 1.1.4 The producer/supplier/marketer should be encouraged to work closely with manufacturers, suppliers and installers of LPG appliances and equipment as part of a coordinated industry approach to good safety practice. The producer/supplier/marketer should influence appliance and equipment manufacturers and installers to promote safety in their mutual interest.

## **1.2 Equipment and Appliance Manufacturer/Supplier**

- 1.2.1 Manufacturers of LPG equipment and appliances usually distribute them through suppliers who may be sellers of household appliances. These supplies may also be LPG suppliers. Where a manufacturer based in another country sells through an import agent, the agent should fully understand the required safety standards and the safety implications for the users. In some countries the importer may be regarded as the manufacturer and assume the manufacturers responsibilities.
- 1.2.2 Virtually all commercial, household and leisure applications for LPG require an appliance. Some appliances are made specifically for LPG, but many commercial and household appliances are manufactured primarily for use with Natural Gas (Methane), and conversion to LPG use is an additional process, post manufacture.
- 1.2.3 Only LPG compatible appliances should be used with LPG. It is a key responsibility of the manufacturer/supplier to ensure that LPG appliances are capable of safe, efficient and convenient operation with the grade or grades of LPG being sold in the market.
- 1.2.4 Manufacturers/suppliers should provide clear operating and safety instructions for the user, including compatibility between burner and product (Butane, Propane or mixtures). If necessary, connections should be designed to avoid the use of incompatible appliances and products.
- 1.2.5 Manufacturers/suppliers of LPG and appliances should collaborate to ensure that consumers are offered a choice of appliances which are energy efficient and which can be operated safely in particular markets.
- 1.2.6 LPG equipment includes a variety of products associated with the storage, handling, distribution and use of the product, such as storage tanks, cylinders, pressure regulators, gauges and controls. These include small volume/high value and mass-produced, high precision items.
- 1.2.7 LPG equipment may be installed in an LPG marketer's plant, on a truck or pipeline at a consumer installation, or at the immediate point of use. Manufacturers and suppliers should ensure that the equipment being used is suitable for the intended purpose and for the intended environment, including climatic conditions. They should prevent illegal use, e.g. product transfer by incompetent persons or via unapproved connections.
- 1.2.8 LPG marketers should take a direct informed interest in the equipment which they employ and recognise the relationship between quality and safety. Sub-standard equipment increases risk and has no place in the LPG industry. Enforcement may be by national type, product approval or by a voluntary code.



## 1.3 Contractor/Installer

- 1.3.1 The function of the contractor/installer is to put the LPG supply in place using appropriate equipment and, having connected the supply to the appliance, ensure the system is working correctly and in a safe environment, including access to proper ventilation and provision for the removal of exhaust gases.
- 1.3.2 While the LPG supplier will be responsible for any installed equipment which remains their property it is usually the contractor/installer who introduces the consumer to the safety features of the installation.
- 1.3.3 Key responsibilities of the contractor/installer includes that:
- The work is in conformance with all relevant statutory requirements and current installation standards / codes
  - The installation is gas-tight and, as far as practicable, protected from damage or interference
  - Adequate combustion air is available and that the products of combustion (or any product leaks) will be safely disposed of
  - Controls and safety systems are functioning correctly
  - The consumer understands the normal operation of the installation, its maintenance needs, the action to be taken in an emergency and has an emergency phone number(s)

## 1.4 Distributor/Agent/Dealer/Retailer

- 1.4.1 The distributor/agent/dealer/retailer is a key link in the distribution chain that supplies the customer with product and services.
- 1.4.2 The distribution chain may likely involve several different third-party businesses that moves the product from the LPG storage depot, cylinder filling plant or bulk loading facility to the customer. For many, the distribution of LPG is their main activity. For others it is only part of their business.
- 1.4.3 The distributor/agent/retailer/dealer all have a common aim - to move the LPG product in a safe and efficient manner to the end user and assist in meeting both the needs of the marketer/supplier and the end consumer.
- 1.4.4 As LPG moves further down the distribution chain from the depot to the customer, the control over safety by the marketer/supplier becomes weaker. This is the point in the distribution chain where the customer interface occurs, and it is critical that safety receives increased and focused attention there. The “chain of responsibility” concept being included in many regulations is a useful guide to the responsibilities faced by distributors, dealers and retailers.

## 1.5 Consumer

- 1.5.1 Because of the wide range of LPG applications, and the variations in the scale of usage, there are many categories of consumer. These range from households (often the largest single category) to

industrial or chemical complexes where LPG may be only one of many hazardous products on site.

- 1.5.2 The 'duty of care' concept increasingly found in the Western European approach to safety, and the 'duty to inform' found in the United States of America, are very appropriate for LPG consumers and could be usefully adopted by other countries. Duty of care includes an obligation on the consumer to heed the safety information provided by the supplier as part of their duty to inform.
- 1.5.3 The consumer should be supplied with clear and easy to read safety notices and instructions. Consumers should heed them and avoid a cut-price, or 'do-it-yourself' approach, to LPG installations. Some LPG applications, especially those in the leisure sector, lend themselves to some self-assembly but most require the services of a competent installer.
- 1.5.4 When the consumer is expected to operate or maintain specific equipment such as vapourisers, they should be trained and approved as competent.

## **1.6 LPG Association**

- 1.6.1 A key responsibility of a national or local LPG Industry Association should be the promotion of good safety practices in the LPG industry. It should have a mission and structure to facilitate the progressive raising of technical and safety standards.
- 1.6.2 Membership of an LPG Industry Association should be open to the appliance, equipment, transporter and installer sectors, as well as to LPG producers and marketers and other relevant stakeholders.
- 1.6.3 National LPG Associations should have a coordinating role in the preparation of LPG related legislation and regulation.
- 1.6.4 National LPG Associations are urged to maintain membership and open communication with the WLPGA, particularly in addressing international LPG issues.

## **1.7 National and Local Authorities**

- 1.7.1 Typically, LPG represents a small component of a nation's energy supply, especially in countries with well-developed natural gas grids and electricity distribution networks. However, the use of LPG is sometimes encouraged for specific energy related or environment related reasons such as the replacement of solid fuel or CFCs, or as an alternative on-road transportation fuel.
- 1.7.2 National Authorities should ensure that they and the relevant public bodies understand and address safety issues in respect of LPG storage, handling, distribution and use. They should appreciate and accept the safety implications of promoting or permitting applications.
- 1.7.3 National Authorities should ensure that appropriate technical and safety standards are in place for LPG, LPG appliances, equipment and installations. It is usually quite practical and sometimes more efficient to adopt standards which have good international recognition rather than develop

national standards from first principles. The emphasis should be on adoption, not adaptation if it does not contradict other adopted practices and suits the local operational environment.

- 1.7.4 National and Local Authorities should initiate or encourage dialogue with the LPG industry to ensure an informed and uniform approach to good safety practice. At national and international level, the LPG industry is encouraging a scientific and risk-based approach to such matters as land use planning.
- 1.7.5 A Local Authority will probably be responsible for sanctioning the development of the LPG distribution infrastructure and the routing of LPG transportation. It may also be responsible for sanctioning the operation of elements of the distribution infrastructure such as cylinder filling plants. These Guidelines are intended to assist Local Authorities in the exercise of these duties.

## **1.8 Retailer Service Station**

- 1.8.1 LPG – known as Autogas when used as a transport fuel in on road engine applications – has very good engine fuel properties and is the world’s number one alternative transport fuel to gasoline and diesel.
- 1.8.2 Autogas may or may not have separate vehicle re-fuelling arrangements and these may be under the control of the marketer, or in some cases, the customer. The customer may for example be the operator of a taxi fleet.
- 1.8.3 The procedures for storage, handling and re-fuelling Autogas at these locations need to be clear and well communicated in the same way that they are for gasoline and diesel. Their role is very similar to that set out in 1.5 above.

## **CHAPTER TWO**

# **Regulatory Framework**

LPG safety may be regulated directly or within the broader regulation of hazardous substances and activities.

The regulatory system should promote safety in storage, handling, distribution and use.

The LPG industry should have a key role in the preparation of regulations through its national or other representative associations.

## **2.1 General**

- 2.1.1 In these Guidelines the focus is only on the regulatory framework for safety.
- 2.1.2 In countries which have wide-ranging systems of regulation for public, employee and consumer safety, it is normal to find LPG included in schedules of hazardous substances. Typically, these systems provide for regulation of many substances, in storage, handling, distribution and use.
- 2.1.3 In the absence of such wide-ranging systems, regulations may be introduced specifically for LPG or the LPG industry may be self-regulating. Self-regulation is usually based on recognised technical standards and codes of practice which are accepted and overseen by an official inspectorate or authority.

## **2.2 Points to be Regulated Directly**

- 2.2.1 The most serious events tend to be associated with large quantities of LPG, and when frequent transfers of product in storage or distribution take place. Events like this may be infrequent but could have consequences beyond their immediate location.
- 2.2.2 The location of LPG storage and handling facilities should be directly regulated within general hazardous substances regulations or in their absence by LPG specific regulations. A threshold level of inventory should be set which will determine whether a facility falls within the scope of the regulations. Progressively more stringent conditions should apply as the assessed risk increases.
- 2.2.3 Planning regulations should take account of the potential hazard, the hazard consequences and the probability of the occurrence of hazardous events.

- 2.2.4 The operation of LPG storage and handling facilities may be subject to license which sets limits to the capacity, throughput and scope of activities. The license should provide for periodic inspection and renewal.
- 2.2.5 LPG transport should be regulated to take account of the inherent hazards, and the risks associated with the distribution mode, e.g. pipeline, water-borne, rail and road. Where national or local regulations are deemed to be inadequate or, in need of strengthening, a code should be adopted which has international recognition.
- 2.2.6 Many of the incidents involving LPG (including those resulting in fatalities) occurs at, or close to, the point of use. They may result from defects in the LPG supply, in the appliance, the equipment or the manner of installation. Some incidents are the result of misuse by the consumer. This type of misuse may be accidental or due to the consumer being inadequately informed: in the extreme, it may not be accidental but deliberate.
- 2.2.7 Broad-based consumer protection regulations will provide a measure of safety for LPG users. The emphasis in direct regulation should be on:
- LPG of the specified grade and standard in containers (tanks and cylinders) manufactured, installed and maintained to the appropriate standard
  - Appliances and equipment manufactured and installed to the appropriate standards
  - Type approval procedures and the exclusion of sub-standard appliances, equipment and installers

## **2.3 Points to be Regulated Indirectly**

- 2.3.1 Where well-developed systems for the regulation of public, employee and consumer safety are in place and effective, many aspects of LPG safety can be regulated indirectly. However, it is important that when LPG is included in these types of regulatory systems the potential hazards are correctly identified and the risks quantified to an acceptable level of accuracy and appropriate infrastructure and procedures installed to mitigate those risks.

## **CHAPTER THREE**

# **LPG Safety**

LPG is potentially hazardous from the point of production, moving through the distribution chain, until it has been used and the combustion products have been safely disposed of.

Safety comes from understanding the behaviour of LPG and keeping it under control.

Every uncontrolled release is a hazardous event and should receive urgent attention. As natural LPG is odourless and invisible, a distinctive odour is usually added to warn of its presence. Then, even the smallest leak can be detected and can receive appropriate attention. However, as LPG is heavier than air an underground or low-level leak might not be detected immediately.

Consumers should be given safety information and having been informed should exercise reasonable care in handling and use.

LPG describes a range of products which have much in common but also have differences which affect safety.

LPG containers should be readily identifiable as such.

Good appliance and installation standards are essential for safety.

