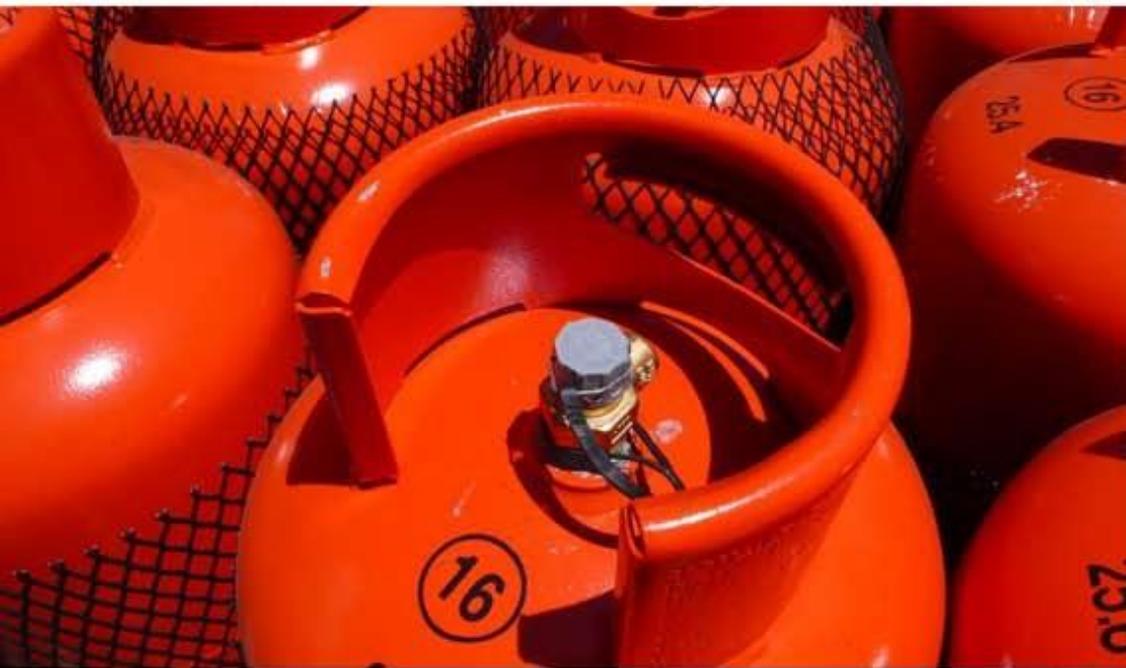


Report on Managing the Life Extension of LPG Cylinders

GOOD INDUSTRY PRACTICES



The World LPG Association

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

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

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

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Chapter One

Background and Purpose

The World LPG Association's (WLPGA) Global Cylinder Network (GCN) group published a report in 2015 on the requalification of LPG cylinders (<http://www.wlpga.org/publication/report-on-the-testing-and-requalification-of-lpg-cylinders/>).

Fifteen countries were selected, which represented a good cross-section of the global LPG cylinder markets, and data and information about the LPG cylinder requalification processes in each of those countries were collected.

The objective of that report (phase one) was to compare the cylinder requalification processes in each of the fifteen countries and provide information that might lead to improvements.

The key findings of the report were:

- The fifteen countries selected had an estimated one billion LPG cylinders in circulation, around two thirds of the estimated total global cylinder population
- The cost of LPG cylinders depends on size but is typically in the range of US\$10 to \$100 each
- The environment for LPG cylinders in circulation is different for each country
- The estimated cost for requalifying the cylinders in all fifteen countries was nearly US\$1billion/year over a projected thirty-year period (this is the average annual cost for requalifying the cylinders in the fifteen countries over a thirty year period to take into account the different requalification periods in each country)
- Each country reported a different method, and requalification period, for cylinders ranging from one year to fifteen years
- Some countries have a finite age limit for cylinders, and once they reach that period they are withdrawn from the market and scrapped
- Other countries do not, and keep the cylinder in circulation as long as it meets the requalification requirements
- Some countries repair valves when the cylinder is requalified, other countries replace them
- Most countries adopt a strict process for scrapping cylinders to ensure they are never reused
- There are opportunities for improving the cylinder design, manufacturing standards, maintenance and handling procedures in most countries in order to extend the life of the cylinder asset

In view of the costs involved in keeping an LPG cylinder circulating in the market in a safe and sustainable manner it was agreed by the GCN to have a follow up to this report, phase two.

Phase two would identify ways to extend the life and reduce the operating costs of keeping an LPG cylinder in circulation without compromising safety.

It was agreed that phase two should not attempt to present a case for extending the requalification period for LPG cylinders. Experience in Europe has demonstrated the difficulties of such an approach in one region. Attempting a global approach would be impractical and flawed.

The first phase of the report highlighted the cost of requalifying LPG cylinders is around US\$1 billion year across the fifteen countries. This is in addition to all the other costs involved in keeping the cylinder in circulation.

It was agreed by the GCN that there are opportunities to improve the management of LPG cylinders, extend their useful life and reduce the cost of managing the LPG cylinder asset without compromising safety of operations.

It was therefore proposed that this would be the scope of the second phase of this work. The main audience for the report will be companies that own, manage, and have responsibility for LPG cylinder assets.

The main objective of phase two is to provide a 'toolkit' of information that could be used in an audit of current practices with the aim of improving the way LPG cylinders are managed, with the specific aim of reducing costs, without compromising the safety of the business.



Cylinders tie up a lot of capital in the LPG business

If these improvements can be demonstrated and quantified they might be used to argue for a change in requalification methods, or requalification periods, but this is not a specific objective of phase two.

Phase two examines the various influences that impact the life of a cylinder starting with the design and manufacture, through its life, to the decision to dispose of it. This includes all aspects of filling, storage, handling, distribution and use. It also includes the impact of the product, and climatic and working conditions.

Phase two highlights some typical bad practices that might shorten the life of a cylinder and provides some mitigating measures and solutions to deal with them. It also highlights some examples of good practices that might prolong the life of a cylinder.

Phase two also includes details from the fifteen countries of the procedures for inspection, repair, maintenance, requalification and disposal of LPG cylinders.

Some of the general information included in phase one of the report has been repeated here for convenience.

Chapter Two

Summary

- This report is a follow up to an original report that compared the requalification processes for LPG cylinders in fifteen countries
- One of the conclusions of the original report was that approximately US\$1billion/year is being spent on requalifying LPG cylinders and that significant cost savings could be made if the life of a cylinder could be extended
- This report provides feedback from the fifteen countries on how they manage LPG cylinders with the objective of providing guidelines for extending cylinder life (see APPENDIX ONE TO FIFTEEN)
- LPG cylinder manufacturers were also contacted to provide their views on how the life of LPG cylinders could be prolonged (see APPENDIX SIXTEEN)
- The report includes examples of the inspection procedures in the fifteen countries as the LPG cylinders enter the filling plants, as well as details of the requalification procedures
- The fifteen countries were also asked for examples of good practices that might lead to a longer cylinder life and examples of bad practices that might shorten the life of a cylinder (APPENDIX SEVENTEEN)
- Nine of thirteen countries that responded to the question indicated that 'corrosion and dents' from the distribution channel were the main reasons for scrapping cylinders
- Most of the countries that applied a zinc metalised coating had low levels of corrosion
- The report concludes that to extend the life of an LPG cylinder there are four main areas to focus on:
 - Design and Manufacture
 - Inspection and maintenance
 - The Product
 - Distribution channel
- Details of how improvements might be made in each of these areas are included in the report along with full feedback from each of the fifteen countries together with comments from some cylinder manufacturers

Chapter Three

The Countries

Fifteen countries were selected for the original report (phase one) and these were all contacted again for phase two.

The countries were chosen to represent a cross section of markets, climatic conditions, cylinder sizes and designs, applications and cultures.

The fifteen countries were:



In phase two of this report the countries were contacted with some follow up questions (see APPENDIX SEVENTEEN) and their responses are included in the following respective APPENDICES at the back of this report:

Australia	APPENDIX ONE	Japan	APPENDIX SIX	Sri Lanka	APPENDIX ELEVEN
Brazil	APPENDIX TWO	Mexico	APPENDIX SEVEN	Taiwan	APPENDIX TWELVE
Cote d'Ivoire	APPENDIX THREE	Morocco	APPENDIX EIGHT	Turkey	APPENDIX THIRTEEN
India	APPENDIX FOUR	Philippines	APPENDIX NINE	UK	APPENDIX FOURTEEN
Indonesia	APPENDIX FIVE	South Africa	APPENDIX TEN	USA	APPENDIX FIFTEEN

The follow up questions concerned the process for routine inspection of checking LPG cylinders as they enter the filling plant and for requalification of cylinders.

The countries were also asked to provide at least one example of bad practices in the country that leads to a shorter cylinder life and at least one example of good practices that leads to a longer cylinder life.

In addition, some LPG cylinder manufacturers were contacted and asked what the key issues were to ensure longevity of a cylinder life from a design and manufacturing point of view. Their feedback is included in APPENDIX SIXTEEN.

Chapter Four

Methodology

A short follow up questionnaire was developed, agreed and circulated to WLPGA member focal points in each country. This is included in APPENDIX SEVENTEEN.

As with phase one, phase two of this report is based on a desk top study.

The fifteen country focal points were then asked to respond to a questionnaire. The information received back from each country is attached in APPENDICES ONE TO FIFTEEN

Feedback from some LPG cylinder manufacturers contacted is included in APPENDIX SIXTEEN.

The timetable for the report is shown in the chart below, with the final version to be available for the GCN meeting in Florence in October 2016.

An interim report was presented to the GCN committee in Australia in May 2016

Activity	Feb	Mar	Apr	May	June	July	Aug	Sept
Confirm 15 countries under review								
Review historic studies								
Develop and agree questionnaire								
Issue questionnaire								
Gather information								
Contact cylinder/valve manufacturers								
Report interim results to GCN								
Analyse data								
Prepare draft report								
Finalise report w/steering committee								
Issue report								

Chapter Five

Some General Information



Refer to the above guide for information on LPG cylinder maintenance, repair & requalification

LPG is a product which is generally stored in a steel or composite cylinder. This steel or composite packaging is more expensive than the contents.

The WLPGA have published a *Guide to Good Industry Practices for LPG Cylinder Management* which contains some relevant information about LPG cylinder maintenance, repair and requalification.

It is recommended to read the above guide in conjunction with this report if a review of cylinder management and requalification procedures is being undertaken.

An LPG cylinder has to be designed to contain product under pressure, be robust enough to withstand the daily handling in the distribution channel, be subjected to extremes of temperature and other weather conditions, and yet

still be presentable to the consumer.

Most steel LPG cylinders are constructed in two or three pieces and are of welded construction.

The basic design has changed little since its introduction in the early 1900's although steel technology has enabled the cylinder to be made from lighter alloys resulting in a lower tare weight.

The introduction and addition of plastic into the steel cylinder design has encouraged a more modern look for steel cylinders. Plastic handles makes the carrying of steel cylinders easier.



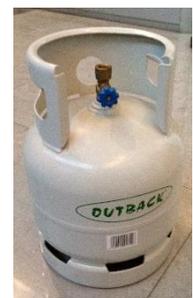
Composite cylinders are more resistant to corrosion, lighter in weight and allow the contents to be seen through a translucent body

Composite cylinders take that modern look a step further and provides a significant reduction in tare weight as well as giving excellent corrosion protection while, in some cases, allowing consumers to see the level of the contents through the translucent body.

Although they are still quite new to the LPG industry the number of composite

cylinders in circulation worldwide is estimated to be between 12 and 14 million.

Ensuring the cylinder is in a presentable condition makes good business sense because it encourages good handling in the distribution channel. It also protects the brand and the asset value of the company.



Most of the smaller LPG steel cylinders are constructed in two-pieces



The use of plastic with steel on LPG cylinders has been a more recent development

If the cylinder has been condemned, or has been deemed to have reached the end of its useful life through a mandatory life expectancy, it is essential that it is never allowed to re-emerge into any LPG market, either in the country of use or in any other country that might be tempted to use it.

The subject of disposing of condemned LPG cylinders is included in this report in order to help prevent the illicit re-use of scrapped LPG cylinders.

In developing countries many consumers often have to rely on traditional fuels, such as wood and charcoal, because they have no access to modern energy or they simply cannot afford it.

For the residential and small commercial markets, the use of LPG in cylinders enables this modern energy to be brought directly to the consumer. This portability is one of LPG's most important properties.

LPG cylinders can contain as little as 1kg of LPG but are normally in the 3kg to 15kg range. Commercial consumers will typically use cylinders that contain up to 50kg of LPG.

The tare weight of an LPG cylinder will often be close to the weight of the contents, or half the gross weight when (80%) full. This has an impact on the consumer proposition as well as the storage and handling challenges.

Although domestic LPG cylinders containing up to 15kg of LPG are common, with a gross weight approaching 30kg when full, they require a strong pair of arms to lift them. If dropped they can be easily damaged, especially around the shroud and foot-ring. LPG cylinders are delivered to the consumer through a complex distribution channel involving wholesalers, dealers, agents and retailers. It is not unusual for an LPG cylinder to be handled several times between leaving the LPG cylinder filling plant and reaching consumer.

