Guide to

Good Industry Practices for LP Gas Cylinder Management

GOOD INDUSTRY PRACTICES

WORLD LP GAS ASSOCIATION

The World LP Gas Association

The World LP Gas Association was established in 1987 in Dublin, Ireland, under the initial name of The World LPG Forum.

The World LP Gas unites the broad interests of the vast worldwide LP Gas industry in one organisation. It was granted Category II Consultative Status with the United Nations Economic and Social Council in 1989.

The World LP Gas Association exists to provide representation of LP Gas use through leadership of the industry worldwide.

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Guide to Good Industry Practices
LP Gas Cylinder Management

Contents

Chapter One

Background

The WLPGA is committed to providing independent advice to LP Gas stakeholders to ensure safety in the operation of LP Gas equipment.

The two WLPGA guides - Best Business Practices and Best Safety Practices - have been used extensively during the last ten years all over the world to provide guidance across all areas of the LP Gas industry.

These two guides have been designed to provide general advice to all stakeholders on best practices throughout the supply and distribution chain.

Following the success of these guides it has been decided to develop and publish more detailed advice in certain areas of the supply and distribution chain that are considered more critical and where more prescriptive advice would be helpful.

The first of these areas is the subject of *LP Gas Cylinder Management,* which addresses the life cycle of an LP Gas cylinder from acquisition through to disposal.

This document deals with the general management of cylinders and covers some specific guidelines related to steel cylinders which comprise the majority of the LP Gas cylinders in circulation. For specific issues on other types of cylinders i.e. aluminium, composite, aerosol or disposal cartridges, etc. other references should be referred to. (Note: for composite cylinders, reference should also be made to the WLPGA document *"Composite Cylinders, Facts and Guidelines"*).

The guidelines in this document are adopted from globally recognised LP Gas Standards and Codes of Practice as well as using best practices from major LP Gas companies. It is recommended that these guidelines be applied in conjunction with any local laws or regulations to enhance the overall safety performance of your LP Gas business.

Chapter Two

LP Gas Cylinder Management

LP Gas is one of those unique products where the packaging often costs more than the contents.

The majority of LP Gas consumed around the world is delivered to the consumer in steel cylinders of various sizes and types.

The cylinder is an important asset of the business that not only needs to be protected for commercial reasons it is also required to withstand all the challenges of the distribution chain in order to keep the contents secure and safe.

This guide focuses on the management of LP Gas cylinders right through the life cycle, including the key principles of selection, design, manufacturing, filling, maintenance, repair & requalification and disposal. There are six main sections:

- Selection of LP Gas cylinder
- Cylinder Design
- Manufacturing
- Cylinder Filling
- Maintenance, Repair and Requalification
- Cylinder Scrapping

Chapter Three

Selection of LP Gas Cylinder

3.1 General

LP Gas cylinders have for many years been manufactured from metal (mainly steel with a small proportion from aluminium) in different sizes and with different valve types. The design has essentially remained unchanged for so long that one criticism of the industry has been its inability to create a more desirable consumer value proposition. In recent years however, apart from aluminium, there has been the development and introduction of light weight steel - some with plastic components - and composite cylinders which offer several advantages over metal cylinders. With different types of cylinders now available in the market it is critical to choose the right one for your business. This will largely depend on the particular application, environment, budget and market conditions where it will be used.

3.1.1 Size

LP Gas cylinders can come in many different sizes depending on the application. The gross weight of an LP Gas cylinder is often one of the limiting factors in selecting the size, especially for domestic applications. The diameter is also a very important factor because it has implications with the dimensions of the conveyors in the filling plant, and the pallets and racks used for storage etc.

For domestic use, cylinders typically will have capacities ranging from 4kg to 15kg whereas for commercial and industrial use, these will range from 45kg to 50kg. Smaller cylinders i.e. 1kg to 3kg capacities are used for camping equipment and in developing countries where they often serve as an entry level for LP Gas applications in low income households - mainly for cooking. LP Gas cylinders will almost always be used in the vertical position although forklift cylinders are typically designed to be used horizontally with capacities ranging from 15kg to 22kg.

3.1.2 Material

- The majority of cylinders in the market today are made of steel. They are robust and can withstand rough handling better. There is generally no internal corrosion (unless there is water inside the cylinder) but they can corrode externally. Steel cylinders can last many years with proper care and maintenance and are essentially repairable if they become damaged. Steel cylinders are known to last up to 50 years in countries where cylinders are handled properly, where cross filling is non-existent and where cylinders are transported properly e.g. in pallets.
- Some cylinders are made of aluminium which is lighter than steel. However, impurities in LP Gas i.e. sodium hydroxide, are known to corrode aluminium and therefore restricts their use only to certain qualities and grades of LP Gas.
- Composite cylinders are recent developments. They can be up to 70% lighter than steel cylinders and are translucent which allow consumers see the level of liquid LP Gas inside the cylinder. Being made of composite material, they are non-corrosive both internally and externally and are easier to keep clean. They also do not explode when engulfed in fire. The price gap between composite and steel cylinders has fallen over recent years to make composite cylinders an increasingly attractive alternative to steel cylinders. For more advice on managing Composite Cylinders refer to the WLPGA publication *'Composite Cylinders, Facts and Guidelines'*.

3.2 Cylinder Valves

There two basic types of LP Gas cylinder valves for vapour service, namely, self-closing, clip-on valves and hand wheel operated valves. They can come with or without pressure relief valves depending on local regulations.

3.2.1 Self-Closing, Clip-on Valve

These are typically used for domestic cylinders where low cost and fit for service valves are required. Common types in the market are compact, bayonet, or snap on (snap tight) valves.

They can be fitted with excess flow limiters and/or anti-dirt tubes (also called eduction tubes). Because these valves are open-topped, plastic dust caps are recommended to be fitted during storage and transportation to prevent entry of foreign matter.

3.2.2 Hand Wheel Operated Valve

These valves are used both with domestic and commercial cylinders and are designed for different applications i.e. liquid fill, liquid service and vapour service. The outlet connection of hand wheel operated valves can come in different forms e.g. CGA 510 (or F.Pol), CGA 555 (or M.Pol), ACME, NPT, etc. When both vapour and liquid connections are on the same valve, they must be designed differently for clear distinction. Liquid service valves are fitted with a tube and an excess flow limiter.

Hand wheel operated valves can accidentally be opened and it is recommended to fit a gas tight plug after filling while the cylinder is in transport or storage.

3.2.3 Cylinder Connection

The valve threads for the cylinder connection are tapered in design and may have different specifications. It is important that the valve thread specifications are compatible with the bung specification (see 4.5.3). The common specifications used are ¾ inch NGT (National Gas Taper), DIN 477 and ¾ inch SGT (Special Gas Taper). Some countries require a standard cylinder connection thread for all cylinders. In countries where this is not specified, it is important to ensure that valves with different cylinder connection threads are not intermixed in the same cylinder population.

3.3 Standardisation

Cylinders (and valves) for individual companies operating in a particular location should ideally be limited to a few standard types and sizes as much as possible. This will allow:

- Filling plants to automate facilities and operate efficiently
- Distribution trucks to optimise carrying capacity
- Distributors' to have uniform cylinder cages and display racks
- Procurement to achieve scale in sourcing

All these will lead to a more efficient business.

Chapter Four

Cylinder Design

4.1 General

LP Gas is a highly flammable product that is commonly stored under pressure. Any leakage of LP Gas from its container has a potential to cause fire and injury. For this reason, cylinders should be designed and manufactured in accordance to recognised codes and standards.

The following guidelines apply to welded steel cylinders with water capacity of up to 150 litres.