### **3.1 General**

- 3.1.1 The term LPG is an abbreviation for Liquefied Petroleum Gas (Gases) and refers to hydrocarbon products, sometimes also described as light fractions. In common with other forms of energy, LPG can be hazardous unless it is kept under control. It is potentially hazardous from the time of production until it has been used and the products of combustion have been disposed of safely.
- 3.1.2 LPG has its own special hazardous characteristics. LPG safety comes from understanding these characteristics and behaviour, and from the exercise of control under both normal and abnormal conditions. The WLPGA has produced a short video highlighting some of these. (<https://www.youtube.com/watch?v=9X6EG3g8JHU>)
- 3.1.3 The behaviour of LPG is predictable and the technology for control is well understood. Good technical and safety expertise is to be found in the production, primary supply and marketing companies and in the major equipment manufacturers. The application of this expertise becomes progressively more challenging as LPG is moved along the distribution chain and away from the direct control of the primary suppliers and marketers.
- 3.1.4 The hazards commonly associated with LPG are fire and explosion. Since any uncontrolled release of LPG can have serious consequences, the primary objective of an LPG safety programme is to prevent uncontrolled releases by containment. However, there are other

hazards inherent in storage, handling, distribution and use which are addressed in these guidelines.

- 3.1.5 Butane and Propane are the predominant constituents of LPG. Butane, Propane and Butane/Propane mixtures are handled and/or distributed separately and for safety, one product should not be mistaken for the other. Propane has different properties to Butane, including a higher vapour pressure which has repercussions on vessel design.
- 3.1.6 The consumer receives LPG at the end of the distribution chain. In practice this can mean transporting the product over long distances, and probably one or more trans-shipments. LPG safety must consider hazards associated with the mode and duration of transport including the risk of traffic accidents and delays, and their possible consequences.
- 3.1.7 Most LPG is used by combustion in an appliance which is itself part of a consumer installation. Adequate combustion air and continuous ventilation are essential for safety. The products of LPG combustion, or product released because of leakage, should be vented to avoid a possible build-up of hazardous secondary products. The installer and the consumer have major roles in this aspect of LPG safety.
- 3.1.8 The vast range of LPG uses and appliances, as well as the variable scale of installations adds to the complexity of LPG safety.
- 3.1.9 Introduction of new applications, especially when accompanied by changes in distribution practices, present new hazards and may call for the introduction of additional safety practices. The safety procedures in a marketer's bulk plant may not be adequate at an automotive re-fueling station. The safety requirements of a household installation with several appliances, e.g. stove, water heater and space heaters, will differ from those of a consumer using a single appliance directly attached to a cylinder.

## 3.2 Physical Properties

- 3.2.1 LPG is produced during the refining of crude oil and the processing of natural gas liquids. Commercial, or fuel grade LPG, mainly consists of Butane and Propane with small amounts of lighter and heavier fractions, such as Ethane and Pentane.

| Typical Properties of LPG                                    |           |            |           |
|--|-----------|------------|-----------|
| Property   | Propane   | Iso-Butane | n-Butane  |
| Boiling point at 101.3 kPa (°C)                              | -42.1     | -11.8      | -0.5      |
| Liquid density at 15 °C (kg/ m <sup>3</sup> )                | 506.0     | 561.5      | 583.0     |
| Absolute vapour pressure at 40 °C (kPa)                      | 1510      | 530        | 375       |
| Flash Point (°C)   | -104      | -83        | -60       |
| Upper flammable limit (% vol. in air)                        | 9.5       | 8.5        | 8.5       |
| Lower flammable limit (% vol. in air)                        | 2.3       | 1.9        | 1.9       |
| Volume vapour per volume liquid                              | 269       | 221        | 235       |
| Relative vapour density (air = 1)                            | 1.55      | 2.07       | 2.07      |
| Coefficient of expansion (liquid) per 1°C                    | 0.0032    |            | 0.0023    |
| Minimum air for combustion (m <sup>3</sup> /m <sup>3</sup> ) | 24        |            | 30        |
| Kinematic Viscosity (centistokes) @ 20°C                     | 0.20      | 0.29       | 0.30      |
| Latent Heat of Vapourisation (kJ/kg) @ 20°C                  | 352       |            | 368       |
| Specific Heat (kJ/kg/°C) @ 20°C - liquid                     | 2.554     |            | 2.361     |
| Specific Heat (kJ/kg/°C) @ 20°C - vapour                     | 1.047     |            | 1.495     |
| Minimum ignition temperature (°C) in oxygen                  | 470 - 575 |            | 380 - 550 |
| Specific Energy (gross) kJ/kg                                | 49.83     |            | 49.40     |

- 3.2.2 It will be apparent from the above table that there are significant differences in the physical properties of Butane and Propane, most notably boiling point, liquid density and vapour pressure. The values for LPG mixtures generally lie between these extremes depending on the ratio of Butane and Propane. However, quite small amounts of Methane and Ethane can have a significant effect on vapour pressure.
- 3.2.3 The differences in their physical properties mean that Butane and Propane behave differently under everyday conditions and more especially under extreme conditions. Such differences can be turned to advantages in certain applications. However, the differences in boiling point, liquid density and vapour pressure between Butane and Propane are particularly important for safety and appliance performance.
- 3.2.4 Differences in the quantity of air required for complete combustion of Butane and Propane should be considered by appliance suppliers and installers. Failure to do so can affect both consumer safety and satisfaction.
- 3.2.5 Poor quality control in LPG refining and production processes can have an indirect bearing on safety as it may lead to hazards further along the distribution chain or at the point of use. Well-intentioned but inexperienced attempts to solve LPG quality problems at the point of use can be risky and are best prevented by appropriate controls during production. Authorities should ensure that relevant product standards are established and observed.



- 3.2.6 Because Butane and Propane have different physical properties it is important that the composition of LPG mixtures being distributed in a market are known to participants and kept within specified limits which are related to product specifications. There are LPG standards which have international recognition and one of these could be adopted, in the absence of a suitable national standard. See Appendix Three - References.
- 3.2.7 LPG is odourless in its natural state so a distinctive odour is usually added to warn of its presence. However, not all LPG is odourised in this way and additional hazards exist in the storage and distribution of unodourised LPG. In many instances, local Regulations will require gas detection or atmospheric sampling systems to be used to detect any leak of the odourless gas.
- 3.2.8 A few applications for LPG may require unodourised product e.g. propellants. Care should be taken when handling LPG with no odour.
- 3.2.9 When selecting the type of odourant to use it is important to recognise their properties as some are toxic and require careful handling. Attention should also be given to their short shelf life as the odour may fade over time.

### **3.3 Inherent Hazards/Potential Risks**

- 3.3.1 The principal potential hazard with LPG is fire and explosion. This derives from its inherent quality of high flammability and in extreme cases may combine with another quality, i.e. pressure, and lead to the BLEVE (Boiling Liquid Expanding Vapour Explosion) phenomenon. With increasing use of thermal barrier coatings or thermally activated surface finishes on LPG pressure vessels reducing the possibility of a BLEVE, the possibility of a large LPG leak must be considered. In this situation, a substantial LPG leak forms a flammable cloud. Ignition of the cloud is called an Unconfined Vapour Cloud Explosion (UVCE), and several studies have been completed on this phenomenon. There are also hazards incidental to the various modes of transport for distribution and use.
- 3.3.2 An additional potential hazard may arise at the point of use if ventilation is inadequate and the products of combustion are not dispersed into the atmosphere. Carbon Monoxide may be produced and reach dangerous levels unnoticed, as it is an odourless gas. LPG 'sniffing' i.e. the intentional inhalation of LPG vapour seeking a narcotic effect can result in injury or, in some cases, death, due to asphyxiation, where the LPG has displaced the Nitrogen / Oxygen (air).
- 3.3.3 The risk associated with such hazards (except for sniffing) can be controlled using available, proven technology, i.e. the safety equipment and procedures normally used by the LPG industry.
- 3.3.4 Liquid LPG will cause cold burns if it contacts the skin. Propane, with its low boiling point is more hazardous in this respect than Butane which, in cold conditions, is slower to vapourise and disperse. The eyes and body must be protected when handling all liquefied products.
- 3.3.5 LPG vapour, being heavier than air, may, in the event of a leak, accumulate in confined spaces and low-lying areas. The means of ventilation and meteorological conditions will influence the movement and dispersion of the LPG vapour.
- 3.3.6 Any uncontrolled release of LPG is inherently hazardous. A liquid LPG leak is more hazardous as it will expand to vapour by a factor in excess of 250. Being heavier than air, vapour will tend to lie, or drift, close to the ground with a risk that it will come into contact with a source of ignition

while it remains within its flammable limits. (See Table in 3.2.1 showing typical properties of LPG).

- 3.3.7 Liquid LPG has a high co-efficient of volumetric expansion which is why cylinders and tanks should never be completely filled. They should be filled with an ullage space included to allow for liquid expansion caused by an increase in temperature. The degree of ullage space necessary will depend on the operating conditions, especially the maximum expected operating temperature. This potential risk is further controlled by a combination of safety devices and procedures and especially by control during product transfer operations. This explains why cylinders and tanks should only be filled under the supervision of competent persons and why illegal filling is dangerous.
- 3.3.8 Because of its much higher vapour pressure, tanks and cylinders containing Propane need to be stronger than those for Butane, although both should be protected against excessive pressure. This potential risk is controlled by safety devices and by segregating the products or, where LPG mixture is handled, ensuring that the Propane content does not exceed a specified upper limit. In cold weather, a cylinder or tank storing Butane – which has a boiling point around Zero degrees Centigrade – may be subjected to negative pressure and it must be capable of withstanding this.
- 3.3.9 During the process of distribution, LPG will normally be transported in one or more modes. There will be hazards associated with the transport mode and with the consequences of traffic accidents and incidents. The risks will vary from country to country and with the mode of transport. The control of transport-related risks is discussed in Chapters Six and Nine.
- 3.3.10 The majority of consumers will use LPG as a fuel in an appliance. The installation which comprises the LPG supply and connection to the appliance may be simple or complex, small or large. Hazard scenarios and risk at the point of use are discussed in Chapter Ten.
- 3.3.11 The products of complete LPG combustion - mainly Water and Carbon Dioxide - are not inherently hazardous. Good installation practice specifies adequate ventilation to supply the air required for complete combustion and to vent the products of combustion. This minimizes the risk by preventing a build-up of carbon monoxide – which is poisonous – or a development of asphyxiating (i.e. oxygen-deficient) conditions.
- 3.3.12 LPG is a clear, odourless liquid and is not readily visible in its gaseous phase. In the event of a leak, it may be present, unseen, in hazardous concentrations. To minimize this risk, an odorant with a distinctive, persistent and unpleasant smell is added to LPG prior to distribution. In special applications requiring odour-free LPG, such as aerosol propellants, or the chemical industry, alternative safety measures are adopted. These might include gas detectors, for example.

- 3.3.13 An accumulation of LPG vapour may result in the development of an oxygen-deficient atmosphere which carries a risk of asphyxiation. The visible cloud might be smaller or bigger than the actual gas cloud, depending on humidity in the air. The photo opposite illustrates a controlled release of LPG liquid. An explosimeter should be used to approach a gas cloud. No one should enter a gas cloud as ignition can make it a fatal area. No one should enter a tank which has been used for LPG storage without supervision and only when all appropriate safety measures are in place.



- 3.3.14 In most activities, zero risk is an aspiration rather than an absolute certainty. Guidelines such as these allow for the management of LPG operations, and for its use, well within the parameters for individual and societal risks acceptable in a modern, industrialised society.

## 3.4 Basic Safety Principles

- 3.4.1 While flammability is the major safety concern with LPG, it is not the only one. Good safety practice addresses the various hazards from production to consumption.
- 3.4.2 The term LPG embraces several products which, while related, have important physical differences which affect safety. If more than one type or grade of LPG is being handled each should be clearly identified and segregated. All should be within specification, especially with respect to maximum permitted vapour pressure.
- 3.4.3 Large LPG installations should not be constructed close to large or sensitive populations. Populations should be restricted close to locations approved for large LPG installations. In planning or evaluating proposals for the location of LPG facilities due account should be taken of the hazards created and of the risks associated with those hazards within and beyond the facility. In established towns and cities, encroaching populations will often dictate increased controls and vigilance in large LPG installations.
- 3.4.4 Space and separation distances are fundamental to safety at LPG facilities – large and small – and should be assessed for each type and size of location and observed.
- 3.4.5 Participants in the LPG industry should actively promote a safety culture within their own businesses and at industry level.
- 3.4.6 Personnel engaged in LPG operations should receive formal training by competent persons for their normal activities and for emergencies. LPG facilities should have emergency planning and response programmes appropriate to the hazards and risks which they represent. These include correct handling procedures to avoid injury.
- 3.4.7 Fuel grade LPG should be adequately odourised prior to entering the distribution chain. When LPG is required to be odour-free, adequate alternative safety measures should be employed. (See Appendix Three - References).
- 3.4.8 LPG cylinders and tanks should never be allowed to become liquid-full. Climatic conditions will influence the degree of ullage space required but it is typical practice to fill to around 80% of the water capacity of the vessel. In some circumstances, over-fill devices may be required to provide protection. In other cases, cylinders and tanks should only be filled under the supervision of competent personnel.
- 3.4.9 Above a certain quantity, LPG should be clearly identified during transportation, using classification numbers and appropriate warning signs. (See Appendix One).
- 3.4.10 Appliances and equipment for the storage, handling, distribution and use of LPG should be fit-for-purpose, correctly installed and well-maintained. Sub-standard appliances, equipment and installations should be excluded, if necessary, by regulation.