Consumer research into the residential sector conducted several years ago in China for a 'cash and carry' project concluded that the biggest LPG cylinder that a woman (the target market in the study) could physically carry back to her home was one containing 4.5kg of LPG. This was because the gross weight of the full 4.5kg cylinder was under 10kg, the same weight of a large bag of rice, which she could already manage to carry home. Anything larger than that would have required some form of home delivery service.

The weight of steel cylinders can be reduced through the use of thinner, stronger alloy steel. The introduction of composite cylinders has presented the consumer with the choice of a lighter cylinder.

Aluminium cylinders enable the tare weight to be reduced by about a third compared to an equivalent steel cylinder. These alternatives to steel are, however, more expensive. Aluminium is also susceptible to internal corrosion from refinery contamination products.

More recently some cylinder manufacturers have succeeded in producing cylinders in one piece through a deep drawing technique. This eliminates the need for welding the body.

The key advantage of an LPG cylinder is its portability, but that is also one of its biggest threats as moving the cylinder through the cycle of use and refilling inevitably inflicts damage that can reduce its working life.

The smaller the cylinder the more likely it is to be damaged. Apart from the more frequent visits to the filling plant smaller cylinders tend to get thrown around more readily, especially in the distribution channel where controls are less strict.

Commercial and industrial cylinders containing up to 50kg of LPG are the most popular of the larger portable cylinders and require lifting aids as the gross weight when full can be close to 90kg. They are often moved by rotating them on the foot ring with the operator 'walking' with them.

The following chapter now deals with some of the factors that can influence the life of a cylinder. The information has been gathered from the fifteen countries under study, two cylinder manufacturers, the *Guide to Good Industry Practices for LPG Cylinder Management* and the GCN Steering Committee.



Aluminium cylinders reduce the tare weight but are known to be susceptible to internal contamination

Chapter Six

Factors impacting the life of an LPG Cylinder

The fifteen countries were asked to provide some good and bad examples - with photos where possible - that influence the life of an LPG cylinder. LPG cylinder manufacturers were also contacted to share their views on design and manufacturing issues that could influence cylinder life, especially if they were not under cost pressure.

There are very few buyers of new cylinders that have longevity in mind but almost always the question to cylinder manufacturers is 'how cheap can you make it?'

The feedback from the fifteen countries and the cylinder manufacturers who responded falls into four main areas:

- (A) Design and Manufacturing issues
- (B) Inspection and Maintenance Procedures
- (C) The Product itself
- (D) Managing the Distribution Channel

The first two areas [(A) & (B)] are more under the direct control of the LPG company, or asset owner. Poor decisions taken when choosing the size and specification of the cylinder, and where and how it will be manufactured, can play a major role in influencing the longevity of the asset.

Having acquired the cylinder, the way it is then inspected and maintained during its life will also have an impact.

LPG is a by-product from the refining of crude oil and the production of natural gas. When the natural gas is 'wet' and contains liquids, controlling the product quality of LPG is not the primary objective for the refinery manager and natural gas producer.

However, the quality of the LPG, (C) and how it is controlled does have an impact on the life of a cylinder. To an extent, this can be mitigated by supply contracts and being vigilant in quality control procedures.

The LPG distribution channel (D) is complex and involves several stakeholders and is from the feedback it is the area where most damage occurs to an LPG cylinder.

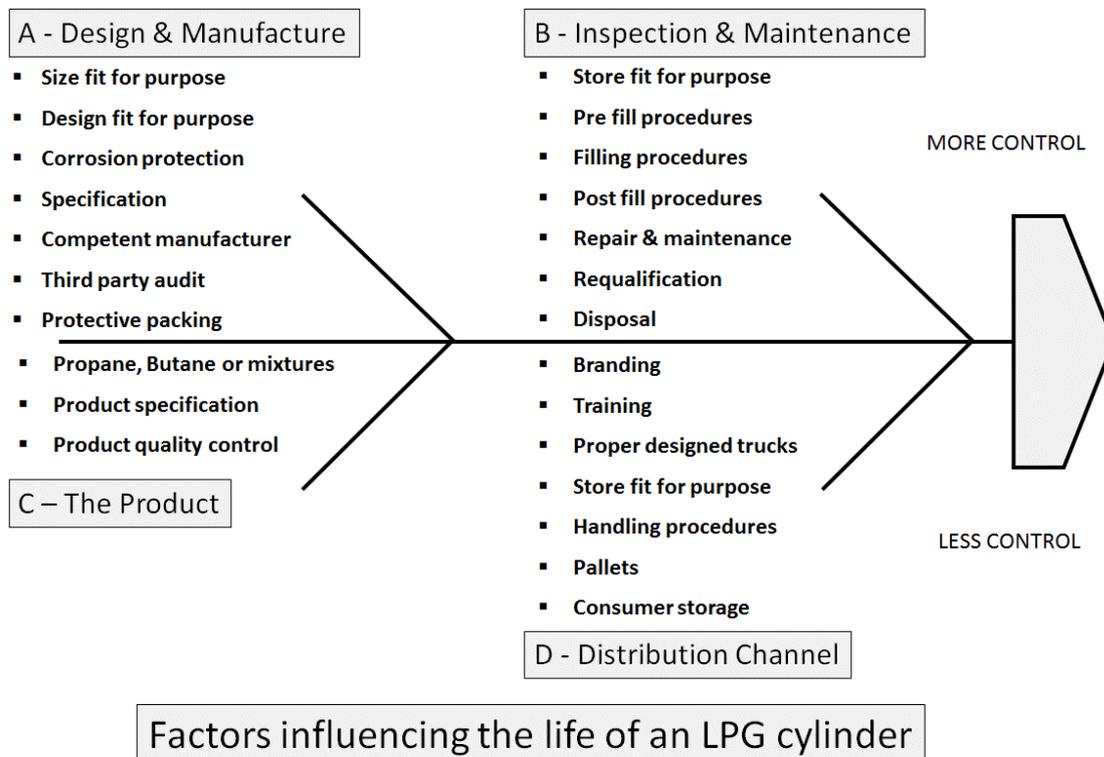
The way a cylinder is stored, handled and distributed during its working life, is something that can quickly lead to a deteriorating asset and an early grave.

This last area is perhaps the most challenging because it is something that is frequently outside of the direct control of the cylinder owner. However, the distribution channel is an area where influence can be applied through contracts service agreements and training.

Each of these four areas have been examined in detail and summarised in the chart below. A more detailed discussion has been included later in this chapter and, as has been mentioned earlier, full feedback from the fifteen countries and the cylinder manufacturers have been included in the Appendices.



A typical LPG distribution channel is complex



A - Design and Manufacture

A.1 Size fit for purpose

Selecting an appropriate size of cylinder (and valve type) for a particular market is important. If the cylinder is too small, it will lead to frequent visits to the filling plant, causing more wear and tear and leading to consumer complaints about the frequent interruptions caused by running out of gas. If the cylinder is too large, it will stay longer in the distribution channel – sometimes beyond its requalification date – and tie up capital, be less convenient for the consumer to manoeuvre, and create a higher barrier to entry for first time users due to the more expensive initial outlay.

One of the first decisions to take before purchasing a cylinder is “what size do I need?”. This decision is influenced by a number of factors not least the consumer. As has been mentioned the maximum size of cylinder that a consumer can comfortably carry will contain up to 5kg of LPG. The consumption patterns of the target consumer will need to be factored into the decision. A domestic family of four could typically use between 10-20kg/month of LPG for cooking.

Larger cylinders are used in the domestic market, although they require physical effort to lift when full. The Australian LPG market uses cylinders with 8.5kg of LPG, which are marketed through a consumer exchange programme, but these cylinders when full are not so easy to carry. The choice of cylinder size in Australia was driven by tradition because the origins of the 8.5kg cylinder go back to the 1940’s when the US exported 20lb cylinders to Australia.

In Indonesia the government’s kerosene to LPG conversion programme is based on a 3kg cylinder as a way to reduce cost and lower the entry barrier. As a result, some of the consumers using the 3kg cylinder have to change it every few days.

Another factor when choosing the size of a cylinder is the current size already being used in the market. Standardising on the size of cylinders, and valves, can facilitate filling plant design and handling methods. Having a variety of different sizes complicates this.

Standardising cylinder sizes and valve types within a business will lead to operational savings through opportunities with:

- Filling plants to automate facilities and operate efficiently
- Distribution trucks to optimize carrying capacity
- Distributors’ having uniform cylinder cages and display racks
- Procurement to achieve scale when sourcing

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

Self-closing clip-on valves 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. These valves are top filled and plastic dust caps are recommended to be fitted during storage and transportation to prevent entry of foreign matter.

Hand wheel operated valves are used with both domestic and commercial cylinders and are designed for different applications i.e. liquid fill, liquid service and vapour service.

The choice of valve will also be driven by a number of factors. Application, brand differentiation, cost, or perhaps government legislation. The cylinder will normally be fitted with the valve before being despatched from the factory. This ensures a gas tight connection. However, cylinders could be supplied by the cylinder manufacturer without the valve, or alternatively valves could be supplied to the cylinder manufacturer for fitting before despatch.

A.2 Design fit for purpose

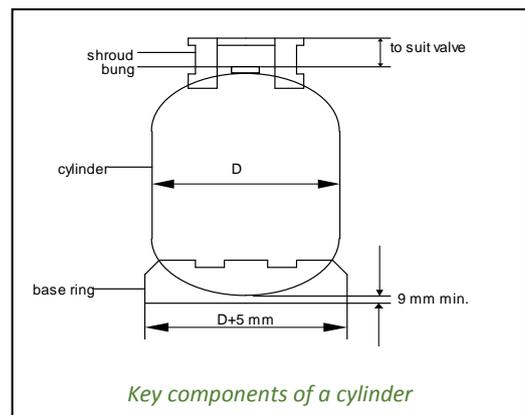
It is good practice to discuss the design of cylinder with the manufacturer. Steel cylinders are manufactured from coil which is stamped and drawn using dies and moulds. This tooling is expensive to produce and the steel will come in a standard width. Cylinder manufacturers will therefore prefer to standardise on the cylinder diameter (D opposite) if possible. Specifying a cylinder diameter, with a particular manufacturer, that matches their current production will reduce manufacturing costs that can be passed on.



Cylinder bodies are stamped from steel coil

If the cylinder is to be used with a particular LPG appliance it's important to make sure they are compatible.

When cylinders are travelling along a chain conveyor at a filling plant, or simply being stacked together in the distribution channel, there will be contact. If the foot ring has a slightly larger diameter (say 5mm), then contact will be more likely on adjacent foot rings than the cylinder bodies. Although there may be an argument against this, because of the additional cost and weight, the larger foot ring will help mitigate this 'body to body' contact.



Damage to cylinder bodies not only affects appearance but it also creates risk of corrosion. Foot rings can be replaced but repairing a cylinder body is more complicated and to be avoided if possible.

The only allowable hole in an LPG cylinder is where the valve is fitted. The quality of both the valve, and the thread on the boss on the top of the cylinder, is critical to ensure a gas tight fit. Liaison between cylinder, boss and valve manufacturer is important to ensure good compatibility.

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 boss (or bung) specification. The common specifications used are 3/4 inch NGT (National Gas Taper), DIN 477 and 3/4 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. This will cause damage to the threads and expensive repairs.



The quality control of the boss and valve threads is a critical item to avoid leakage in service

Having a good understanding of the market where the LPG cylinder is operating may influence the design. LPG cylinders operating in a very aggressive environment may lead to a change in choice of

material. Composite cylinders will not corrode and are ideal if the cylinder is operating in a salt water environment such as in a marine application or if they are being transported at sea by barge. The additional cost will be justified by a longer life compared to a steel cylinder operating in the same conditions.

Ventilation holes in the foot ring (to prevent corrosion from condensation) and comfortable holes in the shroud for carrying (to reduce injury and prevent dropping of the cylinder) are important features. An understanding of the type and size of valve being used is vital to ensure the shroud is high enough (to prevent impact damage on valves from the underside of cylinders being stacked on top).

A.3 Corrosion protection

LPG cylinders are susceptible to both internal and external corrosion. There is strong evidence linking the use of a zinc based corrosion protective base with a prolonged cylinder life.

The use of a zinc metallised based corrosion protective finish prior to the final painting of the cylinder is good practice but is not applied in every country surveyed.

India has very prescriptive advice. The application of a 37 micron (minimum) zinc coating should be followed by a coat of zinc chromate primer and another coat of super synthetic enamel paint. The total thickness of primer and enamel paint to be a minimum 30 microns. The total combined thickness should be minimum 67 microns. The colour and finish of the paint coating of steel cylinders is often linked to the brand in the country and synthetic enamel and powder coating are both commonly used.

Spray booths with water arresters were common ways to apply the finished coat.



Shot blasting before applying surface finish

The colour, and final paint finish on a cylinder is often a statement of the brand. As with any type of painting the preparation is as important as the final application of paint. The avoidance of slag at the welds, particularly around the shroud where water can remain, is important before the application of any paint.

Some LPG cylinder standards insist on the application of zinc metallisation on the bare metal before the top coat of paint is applied to improve the corrosion resistance of the cylinder. The depth of zinc metallisation should be specified, as many of the countries do, and the surface must be properly cleaned and prepared.

The use of galvanising is a very effective way of protecting against corrosion and is sometimes used for industrial cylinders that are subjected to heavier use.