4.2 Design Code

LP Gas cylinders should be designed and manufactured to established international standards such as ISO 22991 or equivalent (e.g. DOT, EN 1442, etc.). Where local regulations require the use of national standards or alternative codes it is important to confirm that they at least equal the requirements of ISO22991.

4.3 Design Pressure

- The design pressure of the cylinder is based on the vapour pressure of the product to be filled. In countries where the product vapour pressure is not strictly controlled, or is variable in practice i.e. different blends of butane/propane mix are supplied, then it should be assumed that product with vapour pressure of up to propane could be filled. Cylinders should therefore be designed for propane service.
- In countries where the vapour pressures of butane or LP Gas mixtures are controlled and there is confidence that the supply will remain unchanged, the butane developed pressure or the equivalent developed pressure relating to the mixture supplied, may be used in the calculation of wall thickness.
- The vapour pressure developed is dependent on the local climatic conditions i.e. the higher the temperature, the higher the vapour pressure. Reference should be made with the relevant standards to determine the appropriate reference temperatures for particular countries. If a low vapour pressure supply changes to a higher vapour pressure supply, and cylinders have been designed for the lower vapour pressure, then the cylinders may not be fit for purpose in which case they will have to be replaced with cylinders designed for the higher vapour pressure.
- Where a local requirement calls for DOT cylinders a test pressure of 480 psig is to be used except where local high vapour pressure product requires a test pressure of 520 psig.

4.4 Wall Thickness and Cylinder Diameter

The wall thickness of the cylinder is calculated using the formula prescribed by the standard or code used. Aside from the design pressure, other factors affecting the minimum wall thickness include the yield strength of the material used and diameter of the cylinder. Wall thickness will decrease with higher yield strength material whereas it will increase if the cylinder diameter increases. One benefit of designing to minimise wall thickness is the resultant reduction of the cylinder weight though this has to be evaluated against the cost of using high yield strength materials. It is therefore important to carefully consider the material used and cylinder diameter when designing cylinders to arrive at an optimum design.

Some codes specify an absolute minimum wall thickness regardless of the design pressure. In ISO 22991 for example, the over-riding minimum thickness limit for cylinders with a diameter greater than 150 mm is 1.5mm.

4.5 Construction

4.5.1 Parts of a Cylinder

A LP Gas cylinder consists of a few basic parts, namely – shroud (collar or handle), bung, body and foot ring. Each part has a specific function and should be designed and manufactured to meet its purpose. A poor design can result in cylinders being easily damaged and/or injury to users.

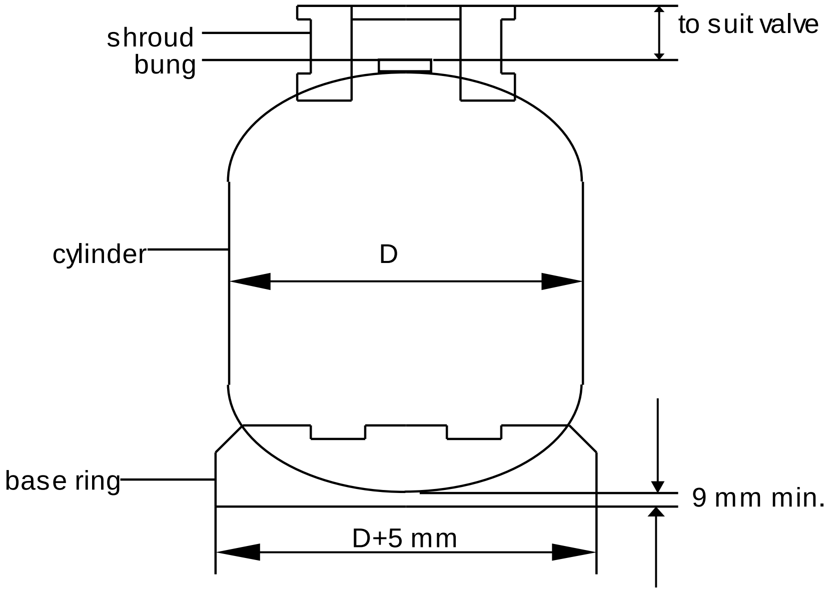

Fig 1 Key parts of a Cylinder

4.5.2 Body

- The cylinder body holds the contents of the cylinder. It is the main component which is subjected to the pressure developed by LP Gas inside the cylinder.
- The body is designed concave to withstand pressure with either tori-spherical or semi-ellipsoidal ends. The wall thickness of the body is calculated using the formula prescribed by the design code (see 4.2). The capacity of the body is expressed in litres of water capacity. When designing the LP Gas capacity of the cylinder, the type of product, assessed temperature of the location (see 4.3), and filling tolerance (see Appendix 2 Table A.2.4 if not prescribed by local regulations) should be considered in the calculation. As a rule, the maximum LP Gas content should not be more than 97% of its water capacity at the assessed temperature.
- The body is generally made in either a two or three piece design depending on the size and application (see Fig. 2 and 3). Two-piece construction is common for domestic cylinders which consist of an upper and bottom cup. Higher capacity cylinders (i.e. cylinders for commercial and forklift applications) will generally require three-piece construction to avoid having to draw the cups too deep to meet the capacity. Cylinders are mainly designed for use in an upright position although some applications will require the cylinder to be horizontal (i.e. forklift cylinders). As the name suggests they are cylindrical in shape with typically only one opening, (some liquid withdrawal valves have two openings) where the valve is positioned.

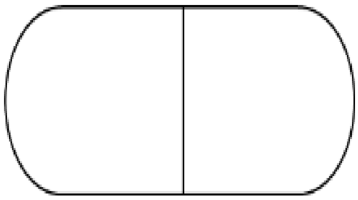

Fig. 2 Two-piece body

Fig. 3 Three-piece body

4.5.3 Bung

- The bung (also called the boss or neck-ring) is the opening on the cylinder which provides a connection to the valve. It should be located on the end of the cylinder and should be clear of any circumferential or longitudinal welds.
- The bung can either be an internal type or an external type and it should be designed to minimise the protrusion of the bung above the cylinder unless it is designed for a screw on cap.
- The thread should be specified to suit the valve thread intended to be used. It is recommended that only one thread specification should be used for the entire cylinder population to avoid intermixing of different valves.
- For cylinders where the cooking appliance is directly connected on top of the valve e.g. 2kg to 3kg cylinder, the concentricity of the bung to the vertical axis of the cylinder is critical and should be kept within a maximum tolerance of 3mm.

4.5.4 Shroud

- The purpose of the shroud (also called a collar) is to protect the valve from damage due to impact and when stacking cylinders on top of each other. It is also fitted to enable the cylinder to be handled. In the absence of a shroud, the valve should be protected using a removal cap which is also to be fitted when the cylinder is in transit.
- Shrouds should be designed so that regulators can be connected easily and that the LP Gas hose is not bent when the regulator is connected.
- Cylinders with self-closing clip-on valves typically will have shrouds totally encircling the valve while cylinders with hand wheel operated valves will have shrouds with openings to accommodate the connection of regulators.
- The shroud should also be designed to allow one cylinder to be stacked on top of the other without the bottom of the upper cylinder touching the valve of the lower cylinder. The material should be robust enough to support the cylinders above it. There may be up to four cylinders stacked on top of the cylinder so the total gross weight of these should be accommodated by the shroud of the bottom one.
- Shrouds should be fully welded to the cylinder unless the country legislation dictates otherwise. The weld attachments should be designed to prevent water being trapped which might lead to corrosion.
- Hand holes in the shroud should be provided to facilitate handling of the cylinders. They should be designed to provide a comfortable grip when lifting and carrying the cylinder and prevent potential injury to the user.
- If a pressure relief valve is fitted to the valve there should be an opening in the shroud to allow vented LP Gas to escape.