- 3.4.11 Installers of appliances and equipment, and those responsible for service, should be formally trained and should have reached a specified level of proficiency.
- 3.4.12 Cylinders for indoor use should preferably be filled with Butane or Butane-rich LPG mixtures although some countries do permit the use of Propane cylinders indoors. Only those cylinders which are in use should be kept indoors. In markets where Butane and Propane are sold as separate products, cylinders should be readily distinguished and preferably fitted with different outlet valves so that they are not easily interchanged or used for Natural Gas appliances.
- 3.4.13 Consumer safety awareness campaigns are an essential part of LPG safety principles and they should emphasise:
- The quality/safety linkage for gas, appliances and equipment
  - The risks associated with inferior installation standards and/or practices
  - The need for care and, in particular, adequate ventilation
  - How to recognise the smell of odourised LPG
  - The action to take when gas is detected

### 3.5 Product Classification and Labelling

- 3.5.1 In practice the products known collectively as LPG include n-Butane, iso-Butane, Propane and Propene/Propylene. They may be supplied separately or in varying mixtures and degrees of purity. All come within the designation 'Hazardous Substances' and are classified 'Highly Flammable'.
- 3.5.2 Transport regulations such as the Agreement for the International Transportation of Dangerous Substances by Road (ADR) and its railway counterpart (RID) include a UN hazard warning and identification system which is useful in emergencies and which should be used. Examples of the system are in Appendix One.
- 3.5.3 LPG cylinders, storage tanks and pipelines should be clearly identified by appropriate markings and warning signs, examples of which are to be also found in Appendix One. These are recommended for use in the absence of a national system of signs and markings.
- 3.5.4 Where Butane and Propane are sold as separate products, cylinders and tanks should be clearly marked according to product. Containers of LPG which have not been odourised should be marked or labelled accordingly.
- 3.5.5 In the absence of national regulations the minimum safety information on a cylinder should state the product, the supplier's name or brand, the net fill amount, a flame symbol and the word 'Flammable', or its local language equivalent. Information should be of sufficient size to be readily legible and in a colour contrasting with the rest of the cylinder.



## CHAPTER FOUR

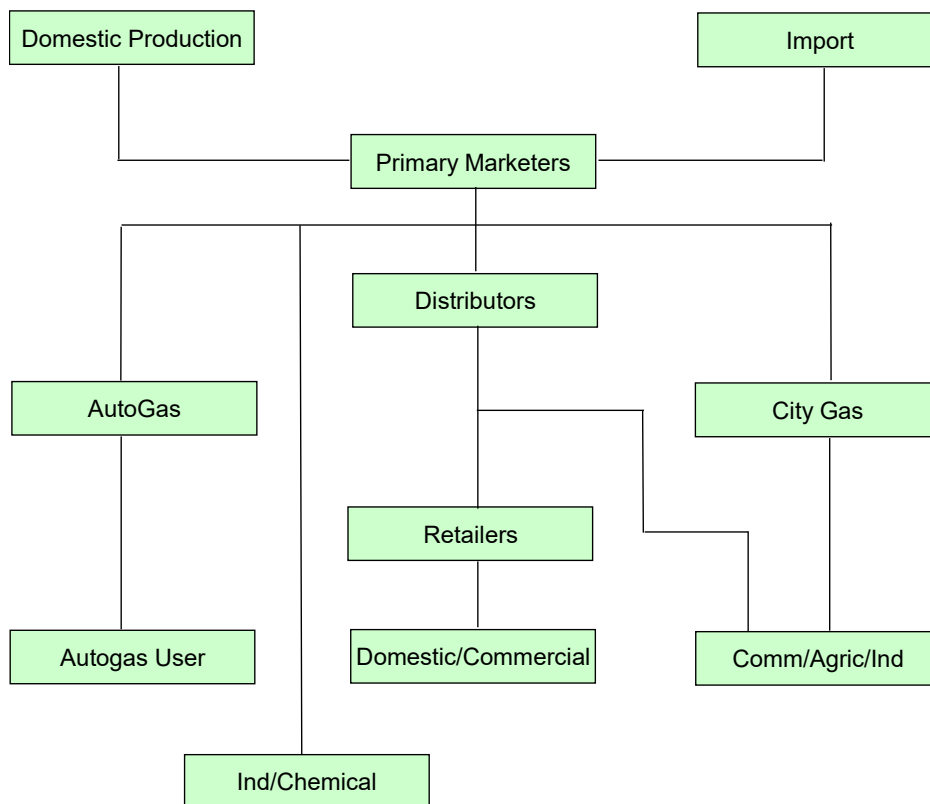
# LPG Distribution Chain

The distribution chain begins with a small number of large installations and ends with large numbers of consumers, some large but mostly small.

Some consumers receive LPG in cylinders others receive it in bulk.

Safety should take account of the distribution system, the different types of consumer and the particular hazards at each stage of the chain.

The exercise of safety becomes more challenging as LPG moves through the distribution chain. A simplified distribution chain is shown below (and pictorially in Appendix Four):



## 4.1 General

- 4.1.1 The LPG distribution chain describes the process by which LPG is moved from production or importation to the point of use.
- 4.1.2 LPG purchased ex-ship or ex-pipeline is considered to have entered the distribution chain at the point and time of custody transfer when ownership and responsibility normally passes to the primary marketer. At this early stage of the distribution process, Butane and Propane are often handled separately and the scale of operations tends to be at its largest.
- 4.1.3 LPG is normally stored, handled and distributed under pressure and at ambient temperature during distribution. Marketers may seek competitive advantage through distribution efficiency which will include optimising the scale and location of their distribution infrastructure. In practice this will include locating certain of their facilities close to consumption centres and may bring the marketers into confrontation with local interests.
- 4.1.4 LPG distribution may be in bulk or in cylinders depending on many considerations such as application, scale of usage and consumer preference. Automotive LPG should always be distributed in bulk. The marketers' distribution infrastructure will include bulk depots and cylinder filling plants unless solely engaged in Automotive LPG (Autogas).
- 4.1.5 Autogas should only be dispensed into the storage tank of the vehicle which is being refueled. Autogas dispensers should never be used to fill cylinders.

## 4.2 Classification and Activities

- 4.2.1 In its basic form the LPG distribution chain starts with a primary marketer purchasing a single grade of LPG, probably the producer's specification, and selling it to consumers within a limited geographical area. The chain becomes more complex as multiple supply sources and possible choices of grades develop, for example as more marketers begin to sell into an expanding geographical area and serve a broader range of LPG applications.
- 4.2.2 Importation of LPG may be required to augment indigenous supply on a seasonal and/or year-round basis.
- 4.2.3 Imports may be made overland but are more commonly made by sea. Sea-fed facilities may be established by specialist terminal or trading companies, LPG marketers, or by joint ventures. It is unlikely that a marketer whose experience is limited to purchasing LPG ex-refinery or from a gas plant will have the technical and safety skills to handle imports without expert assistance.
- 4.2.4 Multiple sources will normally enable the marketer to extend their supply options and possibly to shorten the primary transportation lines. The marketer will probably be drawn towards multi-depot operations and should then be prepared to deploy additional supervision in order to maintain safety standards.
- 4.2.5 Some marketers distribute directly to their consumers, large and small. Companies with retail businesses sometimes use their petrol stations as LPG outlets. Others distribute through appointed agents, distributors or dealers. All must work to implement LPG safety disciplines in distribution networks which may include some unresponsive or disinterested elements.

- 4.2.6 A developed LPG distribution chain will have some (possibly all) of the components shown in the diagram at the beginning of this Chapter. In addition, it will include traders and transportation companies, shippers, pipeline operators, rail and road transport contractors.

### **4.3 Implementation of Basic Safety Disciplines**

- 4.3.1 The effective implementation of safety disciplines should follow from the regulatory/enforcement system working constructively with industry, both directly and through its representative organisations. In these guidelines, industry includes appliance and equipment vendors and installers, as well as LPG marketers.
- 4.3.2 Elsewhere in the guidelines, it is noted that:
- LPG can be hazardous from production to the point of use
  - Safety comes from understanding LPG and maintaining control
  - Understanding and control should be present, and exercised, at every point of the distribution chain.
- 4.3.3 The logical starting points for the process of implementing safety discipline are knowledge and awareness. It is assumed that good technical expertise is to be found in the LPG marketing companies and equipment manufacturers. The main burden of implementing knowledge-based safety and safety awareness should be borne by them and they should have recognition when it is done properly.
- 4.3.4 The majority of LPG-related incidents occur at, or close to, the point of use. Safety discipline must include the consumer who, having been made aware of certain hazards, should respond by exercising every reasonable care.

## **CHAPTER FIVE**

# **Trans-shipment Terminal**

LPG trans-shipment terminals are always major hazard installations whether by reason of their capacity, the scale of transfer operations, and/or proximity to other hazardous installations.

The planning and operation of a trans-shipment terminal should be the subject of hazard and operating studies and environmental impact studies, using Quantified Risk Assessment (QRA) techniques.

In many terminals Butane and Propane will be handled separately rather than as LPG mixtures. The products may be received and stored at sub-zero temperatures. Safety systems should take account of these factors.

Terminal safety is directly linked to the safety of shipping operations.

## **5.1 General**

- 5.1.1 Markets in which LPG demand exceeds indigenous supply invariably build trans-shipment terminals. LPG will be imported through these terminals using special ships, with LPG storage tanks, which may transport different LPG products. LPG may be transported in these ships under pressure, at ambient temperature, or semi/fully 'refrigerated', i.e. at low temperature and reduced pressure. The choice between these modes will be determined by economic considerations which will themselves be strongly influenced by the scale of operation. The compliance of imported LPG with local product specifications must be established and this is usually done in the trans-shipment terminal.
- 5.1.2 A national market may be served by one or more terminals capable of receiving very large ships with part of the cargo for local use and part being trans-shipped to smaller import terminals, by coastal tanker or barge.
- 5.1.3 When transported in large ships LPG is normally refrigerated with Butane and Propane stored in different cargo tanks. The inland market will require, and the coastal shipping will transport, LPG under pressure, i.e. at or close to ambient temperature. The market may require Butane, Propane or an LPG mixture. This will prompt consideration of whether the large receiving terminal storage should be refrigerated and if not, how the incoming LPG should be brought to ambient temperature. These questions all have major safety implications both for the initial design and for subsequent operations.
- 5.1.4 An LPG trans-shipment terminal may be developed as an independent standalone installation with its own ship-handling facilities. More often an LPG terminal becomes an additional activity sharing nearby facilities with others.
- 5.1.5 The planning of an LPG trans-shipment terminal should include major hazard and environmental impact studies for both the onshore and offshore aspects using internationally-accepted



standards and criteria. The hazard study should take account of not only any compounding of risk associated with neighbouring industrial activities but also of the potential benefits from existing safety/security arrangements, including mutual assistance as part of emergency response programmes. Consideration of future adjacent development is also important.