Cylinders receiving top coat of paint

Galvanising of domestic cylinders is not often done as it restricts the use of colour as a branding tool.



Galvanised industrial cylinders

Preparation of the metal surface before any application of paint is critical. Shot blasting is an effective method.

One of the areas of the cylinder that is particularly vulnerable to corrosion is the base, under the foot ring. Cylinders are often stood on ground that is wet. For example, on soil or grass, if the vapourisation rate is severe, condensation may build up and if the foot ring has inadequate ventilation holes the moisture will remain and accelerate corrosion.



The application of a zinc metallised coating under the final paint finish will prevent this aggressive corrosion. The ventilation holes are small too in this cylinder

To compound this threat, the underside of the cylinder is not checked so frequently during its life. This allows corrosion to go undetected. Any cosmetic painting that is done at the plant tends to focus on the cylinder body but it is the underside of the cylinder, inside the foot ring, where corrosion can take place unnoticed.

A.4 Specification

LPG cylinders are manufactured across the world to various standards and many of these standards were mentioned in the previous report. They are also highlighted here in this report in the detailed responses from the fifteen countries. It is imperative that recognised standards are used to manufacture LPG cylinders. Input from the cylinder manufacturers is also included in this section.

The grade of steel used in cylinder manufacture must be compatible with the intended grade of LPG 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°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 and made available for future reference in case of any incident concerning material defects.

Examples of steel specifications used for welded steel cylinder manufacturing includes ISO 4978, EN 10120 or JIS G3116.



Tracking the quality of the steel used to make the cylinders is good practice in the event of failure

Retail chains that buy LPG cylinders to sell into exchange markets might be tempted to focus on meeting the minimum quality standards at lowest cost because they have no responsibility for maintenance of the cylinder once it leaves their store.

LPG marketing companies that retain ownership of the asset throughout its life have a greater need for quality because the cylinders circulate within their control.

LPG cylinder manufacturers are faced with different demands from their clients depending on who is ultimately going to own, and maintain, the asset.

A.5 Competent manufacturer

Companies planning to order new LPG cylinders should seek the necessary credentials from the cylinder manufacturing companies they approach for proposals. Apart from satisfying this initial screening the buyer would also be advised to seek referrals from other companies.

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.

Prior to the commencement of production, the manufacturer and buyer should agree and approve the applicable design code or standards, manufacturing drawings and specifications, and destructive and non-destructive testing requirements.



Final internal inspection of cylinder for contamination

It is always useful to have some traceability on the quality of the steel being used in the event of quality issues with the cylinder, and the need to investigate material failures.

Selecting an LPG cylinder manufacturer that has the competencies to produce a quality product is a key decision and one that can be taken following a thorough selection process. Referrals are useful and if the quantities are large a tender process might be used.

The feedback from the fifteen countries suggested they all used manufacturers that had been in the industry for some time and had good track records. In Indonesia

the LPG industry has grown rapidly over the last decade attracting local manufacturers to emerge. Some of these new companies will have formed alliances with more established international LPG manufacturing companies, but others will be very new to the LPG industry and lack experience.

A.6 Third party audit

It is important 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.

Consider using independent third party inspectors who can not only do random quality checks but also undertake quality control checks and audits. They will also assist with the relevant certificates.

The selection of a cylinder manufacturer will possibly involve a site visit to inspect the manufacturing process but once an order has been placed against the specification it is important to ensure that the product is produced accordingly.



An annealing oven at a cylinder manufacturer

Seeking support from a third party inspector will help ensure the cylinders are properly manufactured against the specification. Audits are also recommended.

One of the important tasks following any welding process is to anneal the cylinder to remove any stresses that may have built up. This is done using an annealing oven.

Unscrupulous manufacturers looking to cut costs have been known to omit this process. The absence of an annealing oven, or one that is cold, will indicate the absence of the annealing process.

The use of checklists to assist in controlling the manufacturing process is useful.

A.7 Protective packing

Cylinders manufactured and exported by road or sea need to be protected from damage during transit. A vessel on the high seas will move thousands of times during the voyage creating the opportunity for the cylinders to rub against each other and cause damage to the surface finish. This can be mitigated by specifying how the cylinders are packed before leaving the plant. The cylinders will generally be stacked on pallets. Tight shrink wrapping will prevent movement.



Specifying adequate packing instructions will prevent damage to cylinders during shipping



Rubber bands being used on cylinders for protection against abrasion

In order to maximise the number of cylinders in a container they might be packed individually in a horizontal position which increases the chance of damage because of the manual handling. In extreme cases cylinders may be packed in individual cardboard boxes before shrink wrapping.

Some countries use large rubber bands fitted horizontally around the cylinder to prevent impact damage. The danger of using this technique is that it allows for water to get trapped inside the top of the rubber band when exposed to weather. This creates a higher level of corrosion risk at that point.

B - Inspection and Maintenance

Controlling the quality of the processes to ensure what is expected is what is delivered is a key factor in the life of a cylinder. Apart from the quality control procedures applied during the manufacturing process described in A above it is equally important once the cylinder commences its working life.

In some countries, such as the US and Australia, empty LPG cylinders are exchanged by the consumer for full ones. In this situation the consumer has 'virtual' ownership of the cylinder because every time he or she buys another full cylinder of gas they are using a different cylinder. Although the consumer may be the original owner, the ongoing maintenance will be the responsibility of the LPG marketing company conducting the refilling.

Where these exchange programmes operate, the consumer may have purchased the initial empty cylinder from a retail outlet. This new empty cylinder will be placed in a cage and swapped for a full (different) cylinder. Responsibility for maintenance lies with the LPG marketing company that receives the cylinder into its plant and would apply all the necessary checks that they would normally apply if it were their own. This reflects the 'virtual' ownership that the consumer has.

Once the cylinder has been unpacked, inspected and released into service it then comes under the control of the asset owner.

B.1 Store fit for purpose

New cylinders arriving in the retail store or at the LPG plant will be unpacked and inspected for damage in transit and checked against the specification. After they have been filled and put into the market they face the physical challenges of moving through the distribution channel to the consumer and then back again for refilling.

Cylinders are designed for external use but it is good practice to store them on well drained hard surfaces and not wet soil which can accelerate corrosion on the base.

They should also be managed like any other consumables and marked and segregated properly.

New cylinders will have all their data, or 'birth certificate', permanently marked on the shroud and this will include their date of manufacture. The time towards the requalification period starts once that date stamp is applied and it is important to ensure the cylinder is not left unnecessarily idle in a filling plant.

Cylinders that are segregated for repair, and are still within their qualification period, should be treated more urgently than those awaiting requalification.

Another important point is that empty cylinders at a filling plant should also be treated as if they contained product. Even an empty cylinder will contain LPG vapour and by treating it as if it contained liquid will avoid any potential accidents.

Cylinders that have been condemned must be quarantined and kept well away from working stock to prevent accidental reintroduction into the market.

B.2 Pre fill procedures

Pre-filling inspection is carried out to ensure everything is in order before the cylinder is refilled. There are a number of procedures at this stage that will ensure the cylinder is fit for purpose and prohibit it from moving into the refilling area unless ready.

Prefilling inspections carried out in Morocco highlight whether:

- Identification and/or the date of the last hydraulic retest are no longer legible
- Date of construction is illegible or nonexistent
- Nature of the marked product on the cylinder is different from the product being used to fill (e.g. an LPG cylinder designed for butane entering a propane filling line)
- Foreign cylinders, i.e. the brand of the LPG cylinder is different from the brand of the operator of the filling plant
- Defective or damaged valve (e.g. blocked, broken handle, valve stuck, distorted stem, loose components)
- Hydraulic retesting (these cylinders to be prepared and presented to an Inspector approved by the Ministry of Energy and Mines)
- Unacceptable distortion (any swelling of the bottle, corrosion, pressed neck, impact damage on the weld, deep penetration, any perforation or deformation that may affect the strength of the cylinder)
- Deformed or damaged shroud or foot ring

- Leaks
- Cylinders requiring washing and/or painting

Most of the pre-filling inspections are visual and rely on the competency of the operators to ensure accurate and consistent results. Apart from being a liability, a cylinder that is deemed to have passed some of these inspections – when in fact they should have failed – will impact on the life of a cylinder because it has avoided the need for repair and maintenance to keep it fit for purpose.

B.3 Filling procedures

LPG cylinders are never filled completely. They will typically be filled to about 80% capacity in order to leave space for liquid expansion in the event they are subjected to heat, for example by being left out in the sun, or being adjacent to a fire. Accurate measuring when filling cylinders is important to eliminate overfilling and possible deformation if the cylinder is subjected to excessive hydraulic pressure. Any under filling is to be avoided to ensure compliance with any consumer weights and measures regulations and to maintain brand image.

Cylinder filling procedures include a regular visual check to verify that cylinders are in a fit state to continue being in service. This check should be carried out by a competent person prior to the actual filling process on every occasion the cylinder is returned to the filling plant.

Cylinders may be rejected as being unfit for filling for a number of reasons, e.g. the cylinder is not to an acceptable standard (i.e. unacceptable damage, unrecognised owner, inadequate pressure rating, dimensionally unsuitable for the filling process, unsuitable valve, date of expiry of hydraulic test, etc.).

Cylinders which are not designed to be filled at the plant should be segregated and appropriately redirected or disposed of.

Third party cylinders should be returned to their owners and cylinders of unknown origin and ownership should be safely scrapped.

B.4 Post-filling procedures

Post filling inspections take place after the cylinder has been filled but before it leaves the filling plant and focuses mainly on identifying leaks and non-conformities. Depending on the result the cylinder will either be released to the market or further work will be done on it. Some of these post filling inspections will involve equipment but they will also rely on the competency of the operators.

Following these post-filling inspections, the cylinders will be sorted depending on the result. Those that pass will enter the market and those that fail will be processed and drained for further review.

Some of the post-filling failures might be as a result of:

- Under or over-filled cylinders (within the allowances of the check-scales)
- Cylinders leaking through the closed valve or the valve housing
- Cylinders leaking through the body
- Cylinders with loose fittings
- Cylinders with no flow limiter (if fitted)
- Pallets that do not have doors or protection bars
- Or pre-filling checks that had not been identified earlier

When the cylinder is undergoing a fully submerged leak test in a water tank small pin hole leaks may go undetected unless carefully scrutinised.



Leaking cylinder identified during post-filling checks

B.5 Repair and maintenance

Cylinders will be exposed to damage as they move through the distribution channel from, and back to, the filling plants. Some of this damage may be cosmetic and require repainting. More serious damage might require some cold work, some may require hot work.

The replacement of shrouds and foot-rings are probably the most common type of major refurbishment. In some cases, the body of the cylinder may have suffered impact damage which may be possible to repair.

It is important that the cylinder is annealed again after any hot work has been completed to ensure no welding stresses have built up.

B.6 Requalification

Periodically, cylinders will be withdrawn for re-qualification.

This report is not designed to challenge the requalification requirements in particular countries, but it may be used to examine the whole cylinder management process, make improvements and to then test the appropriateness of what is required.

The first phase of the report highlighted that the cylinder requalification period varies greatly between countries. From one year to fifteen years. Some countries condemn a cylinder based on age, regardless whether it is fit for purpose or not. Other countries impose more vigorous requalification conditions on a cylinder as it gets older.

Also the requalification standards and practices vary too.

Cylinders must be removed from service for formal requalification when they demonstrate damage beyond the rejection limits. This may be before the recommended requalification period.

The process for this requalification, and the recommended period between when this is done, varies across the world. Details of the requalifying procedures for each of the fifteen companies are included in the Appendices.

The UK makes a case for dispensing with the hydraulic test when requalifying, arguing that it is unnecessary and expensive. Their case is based on other checks identifying when a cylinder is fit for purpose. Their case has been included in APPENDIX FOURTEEN.



A hydraulic test shown above is normally included in the requalification procedures

B.7 Disposal

When a cylinder has reached the end of its life it must be completely destroyed in a safe manner. Even an empty LPG cylinder will contain hazardous vapour and must be handled accordingly. Empty cylinders should always be treated as if they contained liquid, especially if they are to be disposed of.



Scrapped cylinders in Cote d'Ivoire

The fifteen countries were asked how they disposed of condemned cylinders and details are included in the Appendices.

Disposal techniques include punching large holes into both halves of the pressure vessel. Punching a hole in only one half leaves the possibility of the other half being recovered. This was an issue in the Philippines until the disposal procedures were tightened.



This eliminates the risk of cylinders being re-used

Domestic cylinders which have been re-made using the 'good' halves of condemned cylinders present a serious risk as they would certainly not have been heat treated after welding.

Some other typical methods of destruction are:

- Crushing by mechanical means
- Piercing holes, at least 50 mm diameter, in the container in at least three places (simply drilling holes does not meet this requirement as they can be easily repaired)

- Removing the top and bottom, and vertically cutting the body (the practice in Cote d'Ivoire)

The important issue is that after the cylinder has been disposed of there must be no possible way the cylinder can then be recovered and put back into the market.

C - The Product

C.1 Propane, Butane or mixtures

Butane boils at around zero degrees centigrade and propane around minus 40 degrees centigrade. The vapour pressure of propane is around four times higher than butane, at the same temperature, and so it is critical that cylinders are rated for propane when operating in a market where propane is present.