An example of a typical recommended shroud design is shown in 4.5.1 Fig.1. In practice the actual design will vary according to the manufacturer.

4.5.5 **Foot Ring**

- The foot ring should provide stability to the cylinder when standing alone or if stacked on top of another cylinder. It also protects the underside of the body from touching the ground.
- Foot rings should be designed larger than the outside diameter of the cylinder in order to minimise damage to the cylinder walls during handling and transit.
- The foot ring should be designed to prevent water being trapped which might lead to corrosion. It should also have ventilation holes to prevent condensation building up on the underside of the body of the cylinder.
- The material should be of sufficient thickness to resist deformation of the foot ring during handling and to support the weight of cylinders stacked above it.

An example of a recommended foot ring design is shown in 4.5.1 Fig.1. In practice the actual design will vary according to the manufacturer.

Chapter Five

Manufacturing

5.1 General

- Only manufacturers certified to ISO 9001 that can demonstrate their ability to producing cylinders that meet quality standards should be selected. Furthermore, manufacturers selected should have the certifications to produce to specific codes and standards i.e. DOT, EN, etc.
- It is important also to ensure that manufacturers comply with the requirements of the design code and manufacturing specifications by appointing an independent inspection authority during and post manufacturing to verify compliance. DOT specifies the manufacturing inspection for cylinders which should be carried out by DOT approved inspectors.
- Prior to the commencement of production, the manufacturer and buyer should agree/approve the applicable design code or standards, manufacturing drawings and specifications and destructive and non-destructive testing requirements.

5.2 Material

5.2.1 Pressure Parts

- The grade of steel used in cylinder manufacture must be compatible with the intended grade of gas in service. It should be suitable for drawing and welding and when used in locations with sub-zero temperature conditions, they should not be brittle at minus 20^{o}C.
- The manufacturer should have the certificates to show the chemical analysis and the details of the mechanical properties of the steel supplied for construction of the pressure parts of the cylinder. These material certificates should be kept on file for future reference in case of any incident concerning material defects. Materials used for steel cylinders will typically have chemical analysis not exceeding the following values %:
    - Carbon 0.250%
    - Silicon 0.450%
    - Manganese 1.600%
    - Phosphorus 0.040%
    - Sulphur 0.040%

- Where micro-alloying elements are used, their presence and amounts should be reported in the steel manufacturer's certificate.
- Materials should be examined and tested prior to manufacture to confirm their suitability for use for welded steel cylinders. All test reports should be kept on file for future reference.
- Examples of steel specifications used for welded steel cylinder manufacturing includes ISO 4978, EN 10120 or JIS G3116

5.2.2 Non-Pressure Parts

The material used for other parts of the cylinder except the bung i.e. shroud and foot ring, should be of compatible weldable material.

5.2.3 Bung

- The bung should be made of compatible weldable material.

5.2.4 Welding Consumables

- The welding consumables should be capable of producing a consistent weld with a minimum tensile strength equal to that specified for the parent material in the finished cylinder.

5.3 Welding

5.3.1 Welding Qualification

- All welders and welding operators should be qualified and certified. The welding procedures should be agreed by the manufacturer and buyer before the start of production.
- Records of welding qualification should be kept on file by the manufacturer.
- Weld approval tests should be made in a manner that the welds should be representative of that made in actual production.
- Welders should have passed the approval tests for the specific type of work and procedure specification concerned.
- Welders should be re-qualified and re-certified if the specific type of work or procedure has not been done by the welder for three months or more.

5.3.2 Metal Preparation prior to Welding

- The surface to be welded should be free of dirt, oil, grease, mill scale, rust or drawing compound before welding. This will help prevent welding defects such as lack of fusion, inclusions, gas pores, etc.
- Surfaces on both sides of joints (circumferential and longitudinal) to be welded should be cleaned by chemical washing and/or by mechanical wire brushing.

5.3.3 Welding Procedure and Parameters

- The welding procedure for the circumferential and longitudinal body joints should be submerged arc welding. It should be done by using a fully mechanized, semi-automatic or automatic process to provide a consistent and reproducible weld quality.
- Welding of the bung, shroud and foot ring should be by shielded metal arc welding, gas metal arc welding or other welding processes that meet the requirements of this section.
- Circumferential joints should be butt welded with one member offset to form an integral backing strip creating a joggle butt weld. The external surface of the cylinder is smooth and the components e.g. top and bottom halves of a two piece cylinder, correctly line up. They should be made by a two pass welding procedure with one weld laid on top of the first welding pass such that the joint space between the two components is filled with welding material. There should be no more than two circumferential joints per cylinder.
- Longitudinal seams should be butt jointed. Permanent backing strips should not be used for longitudinal joints. There should be no more than one longitudinal joint per cylinder.
- Circumferential and longitudinal welds should show complete penetration and fusion.

The excess thickness should be such that weld integrity is not compromised. Longitudinal welds should be continuous straight beads correctly aligned to the butt joint without demonstrating welding defects i.e. burn through or internal concavity.

- The profiles of all welds should be smooth and have a uniform contour throughout each run i.e. without concave or excessive convex contour. Each weld should fuse into the parent metal without undercutting or abrupt irregularity.
- The welding process should be controlled to ensure minimum weld spatter.

5.3.4 Weld Repairs

- If during the hydrostatic or tightness tests minor leaks are found in the welding, the defect may be repaired by automatic welding in accordance to the agreed repair procedure. Bung welds should however not be repaired.
- After weld repair, cylinders should undergo post weld heat treatment and hydrostatic test again (refer also to 5.13).

5.4 Post-Weld Heat Treatment

- All cylinders must be subject to post weld heat treatment after completion of forming and welding processes to relieve residual stresses from fabrication and restore/enhance the mechanical properties of the metal.
- The heat treatment applied may either be stress relieving or a normalising process as defined in ISO 4706 or a comparable standard. Normalising process is the recommended best practice where the cylinder is heated to a uniform temperature above the upper critical point of the steel (typically 900 deg C or above) to regenerate or homogenise the metallurgical structure of the steel and then cooled in a controlled or still air atmosphere.
- The heat treatment must be carried out in a reducing atmosphere in order to minimise scale formation and achieve a clean internal condition. The furnace should be equipped with appropriate temperature monitoring and recording instruments.
- The manufacturer must maintain records to indicate that the cylinders have been heat-treated to indicate the adequacy of the heat-treatment process used.
- Localised heat treatment must not be used.

5.5 Surface Preparation

- Cylinder surfaces must be free of scale, rust and oil before the application of any surface coating. This will ensure good adherence and longer life of the surface coating.
- All openings and threaded connections must be effectively sealed before any surface cleaning operation to prevent entry of any foreign particles.
- External surfaces must be grit-blasted until they are clean and uniformly grey in appearance to SA 2 ½ (ISO 8501-1) and a medium surface roughness in accordance with ISO 8503-1 suitable for the adhesion of a sprayed zinc metal coating.
- Steel shots or grits or their combinations thereof are used for surface blasting. They should be replaced as necessary to ensure that the surface preparation always meets the requirements given above.
- Shot blasted cylinders must be subject to painting within three hours to ensure the surface remains clean and free from rust.