## 5.2 Refrigerated/Pressure Shipping and Storage

- 5.2.1 The choice between shipping and storing LPG at ambient or reduced temperature and pressure is largely a matter of logistics and economics. There are costs associated with achieving and maintaining low temperatures but under certain conditions the unit costs of a refrigerated LPG containment system will be less than containment at ambient temperature and pressure. Control is essential for safety, whatever the choice of storage. The cost of installing safety systems at these types of terminals will be significant.
- 5.2.2 The design and engineering of an LPG trans-shipment terminal should be in accordance with a reputable standard having international recognition. Volume 1 of The Model Code of Safe Practice No. 9, Liquefied Petroleum Gas by the Institute of Petroleum deals with large bulk storage, both refrigerated and ambient temperature/pressure. Others include Liquefied Gas Handling Principles on Ships and in Terminals by The Society of International Gas Tanker and Terminal Operators (SIGTTO).
- 5.2.3 Each terminal will have its own special features and requirements. However, the terminal operations should adopt the safety principles and procedures developed and refined over the years. These can be found in such publications as:
- *Safe Transport, Handling and Storage of Dangerous Substances in Port Areas*, by The International Maritime Organisation (IMO);
  - *Guidance Notes GS 40: The Loading and Unloading of Bulk Flammable Liquids and Gases at Harbours and Inland Waterways*, by U.K. Health and Safety Executive (UKHSE);
  - *Liquefied Gas Handling Principles on Ships and in Terminals*, by The Society of International Gas Tanker and Terminal Operators (SIGTTO).
  - *International Safety Guide for Oil Tankers and Terminals (ISGOTT), Fourth Edition*, by the International Chamber of Shipping, Oil Companies International Marine Forum, International Association of Ports and Harbors. ISBN 1 85609 081 7
  - *Liquefied Gas Handling Principles on Ships and in Terminals (SIGTTO), Third Edition*, by McGuire and White. ISBN 1 85609 164 3

## 5.3 Single/Multi-Product Terminal Operation

- 5.3.1 A single product terminal has the advantage of comparative simplicity, even if several grades of LPG are being handled simultaneously.

- 5.3.2 For the purposes of these guidelines a multi-product terminal is one in which LPG and another product, or products, are being handled. The multi-product aspect may be confined to a shared ship-handling facility or may also apply to the on-shore storage area.
- 5.3.3 The design, layout and operation of a multi-product terminal should be the subject of the most careful study and evaluation in respect of the compatibility of products and of operations.

## **CHAPTER SIX**

# **Inland Transportation**

LPG is moved in bulk in the initial stages of inland transportation by waterway, pipeline, rail or road.

Some consumers receive their LPG in bulk. Others receive their LPG in cylinders. Final delivery is usually by road.

Traffic risks vary from country to country and with the transportation mode. The LPG industry needs to be extra vigilant when the risk of a traffic accident is high. Transport vehicles should be of a suitably high standard and operated by qualified drivers.

## **6.1 General**

- 6.1.1 Almost invariably LPG is moved in bulk in the initial stages of inland transportation. For many applications, and especially for automotive and industrial use, LPG is transported in bulk throughout the distribution process. For others, LPG may start its journey in bulk but be finally delivered or collected in a cylinder.
- 6.1.2 LPG may be transported by inland waterway, by pipeline, rail or road depending on the strengths and weaknesses of the national or local transport infrastructure or depending on national regulations. There are hazards associated with all these modes of transportation, but the risks will vary with local conditions. There will be times when the most economical method must be forgone in the interests of safety.
- 6.1.3 Tolerability of risk from traffic hazards varies from country to country. The LPG industry depends on transport to deliver its products and therefore should employ good safety practice in its inland transport operations. The industry should be extra vigilant where the external risk is known to be high.

## **6.2 Primary Distribution in Bulk**

- 6.2.1 Primary distribution refers to transportation in the first stage of the distribution chain, i.e. from source of supply to major customers, bulk plants and cylinder filling plants. At this stage of distribution, the LPG is the property and responsibility of the primary marketer who may have entrusted the task of transportation to a specialist contractor.
- 6.2.2 While some primary distribution of LPG is by pipeline or barge the principal transportation modes are rail and road. Whether conveyed in marketer owned or contractors' vehicles, LPG transportation should be in accordance with national regulations and in accordance with good international practice. Comprehensive guidance can be found in codes such as:

- The Agreement concerning the international carriage of dangerous goods by road (ADR)
  - Regulations concerning the international carriage of dangerous goods by rail (RID).
- 6.2.3 In the absence of transportation contractors capable of providing the required standard of safety the marketer should take direct charge and responsibility for primary distribution.

### **6.3 Secondary Distribution in Bulk and Cylinders**

- 6.3.1 Secondary distribution refers to the movement of LPG through the distribution chain from a bulk plant or cylinder filling plant. Ownership of the LPG may remain with the marketer or may be passed to others. A change of ownership will affect the exercise of safe practice as each new owner takes responsibility for safety at each stage of the distribution process.
- 6.3.2 Secondary distribution in bulk is further discussed in Chapter Nine.
- 6.3.3 Secondary distribution in cylinders usually means transportation by road and exposure to the road traffic hazards. Drivers should be carefully selected and trained both in avoiding and in dealing with the consequences of accidents.
- 6.3.4 Trucks regularly employed in the transport of LPG should be designed, or adapted, to minimise the risks associated with the product and the mode of transportation. They should be inspected before they enter service and be routinely inspected and properly maintained.
- 6.3.5 LPG distribution trucks should display product identification plates and be equipped with suitable fire extinguishers.
- 6.3.6 Filled LPG cylinders, which are intended to be utilised in the upright position, should preferably be transported upright with the valves protected against any impact. Full and empty cylinders should, as far as is practical, be segregated on the truck. Pallets or cylinders must be restrained using straps or ropes (natural hemp not nylon) that are secured to properly designed anchorage points.
- 6.3.7 Publications giving more detailed safety guidance for secondary distribution of LPG in cylinders are referred to in the Appendix Three.

## CHAPTER SEVEN

# Bulk Storage and Handling

The location of storage should be considered in conjunction with the nature and scale of the LPG operations and of external risks.

Safety systems and procedures should prevent uncontrolled releases of LPG and the over-filling of storage tanks.

Passive safety features and fail-safe safety systems should be incorporated into bulk storage and handling facilities.

## 7.1 General

7.1.1 LPG may be stored on a large scale at an import or trans-shipment terminal, on an intermediate scale at depots, cylinder filling plants and large industrial consumers, or on a small scale at a household installation. The largest LPG terminals may have storage in excess of 100,000 metric tonnes (MT).

7.1.2 In this section of the guidelines the principal focus is on large and intermediate storage forming part of the distribution infrastructure. Small-scale bulk storage is discussed further in Chapter Nine of these guidelines.

7.1.3 From a safety standpoint, LPG storage should be considered in conjunction with the nature and scale of the associated on-site LPG handling operations. There are well established standards and codes which when effectively employed will substantially reduce both hazard and risk. These include:

- NFPA 58 - *Liquefied Petroleum Gas Code*, by the National Fire Protection Association (USA)
- LPGA COP 1 (UK) - *The Storage of LPG at Fixed Installations*, by the Health and Safety Executive (UK)
- Regulations for LPG service stations and road tank trucks in the Netherlands (for the special needs of the automotive sector).
- EN 12542 and EN 14075 *European Standards*

7.1.4 A fire or explosion involving LPG in bulk storage is potentially a major incident and likely to have an impact beyond the operator's boundary. The development and operation of these facilities should be subject to consultation at official and community level. If national regulations stipulate licensing the criteria should be risk-based.

## 7.2 Single/Multi-Grade Operation

- 7.2.1 Some markets operate with a single grade of LPG and therefore have a simple system for product storage and handling. More often commercial grade Butane, Propane and LPG mixtures are stored and handled separately. Some marketers may offer high purity, chemical grade or de-odourised LPG requiring dedicated storage and handling systems.
- 7.2.2 For safety reasons, the important considerations are that:
- Stored LPG does not develop a vapour pressure in excess of the permitted maximum for any part of its containment system
  - Nobody depends on the characteristic, unpleasant smell of stench product to warn of the presence of odour-free LPG
- 7.2.3 Multi-grade facilities should be equipped with the physical means of segregating the various grades of LPG and should have procedures to check and validate the effectiveness of the segregation.
- 7.2.4 Each LPG storage tank should be suitable for the grade of product to be stored in it at the expected temperature range and resulting highest vapour pressure.

## 7.3 Technical Options - Types of Storage

7.3.1 LPG is stored in bulk in:

- Salt domes, tunnels or caverns
- Cylindrical or spherical steel tanks which may be above ground, underground or mounded



The scale, location and method of operation of the storage facility will influence the choice from among these options. Environmental and safety issues must always be given due consideration. The photo above shows above ground horizontal tanks at an installation in South America.

- 7.3.2 Salt domes, tunnels and caverns are typically created deep underground and are most economical for large-scale pressure storage. However, they can only be realised if the on-site geological and geophysical conditions are favourable. Steel tanks are preferred for large-scale refrigerated storage.
- 7.3.3 With the growing appreciation of the attractions of passive safety, and more confidence in modern corrosion protection technology, more intermediate and small-scale LPG storage is using mounded or underground installations. In some countries these may be the only permitted technical options for intermediate-scale storage.
- 7.3.4 The reduced risk with mounded and underground LPG storage is reflected in a relaxation of safety/separation distances in certain standards. The distances given in reputable publications like NFPA 58 and LPGA COP 1 (UK) are empirical, not scientific. A scientific approach, based on

experimental tests and practical experience and using quantified risk assessment techniques, is well established within the LPG industry.

## **7.4 Technical Options - Product Transfer**

- 7.4.1 LPG transfer is potentially hazardous - an activity where things can, and sometimes do, go wrong because of equipment or procedural failure.
- 7.4.2 Pipelines for the transfer of refrigerated LPG are insulated to protect the product against unwanted heat gain. Product temperatures should not be allowed to go below the design and material specifications. When refrigerated LPG is to be transferred to non-refrigerated storage, an in-line product heater may be employed. At coastal locations in warm or temperate climates, seawater may be used as the heating medium.
- 7.4.3 The most common bulk transfers are between depot tanks and rail tank cars/road tankers or, in the case of automotive LPG, between filling stations and vehicle tanks. Road tankers and rail tank cars may be loaded by weight or by volume, singly or in groups. All transfers of this type must be monitored to ensure that maximum fill limits are not exceeded. It should be constantly borne in mind that cold LPG will expand as its temperature rises.
- 7.4.4 Articulated loading arms are preferred for in-depot transfers, but flexible hoses are currently the only practical option for bulk delivery to consumers and for automotive refueling.

## **7.5 Safety Systems for Operation**

- 7.5.1 The first rule of safety when dealing with LPG is to avoid any uncontrolled leakage of the product. All systems should be designed with this prime objective of containment in mind.
- 7.5.2 The traditional approach to safety is based on the generous use of space and of water deluge systems for emergency response. Increasingly, this approach is giving way to the concept of passive safety (including the use of passive fire protection [PFP] in the form of coatings) and the use of fail-safe valving and control systems. The passive safety concept is evident in mounded and underground tanks. Passive fire protection can be used where ground conditions are not suitable for burying or mounding vessels. A modern valve control system will be capable of automatic and/or remote operation. It will ensure that main valves are closed unless they are required to be open, and only while that requirement lasts, and that they close in case of emergency or alarm.
- 7.5.3 High and low-level alarms fitted to plant storage tanks can be a useful defense against overfilling, but they should not be an alternative to proper supervision.
- 7.5.4 With their emphasis on safety management systems, risk assessment, training and periodic inspections, regulations derived from the European Directive 96/82/EEC (Seveso II Directive) can be a valuable part of a plant safety programme.
- 7.5.5 Many plant incidents take place outside normal working hours, often during maintenance operations. After hours security and supervision of maintenance work are crucial for safety. All critical works, or works done in critical areas, should be subject to a risk assessment and a permit to work.