If there is a possibility of propane being used in a market the cylinders must always be rated for propane.

Mixtures of butane and propane are commonly found in some parts of the world but propane will always boil off preferentially to butane. In colder climates where mixtures are used, as the cylinder nears empty it will contain predominantly butane and this will struggle to vapourise. Consumers may be tempted to accelerate the vapourisation by applying heat which is detrimental to the cylinder. Two examples illustrate this:



A lighted candle was placed under this cylinder resulting in the paint being burnt exposing the metal

The first is where a lighted candle has been placed under the cylinder. Apart from being very dangerous, by having an ignition source against the cylinder, the candle flame will burn off the paint and expose the metal to corrosion at the base where it is most vulnerable.

The other example is where the cylinder has been placed in a hot water bath. This also will accelerate the corrosion process.

Butane was present in both examples. The ambient conditions were too cold and the product should be changed to propane.

In the second example the water bath would be made redundant by introducing a vapouriser into the system.

Care taken when designing the consumer installation will avoid damage to cylinders like these.



These cylinders have been placed in a hot water bath to assist vapourisation but this will accelerate corrosion

C.2 Product specification

Although it is a by-product there are manufacturing specifications for LPG but these vary across the world. LPG is broadly controlled by levels of propane and butane, vapour pressure and density.

LPG is generally free of contaminants but occasionally heavier hydrocarbons and water can be present from the refinery process and ships storage vessels.

To avoid any contaminants entering the cylinders during the filling operation it is good practice to regularly drain storage tanks. Water and the heavier hydrocarbons are heavier than LPG and will collect at the bottom of tanks. Installing a bottom drain and using it regularly will control this.

If this drainage is not done there is a threat of these contaminants passing through the filling plant into the cylinder. They will build up in the cylinder causing complaints from consumers who either can't use all the product, or the contaminants will create problems for the equipment that is installed to control the LPG going to the appliance.

If the LPG originates from a refinery process, and aluminium cylinders are being used, it is particularly important to drain tanks regularly. Any sulphur present in the LPG may attack the aluminium.

C.3 Product quality control

LPG is a by-product of crude oil production and natural gas, when the natural gas is 'wet' and contains liquids, and the quality control of LPG is therefore not the primary concern of refinery and natural gas production managers. The nature of the two processes are very different with LPG from the refining of crude oil being more susceptible to contamination from the production process than from the extraction from natural gas.

The quality assurance process starts with the cargo receipt of LPG and the compliance to the Product Supply Specification. The taking of samples to check compliance to specifications should be included in the terminal procedures so that in the event of a dispute there is a retained sample to revert to.

The contamination of LPG from external sources is virtually eliminated because the product is stored under pressure and unlike diesel or gasoline the threat of water contamination is limited. Where water is likely to be present in the distribution channel is from previously contaminated pipework or storage tanks.

D - Distribution channel

Apart from the above issues probably the single biggest threat to the life of a cylinder is when it is in circulation in the distribution channel. It is here that the degree of inspection from the LPG marketing company starts to diminish and reliance is placed upon the wholesaler, dealer, retailer and consumer. This will be mainly to detect any leaks or abnormalities in the cylinders passing through.

Nine of thirteen countries that responded to the question indicated that 'corrosion and dents' from the distribution channel were the main reasons for scrapping cylinder.

The consumer will have a responsibility to be alert for any issues such as leaking cylinder or malfunctioning equipment and report to the marketing company, normally through a customer service centre.

In any business model it must be very clear as to who has responsibility for the ownership and maintenance of the cylinder asset.

D.1 Branding

Markets where multi-branded dealers and retailers offer consumers a choice from a range of different cylinders discourages brand loyalty. A single branded network creates stronger relationships between the different stakeholders in the channel and will result in greater controls and clearer deliverables. It will also encourage higher standards and elevates the chance of cylinders being treated with more care.

The illegal decanting of LPG from cylinders in the distribution channel and the rebranding of cylinder assets also creates a threat to the integrity of the cylinder in the long term.

Tamperproof seals fitted to cylinders not only discourage this activity, but also give the consumer confidence they are getting what they pay for.

Ensuring the cylinder returns to its rightful owner for refilling will allow the checks described in B to take place. The illegal filling of cylinders is not only bad for cylinder integrity it also discourages investment.

With a branded network the dealer and retailer will be obligated to certain standards of service through their contract with the LPG company including the quality of the cylinder delivered. For example, key performance indicators (KPI's) and remuneration levels can be linked to the condition of the cylinder while under the control of the dealer.

D.2 Training

Global LPG demand continues to increase by about 3 – 4% a year bringing not only millions of new tonnes of product onto the market but tens of thousands of new consumers, retailers, dealers, operatives and other personnel into the



Multi-branded dealers have no incentive to manage cylinders and are often involved in illegal filling operations

industry. All these people need training in how LPG behaves and how it needs to be safely stored, handled and distributed.

The importance of all the factors that influence the life of a cylinder need to be understood. Training has a direct impact on cylinder life.

It was noted by one country that forklift truck cylinders often incur damage when they are changed on the vehicle. They are often dropped to the ground causing damage to the foot ring, shroud or cylinder body. The use of an on-site refilling operation will eliminate the need to physically remove the cylinder every time it becomes empty but operators will need to be trained in refilling and regularly checking the cylinder for damage.

D.3 Properly designed trucks

The portability of LPG brings with it the challenges associated with moving between the filling plant and the consumer. Even small domestic LPG cylinders are quite heavy when filled and if dropped will cause damage to the container.

After filling they are transported onto trucks through the distribution channel which might include wholesalers, dealers and retailers before being delivered to, or picked up

by, the consumer. At every step in the distribution chain there is the potential for damage to the condition or structure of the cylinder.

Cylinder filling plants are generally sited on elevated platforms. Ensuring the height of the truck's platform is at the same level of the filling plant platform will not only make it easier for operators it will also reduce the risk of damage to cylinders as they get transferred, especially if they are being loaded manually.



Cylinders are moved through the channel by a variety of different modes of transport

D.4 Store fit for purpose

Most LPG distribution channels rely on cylinders being manually handled through the chain. A cylinder leaving the filling plant might be handled five or six times before it reaches the consumer. From filling plant to wholesaler's truck...to dealer's store to dealer's truck...to retailer's store to delivery man. Damage may occur at every stage and the education of the distribution channel in good practices cannot be over emphasised.

Cylinders are normally stacked four or five high in rows. It is important to leave a gap between two rows of cylinders to enable access in the event of a leak to any of them, otherwise removing the faulty one might be difficult.

As with filling plants, storing cylinders on hard, well drained surfaces throughout the distribution channel will limit the risk of corrosion to the base.



Cylinders with badly damaged foot-rings

Because of the risks associated with a leak LPG cylinders are recommended to be stored outside in well ventilated areas but this exposes them to the weather. The vapour pressure of LPG increases with temperature and in countries with hot climates overfilled cylinders may be subjected to extreme pressure causing structural damage.

Domestic cooking is the most popular application for LPG but this also encourages cooking fat to be spilt onto the cylinder which has to be removed or it might attract vermin that might chew through hoses or damage paintwork.

D.5 Handling procedures

The portability of LPG is one of its greatest strengths but the fact that the cylinder has to be physically moved between the filling plant and the consumer, through a sometimes complicated distribution channel, often creates opportunities for deterioration of the asset through accidental damage.

The circulation rate of a cylinder – the number of times it is refilled in a given period – will depend on a number of factors. It has an influence on the life of a cylinder because damage is caused every time it passes through the distribution channel. To a certain extent this can be controlled.

The affordability of LPG is a challenge to consumers with limited disposable income and so it is tempting to select small cylinders to lower the entry barrier and keep the cost of a refill to a minimum.



Various ways of distributing cylinders through the distribution channel

Cylinders that are too small might be advantageous in bringing the initial cost - and the cost of a refill - down, but smaller cylinders may result in more frequent refills which may expose the cylinder to a greater risk of

damage to both the cylinder and the valve. On the other hand, cylinders

that are too large can remain with the consumer for months, even years, tying up assets.

Every time a cylinder is empty the regulator is disconnected from the valve by the consumer and it is then passed back through the distribution channel to the filling plant. With some distribution channels being quite complicated there is potential for the cylinder to move through several pairs of hands.



This cylinder suffered severe impact damage in the market making it dangerous and unfit for service

The Japan domestic cylinder business model minimises that risk of damage by locating cylinders outside a domestic property in a ventilated weather proof cabinet and supplying the LPG to the consumer through a meter.

The cylinders are collected when empty and brought back to the filling plant. This distribution channel has no retailer and consequently removes a layer of cylinder handling and potential damage.

Most countries identified poor handling throughout the distribution channel as one of the key reasons for cylinder damage and a shortening of life. Another reason was damage inflicted during storage at both the dealers and consumer properties.

Managing these threats through education and training, and designing out potential areas where damage could occur, will assist in extending the life of cylinders.

D.6 Pallets

The use of appropriate handling equipment throughout the distribution channel can assist, especially the use of pallets and cages.



Pallets increase the efficiency of operations but the distribution channel must be able to handle them through to the retailer

The opportunity to introduce palletising into the distribution channel will minimise the manual handling of cylinders and reduce wear, tear and injury. In Turkey it was reported that dents were responsible for 80% of the scrapped cylinders. In Cote d'Ivoire and India, the figure was over 25%.

The use of pallets has become increasingly popular when moving cylinders from the filling plant to the point of sale.

Modifications to filling plants to accommodate pallets, or designing new ones with facilities to handle pallets, is easier to introduce than converting the distribution channel that may have to make significant changes to the way it operates.



The use of cages at retail sites will increase security and minimise manual handling

The effort will be worthwhile because it will reduce operating costs, cut down the

amount of manual handling and reduce the risk of damage to the cylinder population.

A move to palletising could be useful in arguing that improvements are being made in cylinder condition.

D.7 Consumer storage

When the cylinder reaches the consumer's premises it is the furthest point away from the filling plant and probably at its most vulnerable. The control over the way the cylinder is stored and handled is at its weakest.

For commercial and industrial consumers, the cylinder condition can often be influenced through supply contracts that's not as easy for domestic consumers.

Commercial and industrial consumers can also receive advice and equipment from the distribution channel or from the LPG company directly.

Education programmes can be provided to domestic consumers concerning LPG usage through demonstrations which is what India and Indonesia did in support of their traditional fuel to LPG conversion campaigns.

This type of support can include messages on how to look after cylinders, especially in the case of emergencies.

As was described in B.1 the need for correct storage facilities is just as important for the filling plant and the distribution channel as it is for the consumer.

7.1 Survey Results

Full details of the original survey results from each country are included in the Appendices of this report as excel files.

Each country was then asked to respond to the following request:

A summary of the procedures for:

- Routine inspection and checking of LPG cylinders as they enter the filling plant
- LPG cylinder requalification (or a copy of the local codes)
- Disposal of LPG cylinders

At least one example of bad practices in your country that leads to a shorter cylinder life (with photos if possible)

At least one example of good practices in your country that leads to a longer cylinder life (with photos if possible)

The above examples might be cylinder design or manufacturing methods, ways of handling and distributing cylinders, dealer incentive programmes, etc.

The full responses to these questions have also been included into the Appendices below.

Australia



- Mature market - mainly Autogas
- 9kg exchange programme for domestic
- POL used extensively across cylinder business
- AS 2030 used for design etc.
- Cylinder population over 5m (probably <10m)
- 10 years requalification for steel cylinders
- Five years for Composites
- Valves generally replaced when requalifying
- Scrapping of cylinders mainly due to corrosion/dents
- Corrosion under base of in situ cylinders caused by ground conditions
- Fork lift truck cylinders susceptible to damage when changed
- Purchasing procedures specify corrosion protection

There is routine inspection and checking of LPG cylinders as they enter the filling plant. The safety operating procedures for this consists of a visual inspection prior to each refilling. Operators look for corrosion, dents, gouges, nicks, cuts etc. Where there are doubts the cylinder is quarantined and sent to the retest station for assessment.

LPG cylinder requalification (or a copy of AS-2030). Requalification is done through an authorised test station (certified to AS2337)

Where cylinders do not meet the retest criteria as described in AS 2337 they are deemed to be condemned and are crushed for disposal through metal recycling facilities

At least one example of bad practices in your country that leads to a shorter cylinder life (with photos if possible):

1. When fork lift cylinders are dropped from the forklift cradle when being changed the foot ring is often damaged and can lead to the deformation of the cylinder
2. Corrosion under in situ cylinders where accumulated rotting debris causes corrosion to the base. This is often undetected as the foot ring hides the corrosion. Poor ground support, poor drainage and poor housekeeping are the main contributing factors

At least one example of good practices in your country that leads to a longer cylinder life (with photos if possible):

1. Appropriate purchasing processes where cylinders are supplied with a coating that protects against corrosion

Appendix Two

Brazil



- Growing market - mainly domestic
- NBR 8460/8865 used for design
- Cylinder population around 120m
- Cylinder exchange programme in place
- 15 years requalification for steel cylinders, then every 10 years
- Valves (NBR 8614) repaired if possible
- No PRV fitted to small cylinders
- Costs approximately US\$7 to requalify cylinder
- Corrosion is main cause of scrapping cylinders
- Poor handling leads to damage throughout distribution channel
- Collaborative programme for developing country standards

The Brazilian system works very well because the standards are developed in a democratic way ensuring that the companies, regulators and manufacturers work together in creating the regulations. Once the first draft goes public any person can contribute giving their suggestions. The process is democratic and transparent which are two important conditions for good regulations.