5.6 Zinc Metal Spray

5.6.1 General

- The purpose of applying zinc metal spray is to prevent external corrosion and ensure longer life of the cylinder. The decision to specify zinc metal spray is often a question of ambient conditions and economics. The cost should be compared with the result of cylinder corrosion experienced in a particular location. If a high proportion of the cylinders in the location show evidence of external corrosion then the use of zinc metal spray is probably justified.
- There are also safety reasons for applying zinc metal spray i.e. where the location experiences high external corrosion rates - for example near the coast where sea water corrosion is likely - this can lead to LP Gas leakage through the cylinder wall which sometimes can be catastrophic if a large area of metal has failed.

5.6.2 Process

- If zinc metal spray is required, it should be applied to the external surfaces of cylinders, including the shroud and foot ring, within three hours of grit blasting.
- A minimum coating of 40 microns should be evenly applied in accordance with EN 22063. The area beneath and inside the foot ring which is more prone to corrosion should be coated to a minimum thickness of 100 microns.
- Adhesion test on the zinc metal spray should be carried out in accordance to EN 22063 after application.

5.7 Painting

- Cylinders should be sprayed with a suitable top coat (i.e. epoxy-based paint) that has good impact and scratch resistance to maintain the appearance of the cylinder. A minimum coating of 50 microns dry film thickness should be applied and dried in accordance to the paint manufacturer's instructions. For cylinders without zinc metal spray, a minimum coating of 80 microns dry film thickness should be applied.
- After drying the paint surface should present a smooth opaque finish free from streaks and sagging. Isolating the painting area from dust and dirt will help keep the finished surface shiny and clean. If properly applied, the paint should be capable of retaining a good finish free from flaking and peeling for several years.

5.8 Powder Costing

Powder painting may be used as an alternative to zinc metal spray and paint combination. Care should be taken to ensure that the powder paint is applied on a moisture-free surface to ensure good adhesion on the cylinder and to eliminate any subsurface corrosion. Usually powder coating produces better results.

5.9 Internal Cleaning and Drying

- After completion of the surface treatment, threaded components i.e. bung, should be gauged and cleaned by running a tap with the correct thread form into connections to remove grit, zinc, paint etc. from the threads. The cleaning operation should not remove parent metal from the threads.
- Moisture, loose rust and scale etc. should be removed from the interior of the cylinder by a vacuum pipe and the cleanliness checked using an inspection lamp.
- Cylinders which are not immediately fitted with a valve should be sealed at the bung with a plug to prevent ingress of moisture or foreign material.

5.10 Valving and Torque Application

- Cylinder valves should be fitted immediately after internal cleaning and drying has been completed.
- The sealing compound used should be suitable for use with LP Gas and should be applied to the valve threads avoiding entry of the compound into any part of the valve or the cylinder. The compound used should be a liquid thread sealant which forms an effective seal and remains plastic in service.
- Valves should be fitted correctly to avoid damage to threads and tightened using a torque wrench to within the limits specified by the valve manufacturer

5.11 Tare Weighing

The finished cylinder complete with valve, shroud and foot ring should be weighed on an electronic scale with an accuracy and repeatability of at least 0.1% (1 in 1000). Scales should be approved and regularly checked for accuracy (at least once per shift using standard weights over the measuring range). The tare weight to be recorded on the cylinder should be that indicated on the scale rounded down to the nearest lower 0.10 kg.

5.12 Checking of Water Capacity

Cylinders should be checked for water capacity to ensure compliance with the minimum value shown on the manufacturing drawing. There is no negative tolerance in measured water capacity. If a lower value is discovered in the sample check cylinder then all cylinders produced after the previously satisfactorily checked cylinder must be individually checked. Cylinders which have less than the required minimum capacity must be rejected and scrapped (see Chapter Eight).

5.13 Testing and Examination

- Cylinders should be subjected to the required tests and examination following the methods and procedures stated in the design code i.e. ISO 22991. These tests may include:
  - Mechanical test of parent metal and welds – for checking the mechanical properties of the pressure parts of the cylinder.
  - Burst Test under hydraulic pressure – for checking the ability of the cylinder to contain the pressure of LP Gas to a certain level. The results indicate the other details of the mechanical properties not shown by mechanical tests.
  - Pressure Test under hydraulic pressure – checking for leaks in the weld and other parts of the cylinder. Cylinders should also not show any signs of permanent deformation. This test should be applied to 100% of the cylinders manufactured.
  - Radiographic and Macro examination - checking for defects in the welds such as lack of penetration or fusion, cracks, inclusions, gas pores, etc.
- Test results should be documented. Cylinders failing the test should be referred to the inspection authority for appropriate action.
- If any leakage occurs, the cylinder should be regarded as having failed the test. Leak detection should be by immersion in a water bath or other test of equal sensitivity. If water bath method is used, the water should be maintained clean and clear enough to detect leakage. The water in the bath should also be reasonably stable to allow for leaks to be clearly detected i.e. little turbulence.
- If cylinder valves are fitted by the manufacturer, a pneumatic test should be conducted to check for gas tightness at a pressure agreed between the manufacturer and buyer

5.14 Stamp Markings and Labelling

5.14.1 General

- Cylinders should be stamped or stencilled with manufacturing, operational and certification markings as required by local regulations. In their absence, 5.14.2 and 5.14.3 should apply.
- Stamp markings should be applied permanently and legibly without affecting the integrity of the cylinder e.g. on the shroud or other permanent attachments.
- The characters in the stamp markings should be preferably at least 5 mm in height. On cylinders with an outside diameter less than 140 mm, this height may be reduced, but in no case should the characters be less than 2.5 mm in height.
- The depth of the characters in the stamp markings made by any method should be such that they are legible and durable under all operating conditions.

5.14.2 Stamped Markings

The following stamp markings should be provided on the cylinder:

- Manufacturer's identification
- Design code
- Design pressure clearly stating product to be used (Propane or Butane)
- Test pressure
- Serial number
- Date of manufacture/initial test date (month-year)
- Tare weight
- Water capacity
- Identification of content
- Certification (if require)
- Name of cylinder owner (mandatory)
- Brand name embossed (owner's name may be different from the brand name) e.g. in Vietnam for example, cylinders branded "Saigon Gas" belong to Totalgas.

5.14.3 Labels or Stencilled Markings

Aside from stamped markings, the following should also be labelled or stencilled legibly on a prominent part of the cylinder:

- Identity of content
- Net contents of cylinder
- Date of next requalification
- Tare weight
- Identification of content
- Danger warning sign
- Brand name (optional)
- Other safety information as required

Much of this information can also be incorporated in the form of bar codes that can be fitted to cylinders to facilitate tracking and gathering other information at the filling plant.

Chapter Six

Cylinder Filling

6.1 General

- Filling of LP Gas cylinders is a safety critical activity and must be carried out only by trained and competent workers in a facility designed specifically for cylinder filling. The cylinder filling facility should be well ventilated and clear of any potential hazards while filling is occurring. Workers must fully understand the emergency procedures and comply with the requirements with regard to personal protection equipment (PPE) while on duty.
- Filling of cylinders should comply with local regulations. The correct specifications and quantity of LP Gas should be filled. Cylinders must never be overfilled (see 6.5). Scales used for check weighing should be serviced regularly and checked for fill accuracy and tolerance before and during cylinder filling operation.
- Filling plants with high capacity are usually fully automated with little manual handling of cylinders required. However, for small filling facilities which are typically not automated, manual handling of cylinders could be a major activity and should be carried out with care to avoid damage to the cylinder and injury to workers.