- 7.5.6 Static electricity discharge is a cause for concern and so all steel structures and pipework should be earthed. Road tankers should be bonded to earth before LPG transfers commence.
- 7.5.7 Road tankers admitted to the plant should be equipped to the standard specified in national regulations or in a reputable code, such as ADR. Vehicles should be immobilised during transfer operations and equipped to prevent untimely movement. Loading/unloading bays should be protected against impact. Both company-owned and contractors' vehicles should comply. Drivers should be well trained in road tanker operation, product transfer and emergency procedures.
- 7.5.8 Fire-resistant coatings may provide a useful means of improving safety in vessels. They have the advantage that they can be applied to existing tanks to augment an existing safety system. However, the selection and application of these types of coatings should be entrusted to specialists. One of the disadvantages of applying these coatings on road vehicles is the extra vehicle weight, with increased brake and tyre wear, and the consequential reduction in tare weight leading to more frequent deliveries and increased on-road risk. Tank inspection is also more complicated.
- 7.5.9 Sections of pipework and storage systems carrying liquid LPG, that can be isolated with valves or blinds, should be equipped with safety valves to protect against possible damage as liquid LPG expands with increases in temperature.



## **CHAPTER EIGHT**

# **Cylinder Filling and Handling**

Cylinders should be filled with the intended product – Butane, Propane or specific LPG mixtures – and should never be over-filled.

Cylinders should be checked before and after filling to ensure that they are fit for purpose, fit to fill, have been correctly filled, are gas tight and will be trouble-free in service.

A mishandled cylinder can cause injury and damage or result in an uncontrolled release of LPG.

Handling of LPG cylinders should as far as practical be mechanised to prevent injury.

## **8.1 General**

- 8.1.1 Cylinder filling plants vary in scale and sophistication from simple single-station operations filling small numbers of cylinders on demand, to high-technology plants serving hundreds of thousands of consumers.
- 8.1.2 LPG is sold by weight in cylinders and too often accuracy of filling means ‘not being underweight’ to both consumer and filler. It is not always appreciated that an overfilled cylinder, i.e. one which may become liquid-full, can be highly dangerous with small increases in temperature as liquid LPG expands ten times greater than water.
- 8.1.3 Ownership of cylinders can have an important bearing on safety. They should be manufactured and maintained in accordance with recognised technical standards. Non-compliant cylinders should not be re-filled although this can lead to difficulties when the consumer owns the cylinder and he may suspect a motive in a refusal to fill it. The consumer will have little appreciation of the safety checks which the professional re-filler carries out as a routine part of their work. If the marketing company owns the cylinder the responsibility for maintenance is clear and well controlled.
- 8.1.4 Cylinder maintenance and repair are potentially hazardous activities and when undertaken in a filling plant can become disruptive of cylinder filling operations. Maintenance and repair should be carefully planned in order to avoid such disruption.
- 8.1.5 Filling plants handling more than one grade of LPG should be designed and equipped accordingly. They should have the physical and procedural controls to ensure that one is not mistaken for another.

## 8.2 Cylinder Filling and Checking

- 8.2.1 Cylinder filling operations should be carried out in accordance with a reputable technical standard or code such as ISO 10691.
- 8.2.2 The initial check is to ensure that the cylinder is fit for refilling, i.e. that when filled it will not create a problem for either the refiller or the consumer. This initial check is also for compliance with any national or industry revalidation rules.
- 8.2.3 The cylinder valve is normally dual purpose in that it is used both for re-filling and to supply gas to the consumer. The condition and performance of the valve is crucial for safety.
- 8.2.4 National regulations may determine the permitted filling tolerances. While complying with these regulations the re-filler must ensure that the cylinder is filled with the correct grade of LPG and that the maximum permitted filled volume for the cylinder is not exceeded, i.e. that there is no risk of the cylinder becoming liquid-full.
- 8.2.5 Post-filling checks are specified in the Code of Practice referred to in 8.2.1 above. The objective is to provide the consumer with a cylinder which has been correctly filled, will be safe and trouble-free in use, and meets all national or industry labelling requirements. The photo opposite shows LPG cylinders on an automatic filling carousel.
- 8.2.6 Post-fill procedures should include leak-testing, check weighing and, in the absence of fixed protection (e.g. a shroud), the fitting of a suitable form of cylinder valve protection if this is not already provided for in the valve design. Increasingly LPG marketers are fixing a tamper-proof seal to the cylinder valve after re-filling to reassure consumers of the integrity of the filled cylinder.
- 8.2.7 Both full and empty LPG cylinders can cause serious injury during manual handling and, where possible, handling should be mechanised. Manual handling of cylinders should be done with proper personal protective equipment (PPE).



## 8.3 Care and Maintenance of Cylinders

- 8.3.1 An LPG cylinder is a pressure vessel which may, during the process of distribution and end use, be subjected to rough treatment. Nevertheless, its integrity is essential for safety and therefore it must be properly maintained. Protection of the business asset also makes good sense.
- 8.3.2 Where the LPG marketer retains ownership of cylinders - and the empty cylinders are returned for re-filling - the marketer is also responsible for care and maintenance.
- 8.3.3 When the consumer owns the cylinder he also assumes - probably unwittingly - responsibility for maintenance. In this case compliance with cylinder re-qualification requirements can be challenging. The cost of re-qualification (to be borne by the owner-consumer) and problems of access to re-qualification facilities are likely to be contributing factors. The owner-consumer system also carries the risk of a 'do-it yourself' approach to cylinder valve repair/replacement. It

is imperative that legislation and regulations are consistent with the standards and codes of practice relating to cylinder re-qualification.

- 8.3.4 In the absence of national regulations, there are reputable standards, such as ISO 10464 which specify intervals for inspection and re-qualification. Cylinder filling standards such as ISO 10691 codes (e.g. COP 12) include acceptance/rejection criteria for damaged cylinders. The LPG marketer filling the cylinder must be responsible for checking for compliance with these criteria. Under certain conditions the ADR allows for the period of inspection and recertification for steel cylinders to be 15 years and some countries meet these criteria.

## **8.4 Technical Options for Cylinder Filling**

- 8.4.1 Although the leading equipment manufacturers also offer volumetric filling machines, most LPG cylinders are filled by weight, i.e. by reference to individual tare weights and a specified fill, or weight, of LPG. At high volume, the challenge for the equipment manufacturer is to provide speed and accuracy for both filling and checking together with flexibility to deal with different types of cylinder and different grades of LPG. At low volume, accuracy of filling and checking are equally important for safety. Generally, a check weigh scale is needed for 'weights and measures' compliance with 100% check weighing becoming the norm.

- 8.4.2 Essentially, the technical options for cylinder filling are:

- A small number of high-volume plants
- A larger number of low volume plants
- High automation/few employees and vice-versa.

- 8.4.3 Filling large numbers of cylinders manually is heavy, monotonous work and the risk of injury inherent in a labour intensive plant should be evaluated against that of a well-managed, automated plant. In markets where the local regulations permit the manual handling of cylinders, the personnel handling cylinders manually should be trained for minimising the risk of injuries to themselves and others. Management of safety should always be appropriate to the number, size and type of plants.

- 8.4.4 Advances in electronics, in metering and in data management systems have advanced the technology of cylinder filling and have helped to make LPG operations safer. However, any programme to automate should ensure that safety systems are updated as filling procedures change.

## **8.5 Storage and Handling**

- 8.5.1 LPG cylinders can cause serious injury during manual handling and, wherever possible, handling should be mechanised. Manual handling of cylinders should be done with proper PPE.

- 8.5.2 Conveyors and other parts of a mechanical handling system should be effectively earthed to discharge static electricity. As with all rotating machinery they can also lead to incidents and should be designed to avoid employees being trapped and to have the function to stop if an employee is trapped.

- 8.5.3 Fork lift trucks are invaluable cylinder handling aids. They should be equipped with spark-suppressing features (flameproof) and any hazardous zone restrictions within the filling plant or depot should be observed.
- 8.5.4 Training should be provided for those involved in cylinder handling in order to minimise the risk of injury to employees, and damage to cylinders.
- 8.5.5 The storage of cylinders should be systematic with full and empty cylinders segregated, marked and confined to designated areas. Specific guidance can be found in COP 7 – *Storage of Full and Empty LPG Cylinders and Cartridges*, by the LPG Association (U.K.).
- 8.5.6 Cylinders requiring maintenance, repair or fill correction should be dealt with urgently by trained and properly supervised employees. These cylinders are potentially hazardous and a backlog should never be allowed to accumulate within the cylinder filling area. Should cylinders be unserviceable, then recycling of the different metal components is to be encouraged.

## **8.6 Safety Systems for Operation**

- 8.6.1 A cylinder filling plant has many potential hazards which, in a large plant, may be some distance apart. Plants should incorporate an emergency shutdown system to stop the flow of LPG, pumps and filling equipment in an emergency. An alarm system capable of being operated from key locations and of actuating emergency response measures is considered an essential part of the plant safety system.
- 8.6.2 Clear signage (including road markings), and effective gatehouse control over vehicle and individual access to the hazardous areas, are also considered essential. The reversing of vehicles should be avoided, and traffic flow should be designed appropriately to avoid the need to reverse vehicles.
- 8.6.3 Many plant incidents occur outside normal working hours, often during maintenance operations. After-hours security and supervision of maintenance work are crucial for safety. All critical work, or work done in critical areas, should be subject to a risk assessment and a permit to work.
- 8.6.4 More detailed guidance of safety systems for operation can be found in COP 12.

## **CHAPTER NINE**

# **Distribution in Bulk**

Bulk LPG distribution requires equipment and skills which differ from those required for cylinder distribution.

The consumer's installation and the bulk delivery vehicle should be correctly designed, equipped and maintained.

The driver/operator must be properly trained and equipped to handle both normal operations and emergencies. This will include loading and unloading of the vehicle and on-road driving.

## **9.1 General**

- 9.1.1 In the LPG industry, 'bulk distribution' generally refers to the supply of LPG in bulk by road tanker into a fixed storage tank or tanks. LPG is sometimes distributed in bulk using demountable or containerised tanks, but this is an exception not the rule. All accepted alternatives will be dealt with in these Guidelines.
- 9.1.2 Bulk distribution may be 'full-load', where the customer has enough storage to accept the contents of the supplying road tanker, or 'part-load', where the tanker's LPG cargo is shared among several customers. Full-load distribution may be by weight or by volume while part-load is often by volume, measured by a tanker-mounted metering system. The system should include a temperature correction feature to take account of changes in volume arising from changes in the temperature of the LPG.
- 9.1.3 The possibility of a release of product during transfer may involve both the delivery tanker, the fixed storage vessel or the connecting hose.
- 9.1.4 Bulk distribution is popular with consumers as it often means a higher level of convenience than cylinders. Sometimes, because of the quantity involved, it is the only practical method of supply.
- 9.1.5 Bulk distribution and the bulk installation, which is a necessary part of the system, demand technical, operational and safety expertise which may not be available in a cylinder-only LPG market.
- 9.1.6 Bulk distribution may have the effect of reducing the number of trucks employed in transporting LPG (when compared with cylinders) reducing the traffic accident hazard. On the other hand, the amount of LPG being carried on each truck will be greater with potentially more serious consequences in the event of a major traffic accident. Technical standards for tanker design and construction, on-board safety systems and driver skills should be of a suitably high order.

## 9.2 Technical Options

9.2.1 The technical options for bulk distribution of LPG are:

- Demountable or containerised tanks
- Road tankers without LPG transfer equipment
- Road tankers with on-board LPG transfer equipment.

9.2.2 Demountable tanks may be relatively small capacity (i.e. 1 metric tonne (MT) and upwards) and are sometimes used to distribute chemical grade LPG, where physical access to the consumer is difficult or where the quantity for distribution does not justify the expense of a road tanker. Containerised tanks are mounted within a standard ISO container frame. Both demountable and containerised tanks require specialised handling equipment and are probably at highest risk during handling operations.

9.2.3 Road tankers without LPG transfer equipment are generally used for full-load deliveries and are unloaded using a fixed pump or compressor at the receiving location. These are rated as low-risk operations because transfers are usually made in controlled environments.

9.2.4 Road tankers with transfer equipment, usually a pump driven by the truck's engine and an in-line flow meter, are an essential part of bulk LPG distribution. Making frequent deliveries through a flexible hose requires more elaborate safety equipment also requiring the implementation of a comprehensive hose inspection/renewal programme. One-man operation is normal, but this demands consistent and comprehensive training and assessment of the driver/operator.

## 9.3 Bulk Supply and Delivery

9.3.1 Tanks used on LPG road tankers are specially designed and constructed for this duty, as are skid-mounted and containerised tanks. A tank intended for static storage should not be used for deliveries.