Inspection - Every cylinder entering the filling station is inspected before being refilled and after being refilled. The LPG dealers also do their own inspection when they receive the cylinders before delivering to the customer. Therefore, there is triple inspection.

At the filling station the inspection is done based on NBR 8865. There are two objectives of the inspection. The first is to observe the date of cylinder manufacture or date of the last requalification. Based on this the cylinder can be rejected at the beginning of the filling line and quarantined to be sent to a requalification company. The second objective is to see if the cylinder meets the standards of the industry. There is a visual panel in every filling station that determines the standard.

If approved, the cylinder is filled and the second inspection at the filling station is to assure that it is well painted, leak free, sealed and with the necessary information on how to use the cylinder which is placed on the top. Once it reaches the dealer he performs a date inspection as well to validate if the cylinder is OK.

Requalification - The cylinder requalification is done based on NBR 8865/8866.

Disposal - If a cylinder fails the requalification based on NBR 8866 it means that the cylinder can no longer be used. The standard states that information must be kept on the cylinder company brand, the year of manufacture and the cylinder identification number, if available. This is to generate a data base for every cylinder destroyed. The information is sent every month to the government authorities. After gathering the data, the cylinder is then destroyed by punching a few large holes (the regulation requires at least three large holes in the cylinder). After the holes are punched in the cylinder it is sent to a company that will press the cylinders and then sell to steel mills for recycling of the steel. In Brazil 100% of old cylinders are recycled.

Bad Practices - The major problem that shortens the cylinder life in Brazil is caused by bad handling throughout the distribution chain at the company, at the dealer and at the end user. The cylinder suffers substantial impact during the handling process which creates dents. Although technically the dents may not affect cylinder safety, they do impact customer satisfaction regarding the cylinder.

Cote d'Ivoire



- Fast growing market
- Dominated by domestic demand
- ISO 22991 used for design
- Cylinder population approx. 3.5m
- Five years requalification for cylinders, then every five years
- Zinc metallisation commonly used
- No valve reconditioning done
- Effective scrapping policy
- Scrapping of cylinders is mainly due to collar and foot ring damage

Checking of cylinders by Authorities

The Ivorian LPG market is one of the fastest growing markets in West Africa with lots of new cylinders injected into the market every year. In order to ensure the quality of the cylinders, every single cylinder is inspected by the Directorate of Mines before being introduced into the market.

The control of this governmental body goes through the following steps:

- Checking of the technical and manufacturing documents provided by the cylinder manufacturer to the marketing company to ensure compliance
- Checking the following details of the cylinder:
 - Serial number
 - Date of manufacturing
 - Hydraulic pressure value
 - Quality of product designed for and weight
 - Water capacity
 - The quality of the valve

For each batch of 5,000 cylinders, a sample is taken for non-destructive testing.

The agents of the Directorate of Mines also regularly carry-out the following checks on cylinders in circulation at any point of sale:

- Date of the last hydraulic retest of the cylinders
- Weight of full cylinders to ensure that they have not been under-filled
- Unexpected checks at filling plants to ensure that cylinders are properly and well filled

Routine inspection and checking of cylinders as they enter the filling plant

Every time empty cylinders are returned to the filling plant, they are subjected to a series of vigorous checks and observations to ensure they are fit for filling and reuse.

Typical types of movements at filling plant are:

- Return of cylinders from customers: empty and claimed
- Dispatch of full cylinders to customers
- Filling cylinders – moving from stock of empty cylinders to full cylinders
- Sorting of cylinders – moving from stock of empty cylinders to “for repair, requalification or scrap”
- Sorting of cylinders – moving from stock of empty cylinders to stock of “other brands”
- Return from and dispatch for maintenance
- Scrap – dispatch for scrapping
- Receipt of new cylinders

Specific pre-filling inspections

Only cylinders that are fit for filling and re-use go through the filling chain. They are then checked to ensure:

- Tare weight and requalification date are clearly marked on the cylinder
- There is no corrosion on the body of the cylinder and the cylinder has a good appearance
- There is no significant damage on the body, the shroud and the foot ring of the cylinder
- The valve is not damaged
- That dirty cylinders (mostly small cylinders) are sent to the washing area before filling

After filling

The following checks are made after filling:

- Every cylinder is check-weighed for accurate fill (tolerance)
- Over-filled cylinders have any excess product removed as soon as possible
- Under-filled cylinders are returned to be correctly filled
- Cylinders are fully rechecked after the contents have been adjusted (over or under-filled)
- Each cylinder with valve opened and closed is leak tested
- Each valve is protected with a sealing cap

Only cylinders that are good for sale leave the filling plant.

LPG cylinder requalification process

The following pictures are examples taken during the requalification process.



Empty cylinder to be requalified



Unscrewing of the valve



Degassing of the cylinder



Rectification of the foot ring



Hot repair on the body



Cylinders loaded in the furnace to be annealed



Hydraulic testing of cylinders



After shot-blasting



Painting of cylinders



Pressure control and leakage testing



Tare weight marking



Cylinder after requalification

One example of bad practices in Côte d'Ivoire that leads to shorter cylinder life

Outside the filling plants, the handling of cylinders is still a concern despite the training regularly provided to the staff of the distributors, the retailers and also to the end-users.

Examples of good practices in Côte d'Ivoire that leads to a longer cylinder life

All the LPG marking companies are requested by law to requalify their cylinders every five years. The agents from the Directorate of Mines carry regular inspections to ensure that it is done.

Staff that work in the filling plants and the depots are well trained and competent.

Appendix Four

India



- Large growing market - mainly domestic
- IS 3196 and IS 13258 used for design
- Cylinder population approx. 150m
- 10 years requalification for cylinders, then every five years
- Valves are not generally replaced
- No valve reconditioning done
- Cylinder requalification costs approximately US\$1 (excl. valve)
- Scrapping of cylinders mainly due to body leak (45%)
- Poor handling of cylinders at distributor and consumer leads to damage during loading/unloading

Summary of the procedures for the routine inspection and checking of LPG cylinders as they enter the filling plant, the standard used for requalifying cylinders is ISO 10464:2004, Gas Cylinders Inspection and Testing:

1. Visual Checks on empty LPG cylinders including the segregation of cylinders for:
 - a. Periodic testing (5/10 years)
 - b. Repair of foot ring/VP ring
 - c. Missing O-ring
 - d. Painting
2. Visual checks, followed by technical checks, for the permanent rejection of cylinders due to defects like dent, cut, dig, burn, bulge, corrosion, spurious damage etc. Refer to a copy of IS-13258 released in 2014 and previous copy released in 1991.

SR16054 : 2013, found in the Indian Standard, specifies the inspection and testing procedure for the periodic inspection of transportable refillable welded cylinders for LPG, of water capacity exceeding five litres up to and including 250 litres. The following pdf file is a preview of the standard.

Summary of the procedures for LPG cylinder requalification

1. LPG cylinder once segregated has to pass the following tests for requalification:
 - a. During periodic testing (5/10 yrs)- cold repair:

The tests for re-qualification primarily include the following as per IS 16054:

- (i) Visual inspection of cylinder body, both internally and externally, for dents, cuts, corrosion etc.

(ii) Hydrostatic test after the inspection of cylinders as per IS: 13258 at a pressure of 2.45 MPa (25 Kgf/cm²) for an interval of 30 seconds, after the desired pressure is attained and the external surface is fully dried. Observation time is minimum 30 seconds

(iii) Pneumatic test, after refitting the valve, with a pressure of 1.180 MPa (12 Kgf/cm²) for an interval of 60 seconds

- b. Repair of foot ring/VP ring – (cold repair)
- c. Replacement of foot ring/VP ring – (hot repair) including all tests as shown above in red colour.
- d. Missing O-ring replacement

Summary of the procedures for Disposal of LPG Cylinders:

1. Qualification for disposal:
 - a. Cylinders rejected during periodic testing (5/10 years)
 - b. Cylinders rejected during hot repair testing
 - c. Cylinders having defects like dent, cut, dig, burn, bulge, spurious, bung damage etc.
2. Procedures for disposal:
 - a. Documentation and record keeping
 - b. De-pressurization & Removal of SC Valve
 - c. De-gassing
 - d. De-shaping and scrap sale

Example of bad practices that leads to a shorter cylinder life:

Improper handling of cylinders during loading and unloading at distributor/customer

Example of bad practices that leads to a longer cylinder life:

Use of cylinder foot-ring, VP ring and stay plate straightening machine at LPG plants along with timely statutory testing and repainting of cylinders

Indonesia



- Fast growing market following kerosene campaign
- 3kg cylinders supply over 90% of market
- SNI 1452: 2011 used for cylinder design
- ISO 10464 used for requalification
- Cylinder population over 250 million
- Mostly local manufactured
- four years' requalification for steel cylinders
- No reconditioning of valve
- Poor handling of cylinders causes damage
- Procedures based on Indonesian standards
- Oven dried paint improves quality

The standard used for requalifying cylinders is ISO 10464:2004, Gas Cylinders Inspection and Testing

1. The Standard Operating Procedure in Indonesian filling plants;

- Visual test, leak test and the separation of the cylinders that are need of requalification
- LPG Cylinder requalification process is based on Copy SPPT SNI or the result from the Authorized Test Centres (BBLM or B4T) or pressure vessel certificate
- Cylinders are disposed of or scrapped if they aren't in a good physical condition or they don't pass the requalification test

2. The Routine inspection and production process/quality control are based on the Indonesian National Standard (SNI) 1452:2011

3. LPG retester - in particular for the 12 Kg cylinder - will use the oven for drying the paint during the painting process. Aside from a good performance and quality, this way the lifetime of the paint should be longer

Appendix Six

Japan



- Mature market - mainly Domestic
- Japanese standards used for design etc.
- Cylinder population approx. 40m
- Five years requalification for steel cylinders, then every 5 yrs < 20 yrs (then every 2 yrs)
- Use of composites only just approved
- 3 years for composite cylinders, then every 3 years < 15 years (withdrawn)
- Valves are repaired if possible
- Few cylinders scrapped during life time
- Cylinders well supported at consumer premises on dry flat ground

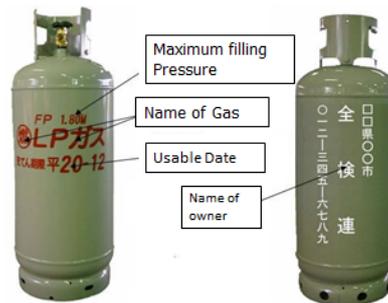
The standard used for requalifying is the Container Safety Regulations

Routine inspection and checking of LPG cylinders as they enter the filling plant:

Before filling the cylinders which are returned from customers, the operators must check the followings by law:

1. Marking (Curved):

- Manufacture's name or registered number
- Name of gas
- Cylinder's identified number
- Capacity (Litter)
- Tier weight (without protector and other accessory)
- Month/Year of qualification
- Maximum test pressure



2. Marking (Painted)

- Name of gas
- Marking of "Flammable"
- Name, Address Tel number of cylinder owner
- Maximum filling pressure
- Month/Year (You can fill LPG until this month/year)

- Curved Seal:
- ✓ Maximum filling pressure
 - ✓ Maximum test pressure
 - ✓ Owner number
 - ✓ Kind of gas
 - ✓ Capacity (litter)
 - ✓ Tier weight

3. Visual check of cylinder (outer surface, protector, skirt)

- Deformation, rust, etc.

LPG cylinder requalification test:

- Cylinders enter the requalification test site
- Any remaining gas is recovering
- Valve removed from cylinder
- Pressure test by water (test pressure 3Mpa)
- Inspection of inner surface
- Shot blast
- Marking (curved)
- Painting
- Fixing valve (Requalification of valve: every six years, but when cylinder is tested usually the valve will be replaced)
- Marking (painted)



Chop, chop or two holes



Bad example:

None provided

Good example:

- Flat concrete platform
- Ventilation holes in foot ring
- Securing chairs to prevent cylinders falling over
- Ventilated cabinet
- Well marked cylinders



Appendix Seven

Mexico



- Mature market – Domestic demand dominates
- NOM-008-SESH/SCFI-2010 used for design etc.
- Cylinder population approximately 25 million
- One year requalification for steel cylinders
- No further requirement to requalify but typically 5-10% are repaired every year
- Reliant on inspection regime before every refill
- Cylinders withdrawn after five years
- Good inspection procedures
- Establishment of industry organisations (Firagas, Cental de Fugas)
- Damage commonly caused by poor handling of cylinders by consumers
- Cylinders refilled by consumer at Autogas stations
- Illegal filling in distribution chain

The standard used for requalifying is NOM-008-SESH/SCFI-2010

NOM-011/1-SEDG-1999 is the Official Mexican Standard on safety conditions of LPG cylinders, and it defines the minimum safety conditions needed on LPG cylinders, as well as the inspection and checking procedures.