6.2 Cylinder Inspection prior to Filling

- All cylinders must be inspected prior to filling to ensure only safe and suitable cylinders are refilled. Particular attention should be given to the underside of the cylinder during inspection. Cylinders inspected can be segregated into several categories i.e.:
  - Leaking cylinders – they must be de-pressurised to atmospheric pressure and gas freed as soon as is practicable.
  - Cylinders due for periodic inspection and testing.
  - Defective/faulty cylinders, e.g. serious dents, bulges, gouges, fire damaged, damaged valves, valves with missing consumer seal, etc.
  - Cylinders with partial or worn markings/finish.
  - Cylinders containing air, e.g. new/reconditioned cylinders.
  - Cylinders owned by third parties where there is no agreement to fill or maintain them. These should be returned to the owner/filler.
  - Cylinders suitable for filling. These cylinders should be sorted according to capacity and product to fill.
- Cylinders with defects/faults should be assessed if they can still be repaired and if it is economically practicable to do so. Where cylinders are deemed not repairable, they should be scrapped (see Chapter Eight).

6.3 Filling of Cylinders

- Only suitable cylinders meeting the required safety standards and with clearly marked tare weights and requalification dates should be filled.

- Cylinders can be filled by weight or by volume. When filling is by weight, the tare weight of the cylinder should be accurately set on the filling scales. When filling is by volume, the cylinder should be emptied of liquid before filling unless the cylinder is fitted with a safe fill level device (e.g. dip tube).
- Every time the cylinder is connected to the filling equipment, leak checks should be undertaken to ensure the connections are safely and correctly carried out. Any faults, which develop during filling, should be promptly corrected by the operator and reported to a supervisor who should investigate the problem and implement any further necessary corrective action.

6.4 Post-Filling Procedure

- Unless the filling scales themselves are approved by the appropriate local regulatory authority and checked daily using appropriate procedures, every cylinder must be check-weighed for accurate fill/tolerance etc. This may be made by manually weighing or by using an automated weight or level checking system.
- Over-filled cylinders must have the excess product removed as soon as is practicable in a safe and controlled manner, i.e. into an enclosed vacuum system or by venting into a vent stack or exhaust fan system connected to a vent stack.
- Under-filled cylinders must be returned for fill correction.
- All cylinders including their valves must be thoroughly checked for leaks. Leaks detected should be made safe as soon as practicable.
- All hand-wheel-operated valves must be leak tested in both the open and closed positions. Faulty seals should be replaced where necessary.
- Self-closing clip-on valves must have the main gas seal and the customer seal checked.
- All valves must also be checked for distortion to ensure that it will be possible to properly attach a regulator
- Valve protection/sealing caps/gas-tight plugs/labels and warrantee seals should be attached to cylinders before despatch.
- Hazard warning information as required by local regulations must be present on the cylinder and clearly legible.
- If the cylinder needs to be gas-freed, it must be done in a safe and controlled manner.
- If there is reason to suspect air is in the cylinder, then it should be checked e.g. by noting the vapour pressure. If air is indicated by a significant overpressure, it should be removed by venting through a suitable venting system.

6.5 Maximum Fill Quantity

- LP Gas has a high coefficient of thermal expansion. If overfilled, a cylinder could become hydraulically full when the temperature subsequently rises. The consequent increase in the hydraulic pressure could lead to liquid LP Gas escaping from the pressure relief valve (if fitted) and/or to distortion or bursting of the cylinder. Fill quantities must be closely controlled.
- After filling a cylinder there must be enough vapour space left to cope with expansion of the liquid content that would occur when the temperature reached the highest level expected in normal service i.e., the “assessed temperature” and to allow for filling tolerances or inaccuracies in the filling method. (The assessed temperature to be used depends on the climatic conditions in the area where the cylinder is to be used and is related to the recorded maximum shade temperature).
- The liquid level must leave at least 3% of the cylinder’s water capacity free of liquid at the assessed temperature. (Beware of the influence of dip tubes fitted to compact valves).
- Overfilling must be avoided by ensuring that the amount of LP Gas filled into a cylinder does not exceed that calculated as shown in Appendix Two.

Chapter Seven

Maintenance, Repair and Periodic Requalification

7.1 General

- The physical condition of LP Gas cylinders can deteriorate with poor handling, use of inappropriate distribution equipment, and continued use and exposure to the elements. Regular maintenance, repair and requalification are necessary to ensure that they remain fit for service. This can be achieved by inspecting and then segregating cylinders with defects and damage for appropriate action when they are brought into the filling plant for refilling.
- Maintenance and repair work can be done in a suitable location inside the filling plant/depot. However, some repairs may require special equipment and competences. Only qualified contractors with properly equipped workshops and manned by trained workers should be selected for this type of work.
- The supervision of work and decisions on fitness for service should only be undertaken by Competent Persons. Many of the operations can be hazardous and/or noisy and due care should be taken to protect workers against the assessed risks.
- Cylinder maintenance and repair entails cost and therefore should be carried out efficiently and properly. Otherwise the business performance will be adversely affected. There may be a temptation to save costs by ignoring maintenance, test and repair. The result is a deteriorating asset base and higher safety risks to customers.

7.2 Cylinder Defects and Damages

7.2.1 Steel Cylinder

Steel cylinders should be inspected for the following defects and damage:

- Partial or worn markings/finish
- Leaking valves, damaged valves, valves with missing consumer seals, etc
- Serious dents, bulges and gouges
- Corrosion pits, lines and general corrosion
- Fire damage and scorching
- Cylinders due for periodic inspection and testing

7.2.2 Cylinder Defects

A description of cylinder defects and damages can be found in Appendix Three. Suggested rejection limits can be found in ISO 10691:2004. These criteria should be applied by a Competent Person when categorising cylinder defects for repair or scrap. If a cylinder is badly corroded or damaged, it might not be possible to recover it and it must then be scrapped.

7.3 Cylinder Cleaning and Surface Treatment

7.3.1 Cylinder Cleaning and Washing

Cylinders covered in dust and grease and other contamination may be subject to cleaning or washing either manually or through the use of automated washing machines. If surface deposits such as bitumen splashes, concrete splashes, excessive grease etc. cannot be removed by routine cleaning or washing, they should be set aside for hand cleaning or shot blasting.

7.3.2 Cosmetic Repainting

- Care should be taken when deciding to repaint for cosmetic reasons. Often paint is applied to the cylinder without any surface cleaning. The result is far from a cosmetic improvement. Any painting should only be done on sound, clean, dry cylinders which have had any loose paint or information or branding stickers removed; for example by wire brushing, to give a good base for the new paint.
- Cylinders for cosmetic repainting need not be gas freed or have the valves removed. However they should not be overheated to avoid excessive internal pressure build up. Valves should be completely closed and protected during repainting.

7.3.3 Shot Blasting

- Cylinders should be devalved, gas freed and plugged prior to shot blasting. This can be carried out using grit or shot. Sand blasting is not permitted in view of the associated health hazards. Note that grit/shot blasting can remove the zinc metal coating from cylinders; care should therefore be taken if the zinc will not be replaced as part of the cylinder refurbishment process.
- Shot blasted cylinders should be subject to repainting within 3 hours to ensure paint is applied on clean and rust-free surface for better adhesion. See also 5.5 and 5.7.

7.4 Repair

7.4.1 Repair of Minor Defects

Repairs of minor defects, such as bent shrouds or foot rings, can be carried out in a designated part of the filling plant/depot. Bent shrouds and foot rings can often be straightened rather than replaced. Straightening is a much cheaper operation than cutting and welding because it avoids hot work, and should always be considered the first option. Machines are available which use mandrills and hydraulic pressure to re-form the shape. Great care should be taken to avoid cracking.