9.3.2 Tank nozzles and valves are fitted internally, recessed into the tank shell or positioned to minimise the risk of impact damage - or protect against shear in a roll over incident - and to prevent unauthorised access.

9.3.3 Road tankers may be loaded by volume or by weight but should always retain a safety margin, or ullage, to protect against the tank becoming liquid-full of LPG.

9.3.4 The time of delivery, i.e. connection, pumping and disconnection, is normally the time of highest risk requiring the full attention of the driver/operator as well as due care on the part of the consumer.

## 9.4 Safety Systems for Operation

- 9.4.1 The bulk distribution system requires the driver/operator to spend some time at the tank and some time at the road tanker during delivery. Ideally, there should be a clear line of sight and unimpeded access between them. Where sight or access are impeded, the driver/operator should be able to shut off the road tanker's engine and close the liquid outlet valve while stationed at the consumer's storage tank and monitoring the filling process. The truck should be safely parked and signaled to avoid traffic accidents and allow easy departure in case of emergency. The transfer area should be free from ignition sources.
- 9.4.2 The vehicle should be equipped with a number of externally-mounted shutdown devices to enable the driver/operator to stop pumping operations quickly and to secure the vehicle in an emergency. It is normal to fit a remote shutdown switch or button at the end of the delivery hose so that the driver can halt pumping without the need to return to the vehicle. Sometimes, a 'dead man's handle' is incorporated so that pumping can continue only in response to a positive action of the driver. In some areas a radio frequency device with a transmitter is used to remotely shut off the engine and the liquid outlet of the road tanker.
- 9.4.3 The vehicle should be protected against moving, or being driven away, when the hose is connected to the stationary tank. Standard systems include wheel chocks, alarms in the driver's cab and pneumatic devices to immobilise the vehicle while the hose is un-housed. The driver/operator should remain in attendance (see paragraph 9.4.1) while transfer hoses are attached.
- 9.4.4 The vehicle must be 'earthed' before the filling/unloading hose is connected and disconnected (see also 7.5.6). Fire extinguishers should be carried on the vehicle and kept ready for use during delivery operations.
- 9.4.5 The bulk delivery driver/operator should be carefully selected, properly and comprehensively trained, and accorded status in accordance with his responsibilities.

## **CHAPTER TEN**

# **Consumer Installation and Usage**

Technical and safety standards should be established, maintained and enforced for LPG appliances, installations appliances and for consumer installations.

Only qualified installers and servicemen should be permitted to undertake LPG installation work.

Consumers should be informed about potential hazards in using LPG and about the safety features of appliances and their installation.

Consumers should exercise due care in the use of LPG.

Consumers should insist that LPG installers and servicemen are properly qualified for such work.

## **10.1 General**

- 10.1.1 The versatility of LPG and its range of applications are reflected in the diversity of installations. These include leisure or household applications employing less than a kilogram of LPG to industrial installations supported by hundreds of metric tonnes (MT) of LPG in on-site storage.
- 10.1.2 For the purposes of these guidelines the installation comprises of an LPG supply (vessel - cylinder or tank) connected to one or more appliances, or to a dispenser. The connection may be direct from vessel to appliance through a flexible hose or through lengths of pipework to a multiplicity of appliances. Automotive LPG falls within this overall classification but is something of a special case.
- 10.1.3 The LPG supplier may also be the supplier and/or installer of the appliance. More often however these activities are separate, and the LPG supplier may not know exactly where and how the product is being used.
- 10.1.4 Consumer safety depends on the performance of the installer as well as the standard achieved by the supplier of the LPG and of the appliance. It also requires an appreciation on the part of the consumer of the importance of such performance and a willingness to demand and pay for it.
- 10.1.5 Most accidents, including fatalities, occur at or near the point of use. Prompted by this, authorities are increasingly regulating the activities of installers and setting appropriate standards for installations.



## **10.2 Role and Duty of the Installer**

- 10.2.1 It is the role of the installer to bring together the LPG supply and the LPG consuming appliance and having connected them ensure that the system is working correctly.
- 10.2.2 The role of the installer is crucial for LPG safety and therefore they should have achieved and maintained a specified level of proficiency i.e. be qualified by training and experience.
- 10.2.3 The installer has a duty to ensure that his work conforms to all statutory or code requirements and to draw attention to any defect in the LPG supply or in the appliance which they are instructed to install.
- 10.2.4 The installer should instruct the consumer in the correct and safe use of the LPG installation, including the provision of adequate ventilation, servicing/maintenance needs and any action to be taken by the consumer in the event of difficulties and emergencies.
- 10.2.5 Recognising the importance of good installation practice, some national authorities regulate the activities of installers. An example may be seen in the Gas Safety (Installation and Use) Regulations of the UK.

## **10.3 Appliance Installation, Inspection, Servicing**

- 10.3.1 The LPG supplier and the appliance manufacturer may not know where the appliance is installed but they nevertheless have a key role in its safety. They should exercise this role by promoting good installation standards and by insisting on qualified installers.
- 10.3.2 A formal system of information exchange between LPG producers and marketers, appliance manufacturers and installers can be a highly effective safety measure. An LPG Association might be a good vehicle for this.
- 10.3.3 LPG delivery personnel should be instructed to inspect the external installation at each visit to their consumers and to report any defects. Marketers must be prepared to follow up such reports promptly.
- 10.3.4 Delivery personnel responding to 'out of gas' calls should additionally check the operation of controls and any pilot lights in the internal installation. If necessary, they should attach a written warning not to turn on the LPG supply until a qualified person has tested the system for safety.
- 10.3.5 Servicing is especially important for appliances which are used seasonally, or which may have remained unused for a long period. LPG producers and marketers should actively promote an internal inspection and servicing programme for their consumers in association with qualified installers. It may be counter-productive to announce a programme unless it is adequately resourced and managed.
- 10.3.6 Builders and consumers should be made aware of the need to have LPG installations inspected when carrying out construction or alteration work which could affect safe operation. They should pay attention to ventilation and the removal of the products of combustion.

10.3.7 Inspectors should pay special attention to the number of spare LPG cylinders at consumers' installations and the storage arrangements for them. Spare cylinders, full or empty, are potentially hazardous and their numbers should be kept to the minimum required for continuity of supply.

10.3.8 Literature concerning operating, service and safety instructions should be kept up-to-date and widely disseminated, preferably in a multimedia format.

## **10.4 Domestic and Commercial Applications**

10.4.1 The diversity of LPG applications means that sometimes LPG is only one of several hazardous substances present. In some applications, such as aerosols and refrigerant applications, the consumer may be unaware of the presence of LPG.

10.4.2 The use of LPG cylinders indoors is normal and accepted practice in some countries. LPG safety programmes should emphasise the need for care, especially when exchanging LPG cylinders indoors.

10.4.3 Water heaters are frequently involved in domestic incidents with LPG, notably Carbon Monoxide poisoning. Because they are high-output appliances, and are often installed in small bathrooms, adequate ventilation and the removal of products of combustion, are especially important for consumer safety. Flues should be checked regularly for obstructions, e.g. snow, and bird and animal nests.

10.4.4 LPG is an indispensable part of commercial cooking but there is a tendency to place cylinders in 'out of the way' places where they may constitute an unseen hazard. Because LPG vapour is heavier than air, cylinders should never be installed or stored in basements, at exits, or in congested or poorly ventilated places.

10.4.5 An efficient delivery service can contribute to safety by removing the temptation to hoard cylinders in unsafe conditions.

10.4.6 Providing the correct grade of LPG and equipment can be an effective safety measure by deterring dangerous practices. For example, a high-offtake application which may be difficult to fuel using Butane is more likely to be trouble-free with Propane, due the latter's higher vapour pressure over a wide temperature range.

## **10.5 Automotive**

10.5.1 The automotive application, i.e. Autogas - the use of LPG as an on-road transportation fuel - has demonstrated very rapid market growth in several countries where the market conditions are right. Autogas has many advantages over gasoline and diesel, especially with respect to tailpipe emissions.

10.5.2 Specific safety measures apply to automotive LPG equipment. For example, the UN/ECE Regulation 67 defines the minimum requirements for automotive LPG equipment fitted on vehicles. It is extremely hazardous to operate a gasoline engine using a household LPG cylinder and hose. LPG should never be used in this way in any vehicle.

- 10.5.3 The opening of an automotive LPG market should be accompanied by a determination to set and enforce appropriate safety standards, i.e. to ensure that a motorist is at no greater risk using LPG than when using gasoline or diesel. For example, CEN, the European Standards Organisation, considered the minimum safety requirements for LPG vehicles, the equipment, components and their installation, as well as the distribution of automotive LPG.
- 10.5.4 Some countries insist on separate re-fuelling stations for LPG while others allow LPG dispensers on gasoline forecourts. Good equipment and procedures will ensure safety for both systems.
- 10.5.5 More detailed guidance can be found in publications such as the Regulations for LPG service stations and road tank trucks in the Netherlands and draft CEN standards on automotive LPG re-fuelling stations and in the LPG Automotive Retail Outlets Code of Practice for Safe Operation.

## **10.6 Consumer Safety Awareness**

- 10.6.1 LPG is marketed based on benefits, i.e. the proposition for LPG is more attractive than competing fuels. As with all fuels, is also hazardous, and most LPG-related incidents occur at or close to the point of use. To win and retain consumers, the marketer should seek to create safety awareness when using LPG without undermining the product.
- 10.6.2 The LPG industry must address the safety issue directly and enlist the support of national regulatory authorities and consumer organisations to create safety awareness. Together, they should publicise the steps which consumers should take, and highlight those to avoid, in the interest of safety, e.g. by providing Material/Safety Data Sheets.
- 10.6.3 As consumer safety depends on the appliance and the installation as well as the LPG supply, authorities should set standards for all three components and make consumers aware of them. An example is the CE mark which is mandatory on appliances sold in EU member states.
- 10.6.4 Cylinder labels, mail shots, point-of-sale notices and media campaigns can all be effective in raising consumer safety awareness. To maintain awareness, messages and presentations should be refreshed from time to time. Brief, timely campaigns are especially useful for seasonal users.
- 10.6.5 The use of detectors and alarms should not be discouraged but neither should consumers become over-dependent on them. Such devices can be particularly useful in warning against a build-up of odourless Carbon Monoxide (CO) and for the safety of consumers with an impaired sense of smell.

## **CHAPTER ELEVEN**

# **Managing Safety**

In any organisation, the most senior management should accept responsibility for safety and should ensure that the resources are available for the safety management programme.

Safety management should be knowledge - based and should operate within a formal structure of policy and action plans.

Safety programmes should be regularly updated based on systematic reviews and advances in technology.

Accident experience can be instructive and should be shared for the benefit of all.

## **11.1 General**

- 11.1.1 LPG is potentially hazardous from the time of production until it has been used and the products of combustion have been safely disposed of. The management of safety is correspondingly wide-ranging.
- 11.1.2 Management of the hazards associated with LPG starts with an understanding of the product and with the exercise of control under all conditions. In the event of a fire affecting LPG in storage, particular care is required to prevent the development of conditions which could lead to a BLEVE. If, under abnormal conditions, control is lost then the management task is to regain it with minimum loss. LPG in isolation is not hazardous but even a small leakage must be dealt with immediately. The possibility and consequences of a large LPG leak must be considered. In this situation, a substantial LPG leak forms a flammable cloud. Ignition of the cloud is called an Unconfined Vapour Cloud Explosion (UVCE), and several studies have been completed on this phenomenon. AS in a BLEVE, the impact of an UVCE may extend well beyond the site boundary and into surrounding areas.
- 11.1.3 The safety management programme should also address hazards incidental to the way LPG is distributed and used.
- 11.1.4 At the beginning of the distribution chain LPG is usually stored and handled in enough quantity to constitute a major industrial hazard and is regulated accordingly. Further along the distribution chain LPG will pass through less skilled hands but the safety management task remains.
- 11.1.5 At the point of use LPG may be a culprit or an innocent party to an incident arising from deliberate misuse of the product or through a faulty appliance or installation. Such exposures further complicate the management task.