A visual revision should be performed on each cylinder. The cylinder must not be filled in the following cases:

- Valve/pressure relief device failure (leak)
- Damage on the protection shroud so it does not protect the valve
- Damage on the foot ring so the cylinder cannot remain vertical by itself
- Corrosion on the paint protection
- Dented cylinder
- Protuberance or bulged cylinder
- Incision on the cylinder
- Cracks

Prior to revision, cylinders must be cleaned out of rust, caked paint or any dirt on it.

The cylinder can either be repaired or sent to a disposal facility for scrapping. To determine so, the cylinder is tested. Hydrostatic test is one of the most common procedures.

LPG cylinder requalification norms and standards: NOM-008: Technical specifications for LPG Cylinders (Standards for cylinder production)

<http://www.dof.gob.mx/normasOficiales/4242/sener/sener.htm>

NOM-011/1-SEDG-1999: Safety conditions of LPG cylinders (Operational standards)

http://dof.gob.mx/nota_detalle.php?codigo=2051633&fecha=31/12/1969

Disposal of LPG cylinders norms and standards: Nowadays there is no normativity of cylinder disposal in force.

Please download the video showing how cylinders are usually scrapped in the following link:
<https://we.tl/3p5ZMrvsL3>

Example of bad practices that leads to a shorter cylinder life:

a) Cylinder filling in autogas stations. Due to economic reasons, customers bring the cylinders by themselves (taxis, barrows) to irregular gas stations and get their cylinders partially filled. The cylinders are not properly handled and transported, leading to a shorter life and most important, to higher risk of accidents.



b) Irregular distribution chains do not respect the property of the container. This practice leads to a deficient control and handling of cylinders, thus a shorter life.

Example of good practices that leads to a longer cylinder life:

- a) The inspection process enlisted above to ensure minimum safety conditions on LPG Cylinders prior to be filled or refilled.
- b) FIRAGAS, a private trusteeship for replacement of LPG equipment. Through FIRAGAS, around 1 million cylinders are replaced every year. Since FIRAGAS was created, over 5 million cylinders have been replaced.
<http://firagas.org.mx/>
- c) CENTRAL DE FUGAS, a private association formed by LPG distributors, which provides free leak suppression services to customers in the metropolitan area of Mexico City, which holds around 35% of the national LPG sales over the country.
<http://www.centraldefugaslp.org/inicial.htm>

Appendix Eight

Morocco



- Steadily growing market - mainly domestic
- Local codes used for design
- Cylinder population approximately 45 million
- 10 years requalification for steel cylinders, then every 10 years
- High rates of rejection during requalification
- Bung and neck ring failures account for 30%
- Valves are not repaired in Morocco
- Strict procedures applied within filling plants for routine inspection and requalification
- Damage occurs within distribution channel despite best efforts
- Cylinders destroyed in presence of authorised inspector
- Cylinders are withdrawn from the market after 40 years

The standard used for requalifying cylinders are codes:

- Dahir du 18 jourmada I 1374 (12 Janvier 1955) portant reglement sur les appareils a pression de gaz
- Arrêté du Ministère de l'Energie et des Mines N° 941-07 du 11 mai 2007

Sorting cylinders before filling - According to the general code of the GPL, it is mandatory to perform a sorting operation before filling the 3kg, 6kg, 12kg and 34kg cylinders. One of the cylinder sorting stations, upstream of the carousel or stationary filling positions, is dedicated to this operation where cylinders are sorted under the following criteria:

- Identification and/or the date of the last hydraulic retest are no longer legible
- Date of construction illegible or nonexistent
- Nature of the marked product on its dome is different from the product being used to fill (e.g. an LPG cylinder designed for butane entering a propane filling line)
- Foreign cylinders - the brand of the LPG cylinder is different from the brand of the operator of the filling plant
- Defective side-entry valve; marked for nonconformity
- Hydraulic retesting (these cylinders to be prepared and presented to an inspector approved by the Ministry of Energy and Mines)
- Unacceptable distortion (any swelling of the bottle, corrosion, pressed neck, impact damage on the weld, deep penetration, any perforation or deformation that may affect the strength of the cylinder)
 - A template or dedicated instrument is used to measure these distortions in accordance with the Circular No. 01-09 of 8 January 2009 (a poster set up at the workstation explaining the degrees and types of deformations and their locations on the cylinder is displayed)
- Damaged side-entry or top-entry valves (e.g. clogged, broken handles, valves stuck, distorted stems, loose components)
- Deformed or torn foot-ring
- Leakage of cylinders
- Cylinders requiring washing and/or painting

Sorting cylinders after filling - LPG cylinders undergo a post filling inspection and sorting according to the following and those failing will be processed and drained for further review:

- Under-filled or over-filled cylinders (respecting the maximum weight indicated by the check-scales)
- Cylinders leaking through the closed valve or the valve housing
- Cylinders leaking through the body
- Cylinders leaking after capping
- Cylinders with a loose hat
- Cylinders with no flow limiter
- Pallets that do not have doors for the 3kg and 6kg cylinders and protection bars for 12kg and 34kg cylinders

Requalification of Cylinders

The requalification of 3 kg, 6 kg, 12kg or 34kg cylinders concerns the regulatory retesting of cylinders and the inspection or replacement of cylinder accessories. For 3kg and 6kg cylinders with a top-entry valve, the accessories involved in the requalification are the top-entry valve itself. For the 6kg, 12kg, and 34kg cylinders with a side-entry valve and flow control, the accessories involved in the requalification are the side-entry valve and flow control. The Circular of the Ministry of Energy, Mines, Water and Environment regarding the strengthening of controls of specific LPG pressure vessels states that filling stations must scrupulously ensure compliance with the regulations concerning gas pressure equipment including the ministerial order regarding the:

- Control of butane gas cylinders (3kg, 6kg and 12kg)
- Reform of butane gas cylinders
- Retesting of the Butane gas cylinders
- Compliance with the provisions of the regulation of LPG in place

An annex of the Circular contains the sorting criteria for 3kg and 12kg LPG cylinders. For 12kg cylinders filled with butane deadlines for mandatory testing after manufacture and then mandatory requalified according to the schedule below:

- 1st requalification in the 10th year;
- 2nd requalification in the 20th year;
- 3rd requalification in the 30th year;
- 4th requalification in the 35th year;
- Beyond the 40th year, the butane gas cylinder cannot be used and must be withdrawn and destroyed.

For 3kg cylinders filled with butane they must undergo mandatory testing after manufacture, and then mandatory requalification in accordance with the following schedule after their date of manufacture:

- 1st requalification in the 10th year;
- 2nd requalification in the 20th year;
- 3rd requalification at 25 years;
- Beyond the 30th year, the butane gas cylinder cannot be used and must be withdrawn and destroyed.

After requalification the side-entry valve or top-entry valve must be replaced, using appropriate machines, by a new or renovated side-entry valve or top-entry valve.

Destruction of Cylinders - In accordance with the decree of 14/01/55, issued by the Circular of the Ministry of Energy, Mines, Water and Environment-strengthening the control of LPG pressure vessels, 3kg, 6kg and 12kg LPG cylinders determined by authorized inspectors, can be condemned for the following reasons:

- Age limit
- Missing date or illegible manufacturer
- Fail result during requalification
- Unacceptable distortion (any swelling of the bottle, corrosion, pressed neck, impact damage on the weld, deep penetration, any perforation or deformation that may affect the strength of the cylinder)

After the decision, by an authorized inspector, to condemn and destroy an LPG cylinder, based on the above criterion, the destruction of these cylinders is done using a suitable machine with a hydraulic ram with a sharp tip to squash and break the cylinder in the presence of an authorized inspector.

There are examples of bad practice that may reduce the life of LPG cylinders. The following table summarizes some bad practices that may have a negative impact on the life of an LPG cylinder and its accessories. These examples not only reduce the life of a cylinder but they also increase the risk of damage or injury during handling and use.

Cause	Design	Method of manufacture	Handling	Storage	Distribution	Use
Deterioration of the LPG cylinder						
Drops on the ground			x		x	x
Transported without hats			x		x	x
Distributed without pallet					x	
No use of handling equipment			x		x	
Application of heat (hot water reservoir or direct heat to base)						x
Deterioration of paint on LPG cylinder						
Rolling cylinders on the floor			x		x	x
Internal or external corrosion						
LPG containing water or corrosive contaminants				X		
Cylinder stored in aggressive atmospheres				X		x
Deteriorating neck/valve						
Improper tensioning						x
Incorrect installation of the tensioner;						x
Deterioration of threads - top-entry valve						
Improper use of stove						x
Incorrect installation of stove						x
Deterioration of side-entry valves						
LPG cylinders Chute on their side-entry valves			x		x	x
Impact damage without valve protectors			x		x	x
Blockage of side-entry valves			x			x
Deterioration of valve seal or flow control or top-entry valve						
Improper installation	x	x				
Bad quality	x					
Deterioration of springs or balls in top-entry valve						
Improper installation		x				
Aggressive use		x				
LPG cylinder's chute on their top-entry valve			x		x	x
Closing of top-entry valves with dirt			x			x
Bad quality	x					

Examples of good practice that may increase the life of LPG cylinders, these include the following:

- Respect for the regulations in force
- Use of pallets when distributing LPG cylinders
- Handling LPG cylinders with their valve protectors secured
- Handling 12kg and 34kg cylinders with proper equipment
- Locating LPG cylinders on firm ground
- Placing LPG cylinders in a well ventilated space, never stored in a basement
- Use of standardized accessories (tensioners, flexible hoses, stoves ...)
- Fitting appliances properly to the cylinders (on stove or on oven ...), with reference to the safety instructions
- Securing 34kg cylinders to the wall with straps
- Proper application of butane and propane according to the General Regulations for LPG

Cylinders for repair:

Some of the cylinders will need repair, replacement of foot ring, or collar support. Once the cylinders undergo repair then the cylinders will automatically undergo stress relieving and hydro testing.

A copy of PNS for requalification (PNS 2014- Part 2) can be found in the Philippine National Standard 03-3:2013 titled *Transportable and Refillable Cylinders For Liquefied Petroleum Gas – Part 2: Method and Requalification*.

A copy of PNS for Repair (PNS 2014-part 3) can also be found in the Philippine National Standard 03-3:2013 titled *Transportable and Refillable Cylinders For Liquefied Petroleum Gas – Part 2: Requirement for Repair*.

South Africa



- Steady but slowing growth
- Split between Industry and Domestic
- Cylinder population approximately 2 million (est.)
- No industry regulations exist for requalification
- Major players 'following own policies'
- Cylinders checked when valves are replaced
- Serious challenges exist with illegal practices in the market

No specific instructions were available from the South African market, but there are a number of photos (shown below) that illustrate some of the challenges in managing cylinders in the country.



'Cloned' shrink wrap on an illegally filled cylinder



Appendix Eleven

Sri Lanka



- Growing market - mainly domestic
- 22mm Compact valve used (to EN13152)
- ISO 4706 & SLS 1178 used for cylinder design etc.
- Cylinder population approx. 2m
- Zinc metallisation applied to cylinders
- 10 years requalification for steel cylinders, then every 10 years
- Cylinders not scrapped on age but weight loss
- Scrapping by crushing and then holes punched through
- Valves are not reconditioned
- Scrapping of cylinders mainly due to corrosion/dents (80%)

Department of Transportation (DOT) standards are used to requalify cylinders

Photos of some cylinders in use were provided by the Sri Lankan industry.



Taiwan



- Growing market – demand across all sectors
- POL used extensively across cylinder business
- Local codes used for design etc.
- Cylinder population over 12 million
- 5 years requalification for steel cylinders, then 4 years, 3 years, 2 years
- Cost of requalifying around US\$12-15/cylinder
- Cylinders scrapped when they reach 30 years
- Valves are not reconditioned in Taiwan
- Controls in place within filling plants with visual inspections
- Scrapping of cylinders mainly due to corrosion (80%)

Taiwan filling plants are generally manually operated.

No opportunity for branding with grey being the mandatory colour.

The industry is quite old fashioned with opportunities for rationalisation and modernisation to improve cylinder handling.



Turkey



- Mature market - mainly Autogas
- Variety of valves used across cylinder business
- EN 1442:2006+A1:2008(TS EN 1442+A1) used for cylinder design etc.
- Other design codes & Specifications TS EN 13222, TS EN 14140
- Pi marking "Π" applied on cylinder acc. to ADR/RID 2015 and directive 2010/35/EU.
- Production sizes (4, 9,5 Lt-108,5 litre)
- EN 1440 (TS EN 1440) used for cylinder design
- Cylinder population over 50 million
- 10 years requalification for steel cylinders, then every 10 years
- No scrapping based on age
- Valves generally replaced when requalifying
- No reconditioning of valves in Turkey
- Scrapping of cylinders mainly due to dents (80%)

The routine inspection and checking of LPG cylinders as they enter the filling plant is carried out as follows:

On the arrival of cylinders, operator checks test dates, damage assessment and whether repairs are needed according to EN 1439:2008 (TS EN 1439 - Procedure for checking LPG cylinders before, during and after filling) and EN 1440:2008 (TS EN 1440 - Periodic inspection of transportable refillable LPG cylinders).

After the controls, cylinders which need test are placed between testing cylinders, and cylinders which need repair are sent to the repairing facility. Cylinders are periodically tested every 10 years by hydrostatic test at different test pressures.

EN 1440 (TS EN 1440) is the standard used for requalification of cylinders.