7.4.2 Repairs Requiring Valve Removal but no Hot Work

These will require either the contents of the cylinder to be reduced down to atmospheric pressure and the work or valve replacement undertaken in a designated Zone 1 area, or the cylinder to be fully gas freed either by evacuation or by using steam or water (see Appendix Four).

7.4.3 Repairs with Hot Work

Cylinders requiring major repair, involving welding and/or de-denting, must be gas freed, tested and certified gas free before being processed. Only competent cylinder repair specialists, who are commonly third party organisations, should undertake such repair. For larger operations it might be possible to safely undertake the work in house. Essential aspects are:

- Removal – If collars and foot rings have to be replaced because they are too damaged to repair, they should be removed using a pneumatic chisel. Do not use flame cutting or grinding which may cause damage to the cylinder wall.
- Fitting new – New collars and foot rings should be of comparable material quality to the originals. They should be welded only by operators who are formally qualified for the work. Original information contained on the collar should be retained to ensure a history of the cylinder's 'birth certificate'.

- Dent removal – Dents can be removed from cylinders by the careful application of external heat together with internal pressure using an inert gas, e.g. nitrogen. See Appendix Five for the procedure. Do not use compressed air because of the danger that, despite proper gas free procedures, residual LP Gas remains in the cylinder and an explosion may result.

All cylinders that have hot work repairs, should be heat treated and hydraulically tested before being put back into service (see Appendix Five and Appendix Six). Furthermore, they should be subject to inspection procedures comparable to that specified for new cylinders.

7.5 Requalification

- Cylinders must be pressure tested at periodic intervals and re-qualified for a further period of service. The periodic examination/testing must be performed according to national legal requirements, the requirements of the code to which the cylinder was manufactured or a local industry standard, whichever is the most stringent. If no such criteria exist, those of ISO 10464 must be adopted for steel cylinders (see Appendix Seven).
- The requalification scheme shall be fully documented by a competent person and appropriate evidence and records maintained in support of the scheme. Note that different requalification may be appropriate for different cylinder types/usage.
- In some countries, cylinders are required to be scrapped by law regardless whether they are still in good condition or not after a specific period of time. This is however not good practice because cylinders can have a useful life many years beyond that specific period of time if maintained properly.

7.6 Repair of Valves

7.6.1 Repair

- Other than the replacement of the consumer seals, valves should generally not be repaired unless by the original manufacturer. If appropriate resources and facilities exist to carry out the repair to appropriate standards this may be considered.
- Replacement parts should be obtained from the original valve manufacturer or from an approved manufacturer to an equivalent standard to the original parts.
- Repaired valves should be subject to the same testing regime required for the original valve. Valves with damaged pressure relief valves should be scrapped.

7.6.2 Replacement

- Valves will suffer from wear and tear and will not last forever. It is therefore recommended that all vertical valves be replaced at least every 15 years and all hand-wheel valves at least every 20 years with new approved valves.
- Replaced valves have a scrap value and some valve manufacturers will pay to recover these.

Chapter Eight

Cylinder Scrapping

- Cylinders that are identified as being outside the rejection limits or beyond the economic cost of repair compared to the price of new cylinders should be processed for scrap. These cylinders should be gas freed before being scrapped and made totally unsuitable for further service.
- Scrap cylinders have been reported in some locations to be recycled back into the market which can result in them being unwittingly refilled. This can cause accidents and injury to filling plant operators and users. It is important therefore to ensure that scrapped cylinders are processed in such a way that they cannot be reused.
- Commonly used methods for destroying scrap cylinders include mechanical crushing, irregular cutting of the neck of the cylinder, irregular cutting of the body of the cylinder into two or more pieces or piercing, with hydraulically or pneumatically operated spikes, at least two 50 mm diameter holes in each separate part of the body of the cylinder. (For guidance, see EN 12816). Mechanical crushing to flatten the scrap cylinders is also an accepted best practice for scrapping cylinders.
- The serial numbers of scrap cylinders should be kept on record, including reasons for scrapping, and also details of the buyer of scrap cylinders. The data can be used for analysis of root causes and development of corrective actions to minimise cylinder scrapping rate. The record is also useful to track sources of recycled scrap cylinders in case these turn up in the plant.

Appendix One

LP Gas Properties and Hazards

1.4.1 **LP Gas** comprises Commercial Propane and Commercial Butane, and mixtures thereof. They are hydrocarbon gases that can be changed into a liquid and changed back into a gas by the simple application and release of pressure.

1.4.2 **Density** - LP Gas vapour is heavier than air and tends to gather at low areas such as drains, pits, cellars and other depressions. As a colourless liquid, LP Gas occupies around 0.4% of its vapour volume, but is about half the density of water and will float on water before vaporising.

1.4.3 **Cooling effect** - LP Gas liquid vaporises and cools rapidly; it can therefore inflict severe cold burns if it comes in contact with bare skin.

1.4.4 **Non-toxic** - LP Gas is not toxic. However it has an anaesthetic effect when mixed in high concentrations with air. The greater the concentration (i.e. as available oxygen declines), the greater the risk of asphyxiation.

1.4.5 **Smell** - What people know and recognise as the 'LP Gas smell' is usually added to LP Gas before distribution. This smell can be detected if the LP Gas content of air is as little as 0.4% (or just 20% of the lower limit of flammability). However, odour is not the only means of detection. Large leaks will also be obvious through hissing or condensation or frosting around the leak; small leaks will show up as bubbles if detergent mixed with water is applied to the suspected leak area. **NEVER try to detect leaks with a naked flame or other kinds of ignition.**

1.4.6 **Flammability** - LP Gas can ignite when it forms between 2 and 10% of a vapour/air mixture, so the risks associated with poor handling, storage or usage should be obvious. Uncontrolled ignition of LP Gas can cause serious fires or explosions (i.e. if ignited within a confined space). A fire started some distance from an LP Gas leak can very quickly travel back to the source of the leak itself. An LP Gas cylinder involved in a fire may overheat and rupture violently. The power and intensity of an LP Gas fire or explosion should never be underestimated.

1.4.7 **Liquid Expansion** - LP Gas liquid has a high coefficient of expansion. Tanks, cylinders, pipelines and equipment must be protected against the high pressure resulting from liquid expansion with temperature rise.

Table 1 overleaf shows some typical physical properties of LP Gas

Typical Characteristics of Propane and Butane **PHYSICAL PROPERTY**		**COMMERCIAL PROPANE**	**COMMERCIAL BUTANE**
Litres/tonne of liquid at 15^{O}C Litres/ton of liquid Litres/kg of liquid US barrels/tonne		1,965 – 2,019 1,996 – 2,051 1.96 - 2.02 12.4 – 12.7	1,723 – 1,760 1,750 – 1,788 1.72 - 1.76 10.8 – 11.1
Relative density (to water) of liquid at 15^{O}C		0.50 - 0.51	0.57 - 0.58
Ratio of gas to liquid volume at 15^{O}C and 1015.9 mbar		274	233
Relative density (to air) of vapour at 15^{O}C and 1013.25 mbar		1.40 - 1.55	1.90 - 2.10
Volumes of gas/air mixture at lower limit of flammability from 1 volume of liquid at 15^{O}C and 1015.9 mbar		12,450	12,900
Boiling point ^{O}C		Minus 45	Minus 2
Vapour pressure at 0^{O}C	barg	4.5	0.9
Vapour pressure at 15^{O}C	barg	6.9	1.93
Vapour pressure at 38^{O}C	barg	14.5	4.83
Vapour pressure at 45^{O}C	barg	17.6	5.86
Upper limit of flammability,	% v/v	10.0	9.0
Lower limit of flammability,	% v/v	2.2	1.8
Gross calorific value	MJ/m^3 dry	93.1	121.8
	BTU/ft^3 dry	2,500	3,270
	MJ/kg	50.0	49.3
	BTU/lb	21,500	21,200
Net calorific value	MJ/m^3 dry	86.1	112.9
	BTUu/ft^3 dry	2,310	3,030
	MJ/kg	46.3	45.8
	BTU/lb	19,900	19,700
Latent heat of vaporisation Latent heat of vaporisation	kJ/kg at 15 °C BTU/lb at 60 °F	358.2 154	372.7 160