## **11.2 Management Commitment and Leadership**

- 11.2.1 Effective safety management requires a clear commitment from proprietors, and their appointed senior managers, to put safety among their key concerns and priorities.
- 11.2.2 Senior management should demonstrate that commitment through unequivocal leadership, sanctioning and implementing the actions required for a safety programme appropriate to the company's role in the LPG industry.
- 11.2.3 The WLPGA have produced a Guide to Good Industry Practice HSE Management Systems. It serves as an essential reference for staff in the planning and implementation of business operations to meet HSE objectives. It also provides an understanding of the mechanisms that need to be put in place to ensure continuous improvement of HSE performance. And finally, it gives interested parties an understanding of how HSE can be managed within the LPG business. It can be found here: (<https://www.wlpga.org/wp-content/uploads/2018/02/Guide-to-Good-Industry-Practices-for-HSE-Management-Systems.pdf>)

### **11.3 Policy, Objectives, Action Plans, Resources**

- 11.3.1 Participants in the LPG industry should publish a safety policy for their companies, explaining its objectives and action plans to their employees and business partners. The manner and format in which safety policy is promulgated will vary from company to company and may be determined, in part, by national and regional regulations.
- 11.3.2 Larger organisations should introduce clear, written definitions of the role of managers at all levels. Individual responsibilities and objectives should be specified in respect of the safety programme.
- 11.3.3 Safety policy lacks credibility without specific action plans and the resources required for implementation. Where licensing of LPG operations is required, the responsible authorities should give due consideration to this.

### **11.4 Laws, Regulations, Standards and Codes**

- 11.4.1 Laws provide the legal basis for regulations intended to safeguard the safety of the general public and consumers. There may be a law specifically enacted for LPG, but the product is sometimes brought within the scope of broader legislation.
- 11.4.2 The public interest requires a measure of safety regulation over hazardous substances, including LPG. Participants in the LPG industry should co-operate with government authorities by making their expertise available to ensure that safety regulations are soundly based.
- 11.4.3 LPG standards and codes embody the technical expertise of a mature industry which constantly seeks to improve its safety image and performance. There are many such standards and codes listed in Appendix Three. Consideration should be given to adopting standards and codes which have achieved international recognition rather than undertake the necessarily laborious work of preparing, or up-dating, national standards.

## **11.5 Hazard Identification, Evaluation, Quantification, Mitigation**

- 11.5.1 It is recognised that in a modern industrial society certain hazards are present and unavoidable as part of basic wants and needs. This has prompted ideas of hazard evaluation and the tolerability of risk.
- 11.5.2 The LPG industry has taken the initiative in LPG related hazard identification, evaluation and quantification, by using its expertise to encourage a science-based approach by the authorities responsible for safety regulation.
- 11.5.3 National authorities and the LPG industry should maintain a dialogue about LPG related hazards and technical advances which might be employed in mitigating risks. Where possible, both parties should engage in international, as well as national, dialogue for this purpose.
- 11.5.4 Contacts between the LPG industry and the authorities should not be confined to times of difficulty. The immediate aftermath of some tragic event or incident is probably not the best time to introduce, or to amend, safety regulations.
- 11.5.5 Leading participants in the LPG industry - marketers, equipment and appliance manufacturers - work constantly and constructively on safety management issues through improvements in technical standards, safety features and procedures. Regulatory authorities should encourage and support hazard mitigation by excluding participants who are not prepared to be part of this process.

## **11.6 Systematic Review, Corrective Action**

- 11.6.1 Having published their safety policies and set their safety objectives, suppliers and marketers should put in place a system of reviews to monitor progress towards achieving those objectives. The review should be a high-level activity receiving top management's attention. Companies should develop and update a corrective action and safety improvement plan.
- 11.6.2 The review should monitor all points of the marketer's distribution chain and provide information feedback to appliance and equipment vendors and installers.
- 11.6.3 Where a licensing system operates, evidence of a systematic safety review process should be a factor in the periodic re-licensing of LPG facilities.
- 11.6.4 There are often useful lessons to be learned from post-incident investigations and such experience should be shared.

## 11.7 The Internet of Things (IoT)

- 11.7.1 The Internet of Things (IoT) refers to the growing range of internet-connected devices that capture, or generate, an enormous amount of information every day. It has been described as a development of the Internet in which everyday objects have network connectivity, allowing them to send and receive data.
- 11.7.2 Telemetry has been used in the LPG industry for many years, mainly for monitoring stocks in the bulk LPG sector where the cost was more easily justified. Initially direct phone lines were used to transmit measurements and data before the cellular networks were introduced. Now the power of the internet cloud is being harnessed which is opening up new opportunities across the whole business
- 11.7.3 The significant improvements with the evolution of communications over the last fifteen years has not only reduced the cost, it has enabled the internet cloud to store data rather than retain it on the ground
- 11.7.4 An example is the way transponders, or tags, have now become just the links to cloud data allowing them to be much simpler and cheaper devices and opening opportunities to monitor low cost assets such as small cylinders
- 11.7.5 Good examples of how the cloud can connect the consumer to the LPG supplier is with smart valves. Small quantities of LPG can be purchased using a smart phone by linking to a smart valve which in turn communicates to the supplier. This enables users of traditional fuels to purchase LPG in affordable amounts allowing them to transition away from wood, charcoal, kerosene etc. which are inherently more dangerous to collect and use.
- 11.7.6 Other examples are where cylinder change-over valves can communicate to the consumer to alert them when the cylinders are being switched.
- 11.7.7 The IoT has created an opportunity to manage LPG assets, and more, to improve the way the LPG industry operates making it safer, smarter and more efficient.

## CHAPTER TWELVE

# Emergency Planning and Response

Planning for emergencies should be an integral part of a safety management programme.

Planning and emergency response should encompass every stage of the distribution chain as well as LPG in storage and in use.

An emergency at an LPG plant may have an impact beyond its boundary fence and the APELL (Awareness and Preparedness for Emergencies at a Local Level) process should be employed for preparedness at local level.



APELL is a programme developed by UNEP in conjunction with governments and industry with the purpose of minimising the occurrence and harmful effects of technological accidents and environmental emergencies.

## 12.1 General

12.1.1 Emergency planning and response is one component of an overall safety management programme. The concept and procedures have been integrated into regulations for the control of major industrial hazards, prompted by such initiatives as the Seveso Directive which specifies 'planning for emergencies' as part of the safety management system.

12.1.2 In these guidelines, we discuss the emergency planning and response process for:

- LPG plants of a size to be classified as 'major hazards'
- LPG in bulk transport.

## 12.2 The APELL Process

12.2.1 APELL is the acronym for Awareness and Preparedness for Emergencies at Local Level, a process developed by the UNEP Industry and Environment Office in co-operation with industry and governments. With its emphasis on preparedness at local level, the APELL process recognises that the extent of an industrial accident's impact depends heavily on the immediate response to an emergency at the plant site and in its immediate vicinity.

12.2.2 Alongside this emphasis on local preparedness APELL recognises the role of government authorities in formulating regulations and in providing the resources which local communities need. APELL neither replaces nor interferes with established emergency response provisions but seeks to increase awareness of such provisions and activities.



- 12.2.3 At local level there are three very important partners who must be involved if APELL is to be successful; local authorities, industry and local community/interest groups.
- 12.2.4 APELL always acknowledges the need and the right of the local community to be informed about and to participate in response planning for hazardous installations.
- 12.2.5 Details of the APELL process can be found in the publication *APELL - Awareness and Preparedness for Emergencies at Local Level: A Process for Response to Technological Accidents*, published by the United Nations Environment Programme, Industry and Environment. Details can also be found on the web site: <http://www.unep.org/pc/apell/>

## 12.3 Emergency Plan, Procedures

- 12.3.1 Expert hazard evaluation and quantification should form the basis of the emergency plan by:
- Identifying the on-site and off-site hazards
  - Assessing the ability for the emergency plans to mitigate the impact of the accident or incident
  - Quantifying the on-site and off-site impact of credible accident scenarios
- 12.3.2 Whether required to do so by regulation or not, the site owner or project promoter should provide the initial hazard evaluation and quantification. He should share this hazard information with the partners described in the APELL process and be prepared to provide independent verification if required.
- 12.3.3 The development of the emergency response plan should conform to any national or local regulatory requirements and ideally the procedures specified in the APELL process.
- 12.3.4 The emergency plan should provide for an escalating sequence of events and emergency procedures should be tiered accordingly.
- 12.3.5 Pipeline and rail operators will have emergency response procedures for the various hazardous products transported by them. LPG marketers and suppliers using pipeline and rail transport should ensure that the operators fully understand the emergency procedures for the products being carried and that transport vehicles display the appropriate product identification labels to warn and assist emergency response teams.

## 12.4 Fire-fighting Principles, Procedures

- 12.4.1 The most effective way to fight an LPG fire is to shut off the LPG supply. If this cannot be done, it may be safer to allow the fire to burn itself out, i.e. to burn until the LPG supply to it has been exhausted, unless the continuing fire will result in an escalation of the emergency. The photo opposite shows an ignited LPG flame in controlled conditions.



- 12.4.2 Dry powder or Carbon Dioxide fire extinguishers are effective against LPG fires.
- 12.4.3 Water is effective in cooling LPG vessels during a fire and in helping to keep the temperature of tanks and their contents below critical levels. Water spray can be useful in protecting fire-fighters attempting to close LPG supply valves in heat-affected areas and in dispersing LPG vapour.
- 12.4.4 Emergency response teams drawn from the plant staff should represent the first line of defense and should be trained for quick decisive action to contain emergencies before they develop and be trained to assist emergency personnel as any escalation of the emergency demands.
- 12.4.5 Emergency response to a fire on or close enough to threaten an LPG road tanker depends critically on the driver/operator. Therefore, the quality of the equipment and training in its use are crucial to recovering control and mitigating the impact of the emergency.

## **12.5 Internal, External Responses**

- 12.5.1 Most in-plant emergencies begin in a small way, or as a result of failure to deal promptly and effectively with a minor incident. Owners and managers should recognise the value of rapid response by trained teams confident in their ability to deal with emergencies. Good equipment, a team spirit and regular training are essential for the commitment and confidence which ensures an effective internal response.
- 12.5.2 External response may be from local authority emergency services or from a mutual assistance group set up to respond to emergencies.
- 12.5.3 The effectiveness of both internal and external response depends initially on the seriousness of the event and then on resources, preparedness and timing. Fire drills and rehearsals for emergencies are an essential part of safety management and should be practiced regularly and also include the fire services. External response will be most effective when everyone is totally familiar with the plant, its hazards and its defenses.
- 12.5.4 Internal and external communications are important factors in determining the effectiveness of emergency response. The slightest delay in reacting to an emergency can make the difference between success and failure. No one should be criticised for over-reacting to an emergency.

## **12.6 Investigation, Corrective Action, Follow-up**

- 12.6.1 The purpose of post-incident investigation is to determine the causes, both immediate and underlying, in order that lessons can be learned, and corrective action taken. The investigating team should include an independent expert who should report to the owners, or to senior management. The licensing authority may wish to participate or to make an independent investigation.
- 12.6.2 An investigation may disclose the need for corrective action in respect of plant layout, equipment, systems, procedures or personnel. While the team should guard against developing an unrealistic 'wish list', senior management should be prepared to sanction their recommendations.

- 12.6.3 Senior management should be prepared to discipline anyone who causes or contributes to an incident by disregarding safety rules and procedures. They should also recognise those who respond well in an emergency.
- 12.6.4 Follow-up should include information feedback to the APELL partners. If relevant information must be withheld or delayed for legal or other good reason this should be made clear to the partners.
- 12.6.5 If equipment or system defects contributed to an incident then equipment suppliers, installers and other plants known to be similarly equipped should be alerted.
- 12.6.6 Authorities responsible for re-licensing should pay attention to any LPG facility where a reportable incident has occurred, or any facility which closely resembles a facility which has suffered a serious accident or incident.
- 12.6.7 Following a serious incident, plant management should immediately start to improve and maintain relationships with employees and the community, while recognising that this may take time.