Periodic inspection and post fill checks will be covered by:

- ADR 2015 European Agreement Concerning the International Carriage of Dangerous Goods by Road
- TPED 99/36 (Transportable Pressure Equipment Directive)
- EN 12816:2010 LPG equipment and accessories. Transportable refillable LPG cylinders disposal
- EN1439:2008 LPG equipment and accessories – Procedure for checking LPG cylinders before, during and after filling
- EN1440:2008 LPG equipment and accessories – Periodic inspection of transportable refillable LPG cylinders
- ISO/IEC 17020:2012 Conformity assessment – Requirements for the operation of various types of bodies performing inspection

Disposal of LPG cylinders - Cylinders which cannot be repaired, are pressed and sent to a licensed waste plan with waste code as waste metal.

There isn't any national information about bad practices that leads to a shorter cylinder life or good practices that leads to a longer cylinder life but the following photos illustrate cylinders at consumers premises in Turkey. In particular, some examples of cylinders located on firm ground in cabinets show good practice.



United Kingdom



- Mature market in decline
- EN1442; 2006 + A1:2008 used for design etc.
- Various valves used across cylinder business
- Cylinder population approximately 20 million
- 15 years requalification for steel cylinders, 10 years for Composites, then repeating over same periods
- Strong case argued for dispensing with the hydraulic test (except for hot worked repaired cylinders)
- There is no scrappage based on age in the UK
- Valves are not repaired
- Scrapping of cylinders mainly due to corrosion

The UK code used for requalifying is EN1440;2008+A1:2012

The following statement was prepared by UKLPG in support of the argument not to carry out hydraulic testing of cylinders during requalification. It has been included here in full in this report but does not necessarily apply to other countries as the circumstances may be different.

Periodic Testing and Inspection of Liquefied Petroleum Gas (LPG) steel welded cylinders UK Position

Introduction

The UK is essentially a discrete market. Liquefied petroleum gas (LPG) cylinders in the UK are manufactured for national carriage only. UK companies that have a LPG cylinder business do not distribute cylinders outside of the UK. European based LPG distributors historically do not distribute to the UK.

The primary objective of the periodic inspection of transportable refillable steel LPG cylinders is that, after the completion of the tests, cylinders are recertified as safe for use prior to entering into service for a further period of time.

The very large population of traditional steel LPG cylinders has led to a drive for continuous improvement in how testing and inspection is conducted.

This document has been prepared to reflect current methodology for periodic inspection of LPG cylinders, and is based on extensive operating experience.

Each time a LPG cylinder is filled, companies already operate to EN1439:2008 (LPG equipment and accessories – Procedure for checking LPG cylinders before, during and after filling) and as such they already reject a number of cylinders for scrap or refurbishment before they reach the test house for periodic inspection.

Cylinders, therefore, are normally rejected well in advance of the pressure test, because they undergo frequent external examination at the filling plant, and rigorous external inspection at the test house. Those cylinders which fail external inspection one could argue may also fail internal inspection, so again these cylinders would never reach the internal inspection stage.

This suggests there is a clear correlation between external inspection rejects and failures on internal inspection.

Hence the reason why we are all finding so few cylinders with internal corrosion is because they have already been detected and scrapped at the external inspection stage.

Executive Summary

EN1440 2008+A1:2012, LPG equipment and accessories – Periodic inspection of transportable refillable LPG cylinders currently requires:

- External visual inspection
- Proof pressure test (hydraulic proof pressure test)
- Internal condition check
- Inspection of threads
- Inspection of valves

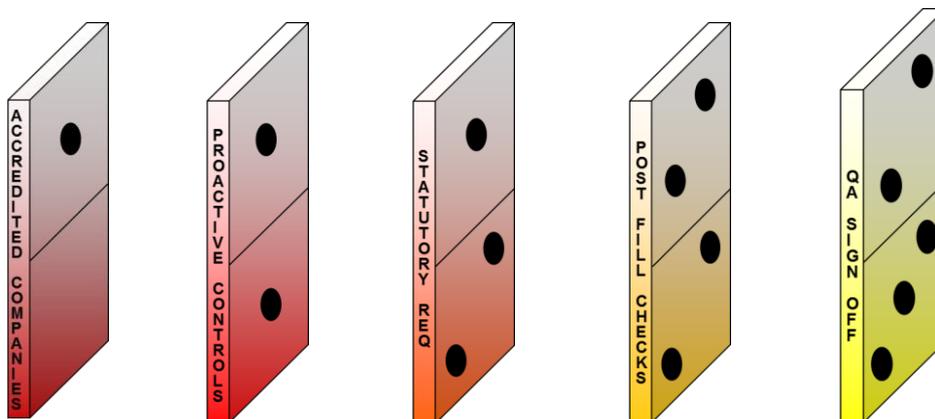
UKLPG confirms that the UK LPG industry continues to carry out an external visual inspection, internal visual inspection of the cylinders including inspection of threads and valves, and hydraulic proof pressure test.

However, some companies would like to use an alternative viable test regime which avoids the need to subject cylinders to the hydraulic proof pressure test. This test is undertaken each time a cylinder is filled, in addition to the checks undertaken at periodic inspection. These checks are in accordance with EN1439:2008 LPG equipment and accessories – Procedure for checking LPG cylinders before, during and after filling, section 7.3 Final Checks; Cylinders, valves and valve seals shall be checked for leakage.

For companies that can provide evidence of a viable alternative test that excludes the hydraulic proof pressure test as sited in ‘New Test Regime Proposal’, the risk assessment indicates that the hydraulic proof pressure test adds no value to the whole inspection and testing process for cylinders and gives a disproportionate benefit to the Industry at huge cost. With cheap imports of LPG cylinders from the Far East, exaggerated further by the collapse in world steel prices, we have already seen an exodus of companies who undertake periodic inspection on LPG cylinders. If this is left unchecked, it will be uneconomic to continue the practice of periodic inspection to the detriment of the UK economy.

Current UK Practice - Control of testing and inspection of LPG cylinders

Taking an industry holistic approach, there are five fundamental areas for controlling the inspection and testing of LPG cylinders as illustrated below.



Proactive Controls - Pre-inspection of Cylinders

When cylinders are returned to the filling plants (from service), they are offloaded from the cylinder trailers, where they will be subject to initial segregation by a trained operative. This involves sorting into the following categories.

Cylinders that:

- Can be refilled
- Require inspection, and possible requalification
- Require re-conditioning and possible requalification
- Require scrapping

Those that require periodic inspection (because they are due for requalification) are gas freed and subject to detailed external and internal inspection by a trained operative. This operative will sort into the following categories.

Cylinders that:

- Can be requalified
- Require reconditioning
- Require scrapping

The instructions for this will be contained in Company procedures, which implement the requirements of EN1440.

Cylinders transferred to the reconditioning plant can undergo the following operations:

- Undenting (removal of dents)
- Base ring (foot ring) replacement
- Shroud (handle) replacement

Following heat treatment (if hot work has been carried out), cylinders are then shot-blasted, recoated with zinc metal spray, hydraulically tested and re-painted prior to valving.

The instructions for this will be contained in Company procedures, which implement the requirements of EN1440.

Periodic Inspection

Statutory Requirements & Normative Standards for inspection and testing

Periodic inspection and post fill checks will be covered by:

- ADR 2015 European Agreement Concerning the International Carriage of Dangerous Goods by Road
- BS EN 12816:2010 LPG equipment and accessories. Transportable refillable LPG cylinders. Disposal
- EN1439:2008 LPG equipment and accessories – Procedure for checking LPG cylinders before, during and after filling
- EN1440:2008 LPG equipment and accessories – Periodic inspection of transportable refillable LPG cylinders
- EN1440 2008+A1:2012, LPG equipment and accessories – Periodic inspection of transportable refillable LPG cylinders
- ISO/IEC 17020:2012 Conformity assessment – Requirements for the operation of various types of bodies performing inspection

ISO/IEC 17020:2012 specifies requirements for the competence of bodies performing inspection and for the impartiality and consistency of their inspection activities. It applies to inspection bodies of type A, B or C, as defined in ISO/IEC 17020:2012, and it applies to any stage of inspection

Post Fill Checks

Following requalification, cylinders are gas charged prior to refilling. Following filling, post fill leak checks are undertaken.

These involve:

- Immersion in a water bath (in order to distinguish between leaks and air trapped under carrying handles), sample procedure - Appendix 1;
- Using leak detection fluid around joints and welds;
- Using electronic gas detection equipment

Final QA checks and returning cylinders to service

Following periodic inspection of cylinders, certification is issued in accordance with ISO 17020:2012

Hydraulic Pressure Testing – Financial Burden on Industry

If hydraulic pressure testing continues to be mandated, this will encourage gas suppliers to purchase cheaper, sub standard, LPG cylinders which may lead to quality and conformance issues in the future. If the only independent cylinder inspection and testing company seizes to trade there will be no facility for regional gas suppliers in the UK to carry out periodic inspections.

Financial Impact & Business Case Study

Independent Validation of Current UK Practice

A Major LPG supplier in the UK commissioned ABB Engineering Services (ABB) to carry out a comprehensive and independent review of the legislation and the current operational practices to determine whether the additional cylinder testing requirements would provide any additional level of safety.

Their conclusion was:

“ABB believe that there is no need to perform periodic hydraulic pressure tests on LPG cylinders as any manufacturing or fabrication defects would have been detected during the initial manufacturing inspections (QA/QC) hydraulic pressure test and no new defects can form that would not be detected during the other routine inspections required by the legislation and performed to a high standard.”

Their report outlined a number of reasons supporting their conclusion.

They found that extending the requirement to test cylinders hydraulically did not result in a higher level of safety:

“In the UK and Ireland, over 10 million cylinders have been subjected, over the last 20 years, to periodic inspection as detailed in EN1440 without the use of hydraulic tests. During this time the entire population has been inspected without any safety issues attributable to the method of inspection. Over the last five years, for which statistics are available, the failure rate of cylinders inspected (according to EN1440) using the external and internal visual examination and pneumatic leak test was 7.19%, compared to the failure rate of the cylinders inspected (to the regime required by ADR) using the external and internal visual examination and hydraulic test, which was 5.08%. It should also be noted that under the ADR regime the failure rate due to the hydraulic test alone was 0.0054% - i.e. practically all the cylinders which failed the periodic inspection failed due to the detailed external and internal visual examination – if they had passed the detailed external and internal visual examination, they passed the hydraulic test too. The small number of failures during the hydraulic test was primarily due to external cylinder base corrosion. Since the introduction of improved external inspection methods in 2006 there have been no failures at hydraulic test.”

Case Study – An Independent Notified Body that undertakes Periodic Inspection

A UKLPG Member ‘Company’ is an accredited Type A inspection body, in accordance with ISO 17020:2012, and a Notified body under 2010/35/EU the Transportable Pressure Equipment Directive.

The ‘Company’ is constantly looking to take unnecessary cost out of their operation in order to compete effectively with the ever cheaper cost of new cylinders that may have questionable quality standards. In 2014, it became more cost effective for the ‘Company’s’ clients to import certain types of these cheaper LPG cylinders than to have cylinders requalified by the ‘Company’. By way of example 30% of their production in 2015 is now completely devoted to scrapping cylinders as a direct result of cheaper cylinder imports; this is up from 21% in 2014.

The ‘Company’ requalifies LPG cylinders to BS EN1440:2008+A1:2012. As such, they carry out the following periodic inspection activities; external inspection, internal inspection, hydraulic testing, cylinder thread inspection and they also carry out additionally and voluntarily a pneumatic air test at 6 bar under water as part of their final inspection.

For the ‘Company’, the cost of undertaking hydraulic testing in terms of maintenance and repairs, capital investment, manning, operating costs, replacement parts and servicing is in excess of £95,000 per year 5% of their turnover (assuming a depreciation on capital equipment over 10 years). Furthermore, they have just spent £70,000 on a new six station facility to expand their periodic inspection on ADR cylinders (whilst this will mainly be used for periodic inspection activities under EN1803:2002).

The ‘Company’ may need to invest more capital if they have to continue the practice of hydraulic testing, which given the data already supplied in this paper, would have no safety benefit to our clients but would add additional cost. An investment that would be far better spent in other areas of the business that would help to reduce their unit costs, a prima facie objective of the company.

It is significantly more cost effective for the ‘Company’ to operate a pneumatic water bath testing facility, in

terms of manning, servicing, capital expenditure and running costs in comparison to a hydraulic testing facility, which is questionable at best.

Furthermore, by dropping hydraulic testing in favour of pneumatic testing of cylinders on EN1440 periodic inspection, activities would return that part of the 'Company' to profitability instantly, therefore incentivising the 'Company' to re-invest and continue periodic inspection.

It is important to note for the UK LPG industry that the 'Company' is the last remaining independent company to carry out periodic inspection in the UK and Ireland. Should their business cease to trade, it would leave a substantial gap in the market for regional gas suppliers to have their cylinders periodically tested. The UK LPG industry will have no option but to purchase new cylinders from abroad, which from experience brings about a different set of issues that can impact of safety.

Cost to LPG industry

UKLPG can confirm that the cost to the industry as a direct result of hydraulic pressure testing would be in the region of £1.5M per annum, with zero benefit. This is at odds with current UK government policy which seeks to give proportionate benefit to all concerned. If we do not reduce costs to Industry there will be no independent facility to undertake the vital role of periodic inspection.