Appendix Two

Calculation for Maximum Fill Quantity

A.2.1 Calculation of Safe Filling by Weight

The safe fill weight is given by:

$Q_f = 0.97 \times V \times g_l$ - (allowance for tare and filling errors)

Where: Q_f = maximum safe fill, kg

V = water capacity of the cylinder, litres

g_l = density of LP Gas at the assessed temperature, kg/litre

Densities of commercial LP Gases vary considerably and in the above equation, the lowest value in the product specification range should be taken to ensure safe filling at all times. Where the proper facilities exist it is possible to control the density by mixing product. This can give great cost savings in marginal cases, e.g. 14.5 kg versus 15 kg into a 30 litre cylinder.

The actual safe fill quantity used in filling operations in which the quantity is expressed as a mass should be rounded down to not less than the nearest 0.1 kg e.g. a calculated safe fill of 11.19 kg would become 11.1 kg.

A.2.2 Calculation of Safe Filling by Volume

The safe filling volume is given by:

$V_f = 0.97 \times V \times g_i / g_L$ - (filling and tare weight errors)

Where: V_f = maximum safe fill volume, litres

V = water capacity of cylinder allowing for internal fittings, litres

g_i = density of LP Gas at assessed temperature, kg / litre

g_L = density of LP Gas at lowest possible fill temperature, kg / litre

A.2.3 Fill Errors

Measured tare weights should be rounded down as a margin of safety for use in safe calculations as shown in Table A.2.3 below. Rounding down means reducing the tare weight scale reading to the nearest scale division (of a typical cylinder filling machine) stated in the table, e.g., a tare weight scale reading of 5.186 kg would be recorded as 5.15 kg whilst a reading of 5.10 kg would not be rounded down.

Table A.2.3 Fill Error

CYLINDER LP GAS CAPACITY, KG	ROUND DOWN FACTOR, kg
Up to 10kg	0.05
Above 10kg and up to 20kg	0.10
Over 20kg	0.20

A.2.4 Fill Tolerances

Typical filling tolerances are shown in Table A.2.4 below. Local regulations may require other tolerances to be adopted. When calculating the safe fill quantity the positive tolerance is to be deducted in the equation.

Table A.2.4 Fill Tolerances

CYLINDER LP GAS CAPACITY, KG	ROUND DOWN FACTOR, kg
Below 15kg	+ 0.10/ -nil
15kg and above	+ 0.20/ -nil

Note: +/- tolerances may be adopted for cylinder fill quantity (e.g. +/- 0.1 kg) where permitted by local regulations.

Appendix Three

Description of Steel Cylinder Defects

DEFECTS	DESCRIPTION
BULGE	Visible swelling of the cylinder
DENT	A depression in the cylinder that has neither penetrated nor removed metal, and its width at any point is greater than 2% of the external cylinder diameter. See Fig A.3.1 below
GOUGE	A sharp impression where metal has been removed or re-distributed
INTERSECTING CUT OR GOUGE	The point of intersection of two or more cuts or gouges
DENT CONTAINING CUT OR GOUGE	A depression in the cylinder within which there is a cut or gouge. See Fig A.3.5 below
CRACK	A split or rift in the cylinder shell
LAMINATION	Lamination may show itself in the form of crack or bulge
ISOLATED CORROSION PITS	A pitting of metal occurring in isolated areas. A concentration not greater than 1 pit per 500 mm^2 of surface area
AREA CORROSION	Reduction in wall thickness over an area not exceeding 20% of the cylinder surface
GENERAL CORROSION	A reduction in wall thickness over an area exceeding 20% of the cylinder surface. See Fig A.3.2 below
CHAIN PITTING OR LINE OR CHANNEL CORROSION	A series of pits or corroded cavities of limited width along the length or around the circumference
CREVICE CORROSION	Crevice corrosion occurs in the area of the intersection of the foot-ring or collar with the cylinder
DEPRESSED BUNG	Damage to the bung, which has altered the profile of the cylinder
ARC OR TORCH BURNS	Burning of the cylinder base metal, a hardened heat affected zone, the addition of extraneous weld metal, or the removal of metal by scarfing or crating
FIRE DAMAGE	Excessive general or localised heating of a cylinder usually indicated by: a)Charring or burning of paint b)Fire damage of the metal c)Distortion of the cylinder d)Melting of metallic valve parts e)Melting of any plastic components, e.g. data ring, plug or cap See Fig A.3.3 below
Weld Leaks	Pinhole leaks in welds

Source: ISO 10691:2004 (The rejection limits will be found in this ISO document)

Fig. A.3.1 Examples of dent defects

Fig. A.3.2 Examples of corrosion defects – General (right) and Corrosion pits (left)

Fig. A.3.3 Examples of fire damage

Fig.A.3.4 Example of collar damage

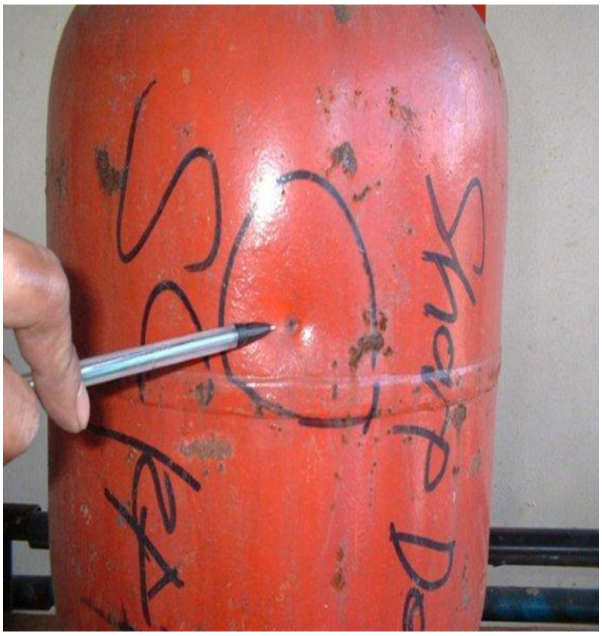

Fig.A.3.5 Example of gouge defect

Appendix Four

Procedures for Gas-freeing Cylinders

A.4.1 Emptying of Liquid

Evacuate liquid from the cylinder using a compressor and holding tank before pumping back to main storage.

A.4.2 Gas Free

Reduce the vapour content to less than 1% of the lower flammable limit by volume in air. The gas content should be measured by an explosimeter which is regularly calibrated for accuracy according to the manufacturer's instructions. Cylinders which have been gas freed should be clearly identified and controlled by a system which prevents mixing of gas free and non-gas free cylinders. Any cylinder which is gas-freed and then not immediately processed should be re-certified gas-free before reprocessing. Proper care should be taken to avoid contamination of the environment by wastewater, oily residues, odour emissions, etc. Gas-freeing can be achieved by one of the following methods:

A) Using Steam

- Remove the valve using the proper tool for the valve type.
- Invert the cylinder over a collecting system to drain out any heavy ends which might be present.
- Insert a steam probe of about half the bung diameter into the cylinder. The cylinder and steaming equipment should be electrically bonded and earthed since steam jets generate static electricity.
- Continue steaming for at least 15 minutes.
- Check and certify that the cylinder is gas free.