## APPENDIX ONE

# Product Classification and Labelling

### Hazard Warning Notices and Signs (UN)

Depending on the mixture, there are three UN classification numbers to be considered for LPG:

- Butane or Butane mixtures – UN 1011
- Propane or Propane mixtures – UN 1978

Or a common classification:

- Petroleum Gas, Liquefied or Liquefied Petroleum Gas – UN 1965

All these gases fall under the Hazard Classification (Transport): Class 2 Division 1, indicated as 2.1 and must be marked with the label 2.1 'Flammable Gas'.

The colour of the placard or label is red.



## APPENDIX TWO

# Glossary of Terms

|                        |   |
|------------------------|---|
| <b>Appliance</b>       | LPG consuming device e.g. stove, water heater, space heater   |
| <b>Bulk Supply</b>     | LPG supply to a consumer's tank   |
| <b>CFCs</b>            | Chlorofluorocarbons   |
| <b>Cylinder</b>        | Portable LPG container  |
| <b>Tank</b>            | LPG container for bulk supply and transportation  |
| <b>Cylinder Supply</b> | LPG supply in cylinders   |
| <b>Equipment</b>       | Device(s) connecting and/or controlling LPG supply from a tank/cylinder to appliances   |
| <b>Grade of LPG</b>    | Type of LPG, e.g. chemical, commercial, high purity. Proportion of Butane/Propane in LPG mixtures, e.g. Butane rich mixture   |
| <b>Hazard</b>          | A threat which could cause an accident. <i>(definition in APELL process)</i>  |
| <b>Risk</b>            | Probability of an accident occurring within a certain time, together with consequences for people, property and the environment. <i>(definition in APELL process)</i> |
| <b>Passive Safety</b>  | Safety not dependent on active safety systems   |
| <b>Requalification</b> | Periodic inspection/testing to ensure that LPG cylinders and tanks remain fit for service   |

## APPENDIX THREE

# List of References

## General

European Directive 96/82/EC 'Seveso II'

IAEA - TECDOC - 727: Manual for the classification and prioritisation of risks due to major accidents in process and related industries.

International Atomic Energy Agency

Product Dossier 92/102: Liquefied Petroleum Gas.

CONCAWE

LPG Safety: Quantified Risk Assessment for LPG Operations.

European LPG Association (AEGPL)

APELL - Awareness and Preparedness for Emergencies at Local Level: A Process for Response to Technological Accidents.

UNEP

## Technical

ISO 9162: Standard for LPG.

International Standards Organisation

K 2644-87: Standard for LPG.

Japanese Institute of Standards

Standard 2140: Liquefied Petroleum Gas Specification and Test Methods.

Gas Processors Association, US

IS 4576: Indian Standard for LPG

Indian Standards Association

BS 4250: Standard for Commercial Butane and Propane.

British Standards Institute, UK

Standard D-1835 Specification for Liquefied Petroleum (LP) Gases.

American Society for Testing and Materials (ASTM), US

Standard 54, National Fuel Gas Code.

National Fire Protection Association, US

Technical Report No. 3: Storage of Hazardous Materials.

UNEP IE/PAC

Liquefied Gas Handling Principles on Ships and in Terminals  
Society of International Gas Tanker and Terminal Operators

Guidance Notes GS 40: The Loading and Unloading of Bulk Flammable Liquids and Gases at Harbours and Inland Waterways.  
Health and Safety Executive, UK

Safe Transport, Handling and Storage of Dangerous Substances in Port Areas.  
International Maritime Organisation

Ship-to-Ship Transfer Guide (Liquefied Gases).  
ICS, OCIMF, SIGGTO

Publication 2218  
API

Underground and Mounded Vessels Standards  
EEMUA standard 190

Safety Guide for Terminals Handling Ships Carrying Liquefied Gases in Bulk.  
OCIMF T14

NFPA 307 Standard for the Construction and Fire Protection of Marine Terminals, Piers and Wharves.  
National Fire Protection Association, US

NFPA 58 Liquefied Petroleum Gas Code.  
National Fire Protection Association, US

COP 1 The Storage of LPG at Fixed Installations.  
UK (LPGA)

Model Code of Safe Practice No. 9 - Liquefied Petroleum Gas Volume 1, Large Bulk Pressurised Storage and Refrigerated Storage.  
Institute of Petroleum, UK

ADR - European Agreement concerning the International Transport of Dangerous Goods by Road

RID - Regulations concerning the International Transport of Dangerous Goods by Rail.

Regulations for LPG service stations and road tank trucks in the Netherlands.

Code of Federal Regulations - Transportation CFR 48.  
Department of Transportation, US

Guide to Propane Transportation.  
National Propane Gas Association, US

COP 2 Safe Handling and Transport in Bulk in Road Tankers and Tank Containers.  
UK LPG Association, UK

AS 2809: Road Tank Vehicles for Dangerous Goods Part 1: General and Part 3: LPG Road Tankers  
Australian Standards

ASME section VIII: Rules for the Construction of Pressure Vessels.  
American Society of Mechanical Engineers, US

PD 5500: Specification for Unfired Fusion Welded Pressure Vessels  
British Standards Institute, UK

Title 49 CFR Parts 171 - 190 Transportable LPG Cylinders.  
Department of Transportation, US

EN 1142: European Standard for LPG Cylinders.  
CEN

BS 5045 (or the equivalent EN Standard): Welded Cylinders up to 130 Litres Water Capacity.  
British Standard Institute, UK

Directive 84/527/EC: Welded Unalloyed Steel Gas Cylinders.

BS 5355 (and EN 13099): Filling Ratios and Developed Pressures for Liquefiable and Permanent Gases.  
British Standards Institute, UK

COP 7: Storage of Full and Empty Cylinders.  
UK LPG Association UK

COP 12: Recommendations for Safe Filling of LPG Cylinders at Depots,  
UK LPG Association, UK

49 CFR Parts 107-180 Hazardous Material Regulations, Requalification of DOT cylinders  
Department of Transportation, US

49 CFR Parts 350-399 Motor Carrier Safety Regulations  
Department of Transportation, US

LPG Safety Handbook.  
National Propane Gas Association, US

COP 1 Installation and Maintenance of Bulk LPG Storage at Consumers' Premises.  
UKLPG Association, UK

The Gas Safety (Installation and Use) Regulations (latest edition)  
Health and Safety Executive, UK

Aerosol Conversion Technology Handbook.  
UNEP IE

Hazardous Substances Risk Assessment: A Mini-Guide for Municipalities and Industry.  
Major Industrial Accidents Council, Canada

Uniform provisions concerning - Approval of specific equipment of motor vehicles using liquefied petroleum gases in their propulsion system.  
TSE ECE R 67

Fireproofing practices in Petroleum and Petrochemical Processing Plants 2218  
API



Guide for the Design, Construction and Use of Mounded Horizontal Cylindrical Vessels for Pressurised Storage of LPG at Ambient Temperatures

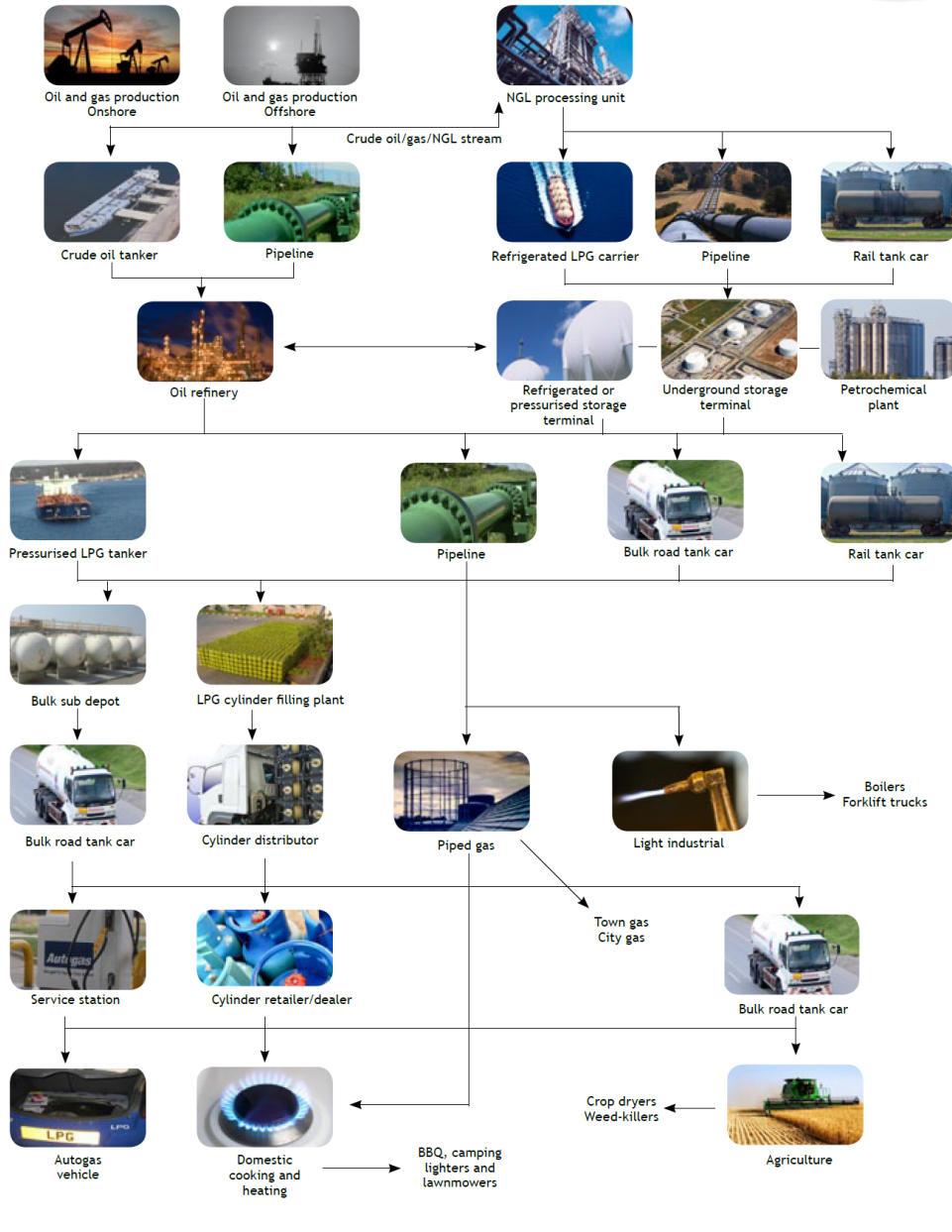
Engineering Equipment and Materials Users Association (EEMUA) 190

**APPENDIX FOUR**

# LPG Distribution Chain



**LPG DISTRIBUTION CHAIN**



# About UNEP Industry and Environment

The Industry and Environment (IE) Centre was established by UNEP in 1975 to bring industry and government together to promote environmentally sound industrial development

The mission of UNEP IE is to 'encourage the development and implementation of industrial policies, strategies, technologies and management practices that contribute to sustainable development by making efficient use of natural resources as well as by reducing industrial pollution and risk'.

The goals of UNEP IE are to:

- Build consensus for preventive environmental protection through cleaner and safer industrial production and consumption
- Help formulate policies and strategies to achieve cleaner and safer production and consumption patterns, and facilitate their implementation
- Define and encourage the incorporation of environmental criteria in industrial production
- Stimulate the exchange of information on environmentally sound technologies and forms of industrial development

To achieve these goals, UNEP IE has developed seven work programme areas:

- Cleaner Production
- Safer Production (Awareness and Preparedness for Emergencies at the Local Level - APELL)
- Industrial Pollution Management
- Environmental Technology Assessment (EnTA)
- Energy
- Tourism
- Protection of the Ozone Layer (OzonAction).

UNEP IE provides access to information through two information exchange clearing houses (ICPIC and OAIC), a query-response service, a series of technical publications, a quarterly journal, four newsletters, and through training workshops and seminars.

# **About the World LPG Association (WLPGA)**

Established in 1987 and granted Special Consultative Status with the United Nations Economic and Social Council in 1989, the World LPG Association (WLPGA) unites the broad interests of the worldwide LPG industry into one independent organisation. To accomplish its objectives, the WLPGA develops partnerships with international organisations and implements global projects.

Representing all sectors of the LPG industry, the WLPGA brings together international and national, private and public companies involved in one, several or all activities of the LPG chain.

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