Related documents

EN1439:2008 LPG equipment and accessories – Procedure for checking LPG cylinders before, during and after filling

EN1440:2008 LPG equipment and accessories – Periodic inspection of transportable refillable LPG cylinders. This standard cannot be included as there is restricted access – it can be purchased.

EN1440 2008+A1:2012, LPG equipment and accessories – Periodic inspection of transportable refillable LPG cylinders

ADR 2015 European Agreement Concerning the International Carriage of Dangerous Goods by Road

BS EN 12816:2010 LPG equipment and accessories. Transportable refillable LPG cylinders Disposal

ISO/IEC 17020:2012 Conformity assessment – Requirements for the operation of various types of bodies performing inspection

New Test Regime in Consideration

- *Enhanced external inspection (particular focus on vulnerable areas e.g. cylinder base)*
- *Internal inspection using specialist equipment*
- *Leak checking following filling:*
 - *by immersion in a water bath; or*
 - *using leak detection fluid around joints and welds; or*
 - *using electronic gas detection equipment*

Justification

- UK Companies have documented evidence that has shown by concentrating their efforts on external inspection prior to the periodic inspection process - subsequent failure rates on hydraulic test failures and internal inspection have fallen more than proportionately.
- No defects have been picked up by the hydraulic test (reference: Case Study) as these are detected and rectified during the pre-periodic inspection process. Therefore, remedial action is taken before cylinders get to hydraulic test stage
- An additional check ensures that any defects undetected at the external and internal inspection stage will be detected during the post fill leak check process
- There is documented evidence to support the application of this alternative test regime (see case study); additional company specifications are available upon request.
- A consistent test regime will exist for both types of cylinders constructed to BS5045 and EN1442. This will eliminate the need to segregate and avoid the risk of over pressuring old cylinders at hydraulic test (which are designed for lower test pressures).

Important Note

Cylinders that have undergone reconditioning (involving hot work, repairs) will continue to be subject to the hydraulic proof pressure test immediately following reconditioning.

Disposal of Cylinders and Cartridges

UKLPG advises that consumers should return cylinders to their supplier or their nearest stockist. LPG cylinders remain the property of the gas company who supplied them. Consumers should dispose of empty gas cartridges with care. Cylinders and cartridges should be always treated as FULL, the gas residue that they contain could lead to danger.

Under no circumstances should cartridges be thrown onto fires. Small numbers of empty cartridges can be disposed of by recycling or including them in normal refuse but significant quantities should be disposed of by arrangement with the Local Authority or by a specialist waste contractor.

UK examples of good practices to extend the life of the cylinder:

- Suppliers conform to the European Manufacturing Standards and they have procedures for quality control when cylinders arrive from the manufacture
- We have a number of LPG companies that are Government Approved Inspection Bodies and have accreditation to test and inspect cylinders. Their internal procedures are audited against an ISO standard. For example as mentioned in this document, A UKLPG Member 'Company' is an accredited Type A inspection body, in accordance with ISO 17020:2012, and a Notified body under 2010/35/EU the Transportable Pressure Equipment Directive
- UKLPG issued a consumer information sheet detailing best practice (UKLPG UIS 028). It can be found in the British Standard BS EN 1440 : 2008, titles *LPG Equipment and Accessories –Periodic Inspection of Transportable Refillable LPG Cylinders*
- Gas suppliers in the UK have stockists that retail and distribute LPG cylinders to consumers. They receive training from the gas supplier in accordance with company standards
- UKLPG have Codes of Practice for the storage and filling of cylinders that industries adhere to and regulators use as normative standards for inspection
- UKLPG now have a cylinder disposal scheme that is agreed with the local authority so that consumers can return cylinders to a local authority site if gas suppliers have not collected them. This will hopefully lead to cylinders having a longer life as they are not kept in someone's garden for many years. The gas suppliers routinely pick up empty cylinders from the local authority sites
- UKLPG has an agreement with the Competent Authority to extend the life of cylinders to 15 years
- Cylinders are painted in accordance with European Standards and often company's internal specifications may be more demanding to ensure correct thickness of coating and that adequate protection is applied to take account of cylinder use in the field

APPENDIX (i): Sample procedure (in use by LPG operators)

LEAK CHECKING OF WELDS & JOINTS

Water Bath Test

1. Cylinders placed onto the conveyor.
2. The operator checks to ensure the valve has been torqued to the required torque pressure, via an auto bench gun.
3. The operator checks the valve alignment is correct to the specific valve, and that the test disc is fitted correctly and that the tare weight has been correctly placed on the shoulder.
4. The Operator checks that the cylinder has been charged to 6 Bar using air or LPG.
5. As the Cylinders move along the track, they are lifted to test height and are held above the water bath in the test rig.
6. As the Rig turns through 90 degrees, the operator checks to ensure the cylinders are fully submerged in the water.
7. The cylinders are held submerged to allow any surface air to escape from the cylinder shroud or basering. The cylinders are held still to not create any water currents.
8. The operator is required to visually detect any leaks whilst the cylinders are submerged under pressure. Close attention is paid to the valve boss and all weld areas.
9. The area is fully lit.
10. At the end of the conveyor each cylinder is checked externally for 'Final Acceptance'.

Appendix Fifteen

United States



- Mature market - mainly Chemicals/Domestic
- DOT used for cylinder design etc.
- Cylinder population over 90m
- 12 years requalification for steel cylinders, then it varies (e.g. visual five years, hydro seven years)
- Valves are not repaired in the USA
- Inspection on valves includes check for illicit drug use
- CGA C-6 used for requalification of cylinders
- Valve protection highlighted as a key issue

DOT is the code used in the USA for requalifying cylinders

USA summary of the procedures for the:

- Routine inspection and checking of LPG cylinders as they enter the filling plant
 - Cylinders are checked by removing any plastic sleeve; they are checked for surface rust and any severe dents or gouges; the valves are checked for blue coloured degradation, which would indicate cylinder usage in the illicit manufacturing of methamphetamines; the valve “face seal” is checked for cracking, splitting deformation. Different companies have different procedures for checking these items and others.
- LPG cylinder requalification (or a copy of DOT)
 - Cylinder requalification is performed using CGA C-6 (published by the compressed gas association) for steel cylinders. Since this is copyright information, we cannot attach a copy. You can download that standard here:
 - http://webstore.ansi.org/RecordDetail.aspx?sku=CGA%20C-6-2013&source=google&adgroup=cga&gclid=CjwKEAiw6_q5BRcOp-Hj-IfHwncSJABMtDaikK0uM4hDLPoH4E6laswGOSOPfR3PJOhHj1zmIFYN_hoCqUbw_wcB
 - It contains some useful information quantifying the degree of damage on a cylinder

Disposal of LPG cylinders

Cylinders are disposed of by removing the liquid, then filling with water to remove any remaining vapour, or just left in the open to allow the vapour to dissipate. The cylinder may be sent to a recycling facility for disposal.

At least one example of bad practices in your country that leads to a shorter cylinder life

When cylinder valves are not protected by the customer, the valve can degrade; Also, cylinders that are stored on the ground may experience a higher rate of corrosion.

At least one example of good practices in your country that leads to a longer cylinder life

Cylinder valves that are protected by caps when not in use can lead to a longer usable life.

Appendix Sixteen

Cylinder Manufacturer's Feedback

Some large international LPG cylinder manufacturers were contacted and asked the following:

'The WLPGA is conducting a project on LPG cylinder management to determine what the key issues are for prolonging the life of an LPG cylinder. The background is that the requalification period for LPG cylinders varies greatly around the world and if countries are seeking to extend this they will need some evidence to support it. Much of this will focus on storage and handling issues, but from your perspective, what are the key design and manufacturing issues for prolonging the life of a cylinder?'

The responses received from one cylinder manufacturer (TPA – Taiwan) confirmed they broadly have two types of customers.

- (i) Retail outlets – that sell LPG cylinders directly to the consumers. The retail outlets are 'more price driven and not so concerned about quality as long as the appearance is acceptable'.
- (ii) LPG marketing companies – that retain ownership of the cylinder and are responsible for the asset. 'They care about everything and want the cylinders to last forever'.

To ensure longevity, zinc metalizing, footing/shroud design and the quality of the neck ring (boss) thread are 'very important'.

Most qualified cylinder manufacturers will have adequate procedures and systems 'to ensure the deep draw, welding, heat treatment, and testing of the cylinder'.

According to TPA 'the surface coating is one of the most important factors to ensure the cylinder lasts longer'

They claim that 'most LPG marketing companies prefer to have a zinc metalised based paint coat.' However, the process of zinc metalising is challenging for the operators. There is a need for protection for the operator, and the workstation has to be well designed to avoid polluting the operators and the environment. It is not an environmentally friendly process. They state 'according to our experience the #2 coating in the AGA standard 2469 is preferred. It is a zinc rich coating. The application of the zinc powder onto the cylinder is like the normal powder paint process. However, according to our internal tests, rust proofing is just as good as zinc metalising, but much easier to operate with less pollution.'

They add 'having a larger and thicker foot ring definitely helps mitigate damage during cylinder filling and transportation.' Regarding the neck ring, or boss, they claim 'we use Japanese made neck rings mostly, and the rest made in house. The main concern is the neck ring thread. As we are a valve manufacturer as well, TPA understands the thread requirement, and as a cylinder factory we understand the importance of the thread which could cause leak.'

TPA claims 'many neck ring manufacturers we found are not very good at making threads. To qualify a few neck ring factories and make recommendations to the industry might not be a bad idea.'

They say major LPG companies have started to use higher grade and thinner steel to replace the thicker and lower grade steel that was used in past years. The lighter cylinder makes for easier handling, and saves on transportation cost.

In contrast, some countries are still insisting on using thicker and low grade steel. Their theory is that the thicker material is harder to deform during bad handling and takes longer time to rust through.

Regarding the steel quality TPA says 'we did find that good steel companies have very consistent material thickness and mechanical results. That makes for smoother cylinder production and consistent quality. This is an important factor if you want cylinders to last longer time and creates fewer problems.'

Manchester Tank Australia provided this feedback:

The question is an interesting one when it comes a cylinders' life. The cylinder life varies from country to country and the acceptance level of cylinders also varies from country to country.

Surface coating of cylinders can vary from galvanizing, zinc metalising and top coating with powder coat or wet solvent spray, zinc rich primer with a powder coat or wet solvent spray or just straight powder coat or wet solvent spray coating. The decision on coating in most cases is made by the customers and is generally always price driven, not code driven. Galvanising will always provide the superior corrosion resistance and this is evident with cylinders in Australia still in service after 60 years. The surface condition of cylinders will always be subject to the amount of times they are handled and how they are handled. As we have all travelled we have seen cylinders thrown off and on trucks, rolled down the road or on the back of motor bikes. In Australia the handling is controlled better and the life of cylinders is extended.

Several countries have cold rework and hot rework in their codes, resulting in cylinders practically getting rebuilt with a new collar and footing. We have seen many of these with new attachments and the body of the cylinders in very poor shape.

We are starting to see light weight cylinders in some markets as manufacturers try to lower their cost with less steel weight. We have seen many times these cylinders dented and have concerns of how they will last in the cylinder exchange markets.

In relation to foot ring diameters, we have most customers wanting the foot ring smaller than the cylinder. The reason for this is most of their transport and their storage cages are based on the diameter of the cylinder. This allows for the maximum amount of cylinders to be stored in the smallest area. These customers also have built their filling lines on these diameters. We can see your reasoning for the foot ring to be larger to reduce rubbing on the cylinders wall.

There are many types of boss design but the constant is the thread spec. Some valve manufacturers build their own sockets and several don't. You will find there are many high volume socket manufacturers building high quality sockets and supplying to the cylinder manufactures. We find most valve and cylinder manufacturers focus on their core business and do not manufacture the boss / socket. All sockets that are used in our cylinders are inspected and gauged to the relevant thread standards.

Appendix Seventeen

Follow up Questionnaire

The WLPGA Global Cylinder Network has agreed to have a follow up to the *'Report on the Testing and Requalification of LPG Cylinders'* to which you kindly contributed.

The main objective of phase two is to provide a 'toolkit' of information that could be used in an audit of current practices with the aim of improving the way LPG cylinders are managed in a business, and how the costs of doing this might be reduced.

Phase two will examine the various influences that impact on the life of a cylinder from the design and manufacture through to the decision to dispose. This includes all aspects of filling, storage, handling, distribution and use. It will also include the impact of climatic and working conditions.

It will highlight some typical bad practices that might shorten the life of a cylinder and provides some mitigating measures and solutions.

Phase two will also examine in detail the procedures for inspection, repair, maintenance, requalification and disposal of LPG cylinders.

As a follow up to phase one we would like to ask three questions:

- Could you please send a summary of the:
 - Process for routine inspection of checking LPG cylinders as they enter the filling plant
 - Procedures for LPG cylinder requalification (or a copy of IS-13258)
- At least one example of bad practices in your country that leads to a shorter cylinder life (with photos if possible)
- At least one example of good practices in your country that leads to a longer cylinder life (with photos if possible)

The above examples might be cylinder design or manufacturing methods, ways of handling and distributing cylinders, dealer incentive programmes, etc.

We will include all the feedback in the final report for phase two along with other information gathered.

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