NOTE: If the cylinder contained heavy ends, a flammable atmosphere could re-generate in the cylinder after the above procedure. If the presence of heavy ends was suspected, cylinders should be re-checked for the gas free condition 15 minutes after the first test.

B) Using Water

- Remove the valve using the proper tool for the valve type.
- Invert the cylinder over a collecting system to drain out any heavy ends which might be present.
- Fill the cylinder with water and allow to stand until no more bubbles are seen.
- Empty out the water into a suitable collecting system for treatment.
- Re-fill the cylinder with fresh water and allow to stand for 24 hours.
- Empty out the water into a suitable collecting system for treatment.
- Check and certify that the cylinder is gas free.

Appendix Five

Procedures for De-denting of Cylinders

This procedure should only be done by qualified personnel, after gas freeing (see Appendix Four):

- Charge the cylinder with nitrogen to a maximum of 5.5 bars. A pressure relief valve should be fitted into the nitrogen supply line.
- Gently apply flame from an oxygen-LP Gas torch to the dent. The flame should be neutral since an oxygen rich flame will burn the metal of the cylinder.
- Maintain the flame until the dent is seen to move out.
- Remove the flame and if necessary dress the surface with light blows using a wooden mallet.
- Allow the cylinder to cool in still air.

The temperature for de-denting should be about 850°C. The temperature can be assessed from the colour of the steel during heating using the table below. Cylinders heated to above this temperature can be damaged by cracking. Overheated cylinders should be scrapped.

The actual pressure of nitrogen required to remove a dent at this temperature will vary with the size and shape of cylinder and this can be found by experience. The maximum pressure should not exceed 5.5 bars.

COLOUR	TEMPERATURE RANGE °C
Dark cherry red	700 - 750
Cherry red	750 - 825
Bright cherry red	825 - 875
Bright red	900 - 950
Orange	950 - 1,000
Light orange	1,000 - 1,050
Lemon	1,100 - 1,200
White	1,200 - 1,300

Appendix Six

Procedure for Requalification of Cylinders

A.6.1 Interval Between Periodic Requalification

The following criteria should be addressed when determining the interval between periodic requalification in applying procedures such as ISO 10464 and EN 1440 for requalification:

A.6.1.1 Whether the cylinders are designed, manufactured and tested to internationally recognised standards, e.g. ISO22991, a national standard or an equivalent

A.6.1.2 Whether there is a system of external protection against corrosion, which is being maintained

A.6.1.3 Whether the cylinders are being filled in accordance with the criteria contained in an internationally recognised standard, e.g. ISO 10691, a national standard or an equivalent

A.6.1.4 Whether the cylinders are filled with LP Gas of a quality in accordance with a specification/standard acceptable to a competent body, such that internal corrosion is not caused

A.6.1.5 Whether the cylinders are under the control of filling plant responsible for their distribution, filling and maintenance

A.6.1.6 When criteria A.6.1.1 to A.6.1.5 inclusive is fulfilled, a 15 year interval could apply but subject to the approval of a competent authority.

A.6.1.7 When criteria A.6.1.1 and A.6.1.2 are fulfilled, a 5 year interval could apply.

A.6.1.8 When criteria A.6.1.1 and A.6.1.2 and at least one of either, A.6.1.3, A.6.1.4, or A.6.1.5 are fulfilled, a 10 year interval could apply.

A.6.2 Internal Visual Inspection

A.6.2.1 Preparation of Cylinders

- The cylinders should be emptied of liquid and de-pressurised in a safe and controlled manner before proceeding.
- Cylinders with inoperative or blocked valves should be brought to a place for safe valve removal.
- Valves should be removed from cylinders for inspection and maintenance.

A.6.2.2 Procedure

- Where necessary, residual liquid, loose scale, and any other foreign matter should first be removed from the interior. Cylinders should then be inspected internally for any sign of corrosion or other defects that may affect their integrity, using a safe inspection lighting system with appropriate internal illumination.
- Cylinders showing signs of internal corrosion, unless these signs are just surface rust, should be scrapped.
- If cleaning is required care should be taken to avoid damaging the cylinder walls. Cylinders should be re-inspected after cleaning.

A.6.3 Hydraulic test

A.6.3.1 Test Fluid

- A fluid should be used as the test medium, e.g. water.

A.6.3.2 Preparation of Cylinders

- The cylinders should be emptied of liquid and de pressurised in a safe and controlled manner before proceeding.
- Cylinders with inoperative or blocked valves should be brought to a place for safe valve removal.
- Valves should be removed from cylinders for inspection and maintenance, or replacement.
- If the cleaning method involves the wetting of the outside surface, the outside surface should be completely dried before commencing the hydraulic test procedure.

A.6.3.3 Test Equipment

- All rigid pipework, flexible tubing, valves, fittings, and components forming the pressure system of the test equipment, should be designed to withstand a pressure of 1.5 times the maximum test pressure of any cylinders to be tested. Flexible tubing should have characteristics to prevent kinking.
- Pressure gauges should be used to read the cylinder test pressure with an accuracy of at least 2%. They should be checked at regular intervals and in any case not less frequently than once a month. The design and installation of the equipment, and the cylinders connected to it should ensure that no air is trapped in the system.
- All joints within the system should be leak tight.
- A device should be fitted to the test equipment to ensure that no cylinder is subjected to pressure in excess of its test pressure by more than the tolerance given.

A.6.3.4 Procedure

- The test pressure should be established from the marking on the cylinder.
- More than one cylinder may be tested at a time as long as they all have the same test pressure.
- Before applying pressure, the external surface of the cylinder should be in such condition that any leak can be detected. The cylinder should be positioned so that welds are visible during the test.
- The pressure should be increased gradually in the cylinder until the test pressure is reached.
- The test pressure should not be exceeded by more than 10% or 2 bar, whichever is the lesser.
- The test pressure should be held for the time necessary to carry out the test.
- If there is a leakage in the pressure system, it should be corrected and the cylinders retested.
- Cylinders that do not leak or show any permanent distortion should be deemed to have satisfied the requirements of the hydraulic test.
- Any cylinders that fail should either be rejected or, in the case of cylinders which leak through pinholes at the weld, be examined by a competent person to determine whether they can be repaired by welding.

References

WLPGA - Guidelines for Good Safety Practices in the LP Gas Industry

WLPGA - Guidelines for Good Business Practices in the LP Gas Industry

ISO 22991 - Gas cylinders -Transportable Refillable Welded Steel Cylinders for Liquefied Petroleum Gas (LPG) - Design and Construction

ISO 10691 - Gas Cylinders - Refillable welded steel cylinders for liquefied petroleum gas (LPG) - Procedure for checking before, during and after filling.

EN 1439 - LPG equipment and accessories - Procedure for checking LPG cylinders before, during and after filling

ISO 10464 - Gas Cylinders - Refillable welded steel cylinders for liquefied petroleum gas (LPG) - Periodic Inspection and Testing

BS 5355: 1976 - Specification for filling ratios and developed pressures for liquefiable and permanent gases

EN 1442 - LPG equipment and accessories - Transportable refillable welded steel cylinders for liquefied petroleum gas (LPG) - Design and construction, European Committee for Standardisation

EN 1440 - LPG equipment and accessories - Transportable refillable welded steel cylinder for LPG - Periodic requalification,
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UKLPG Association - Code of Practice 12 Recommendations for the Safe Practice in the Design and Operation of LPG Cylinder Filling Plants

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