Photo courtesy of Eurotainer

Photo courtesy of MannTek & Rego

Good Industry Practices Guide for LPG ISO Containers

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WLGA
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Acknowledgements

WLGA Director, David Tyler, drafted this Guide which was peer reviewed by Vic Marinas, an LPG consultant based in The Philippines with extensive international experience in LPG operations. The draft was also reviewed by the WLGA Core Safety Group members. The WLGA would like to thank all those members of the Core Safety Group who contributed material, reviewed the initial draft, and made valuable comments. Finally thanks to Eurotainer, France (www.eurotainer.com) and MannTek (www.manntek.se) for providing the cover photos.

1.0 Background

The World Liquid Gas Association (WLGA) is committed to providing independent advice to LPG stakeholders to ensure their safety in the operation of LPG equipment and in the running of LPG businesses.

The two WLGA Guidelines, Good Business Practices and Good Safety Practices, have been used extensively during the last two decades all over the world to provide guidance across all areas of the LPG industry.

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

Following the publication of these guidelines it was decided to develop and publish guides that provide more detailed advice, particularly in certain areas of the supply and distribution chain that are considered more critical and where more prescriptive advice would be helpful (Safety & Good Business Practices - World Liquid Gas (WLGA)).

This is one of the many guides issued by the WLGA and deals with the subject of *LPG ISO Containers*. The document addresses the engineering, operation and safety requirements for using LPG in ISO containers in terminals, depots and cylinder filling plants.

ISO containers in the LPG industry are used mainly for the development of new and often challenging LPG markets. There are specific risks associated with their application and the advice presented in this guide has been taken from companies that are using LPG in ISO containers in their business, and from companies that manufacture and lease LPG ISO containers. There is also some important information that is applicable to the use of bulk LPG storage tanks that is equally relevant when using LPG ISO containers. For this, reference is made to the *WLGA Good Industry Practice Guide for Bulk LPG Installations* (2020 Guide to Good Industry Practices Bulk LPG Installations)

It is recommended that the advice in this guide be applied in conjunction with any applicable local or regional laws/regulations to enhance the overall safety performance of the LPG business.

2.0 What are ISO Containers and why are they used?

Figure 1 - Typical LPG ISO Container located on a flat-bed truck (courtesy Fogas)

ISO containers, or ISO tanks, are intermodal containers used for storing and transporting hazardous and non-hazardous substances.

They are designed and manufactured in such a way that makes them transportable seamlessly on container ships, rail cars and flat-bed trucks.

LPG ISO containers are essentially LPG tanks fitted with all the required appurtenances and supported with a protective framework that is built to standard configurations to meet ISO tank standards i.e. ISO T50. There are two configurations for ISO containers, i.e. 20 feet and 40 feet, with the 20 feet version more commonly used in the LPG business.

LPG ISO containers are used in situations where the conventional LPG storage facilities are not suitable or practicable at the location. These include new market development locations and sites with constrained access to bulk LPG supply.

2.1 New Market Development

The LPG industry is capital intensive, and developing new markets requires up-front investment in storage facilities, cylinders and cylinder filling plants. Although the quantity contained is relatively small, ISO containers allow the opportunity for introducing bulk LPG into new markets without large scale investment in permanent storage tanks.

Figure 2 - Containerised cylinder filling plant (courtesy Makeen Energy)

ISO containers are modular in design and so the initial bulk storage capacity can be increased as the market grows. Containerised cylinder filling plants can be used alongside LPG ISO containers to supplement this early-stage market development.

It should be noted here that a standard 20-foot shipping container cannot be used safely for LPG cylinder storage in its original condition, they should be modified to be aligned with recognised regulatory and engineering requirements such as NFPA 58 and Liquid Gas UK - COP 7 (Code Of Practice 7 — Liquid Gas UK: The trade association for the LPG and biopropane industry in the UK) as well as local regulations. Very close considerations shall be given to ventilation, ignition source, fire protection, explosion venting requirements and gas detection.

Although LPG ISO containers are not restricted to early stage markets it would be prudent to design the pressure vessel for propane when they are. This gives full flexibilty to use propane (with its higher vapour pressure), butane - and mixtures of the two - without compromising safety.

When a market has developed sufficiently in size to justify permanent storage facilities, the ISO containers can be relocated to other green field sites and the process repeated.

2.2 Market Access Challenges

In some markets it may be difficult to introduce bulk LPG into the preferred location because of accessibility challenges – for example island geography or shallow water - that prevents ships carrying bulk LPG to access the storage site. In these situations, LPG can be supplied using ISO containers filled from an offshore LPG terminal, loaded onto container ships, and then transferred to a flat-bed truck for delivery to the site. Empty ISO containers are swapped with the filled ones, and the empty ones are shipped back to the terminal for refilling.

2.3 Temporary Installation

LPG ISO containers are also suitable for situations where LPG supply is required for a limited duration for specific applications, e.g. temporary power generation, or fuel for construction activities. In these cases, ISO containers can be brought to site and used as a temporary storage facility that is installed according to the guidance notes of the *WLGA Good Industry Practice Guide for Bulk LPG Installations* (2020 Guide to Good Industry Practices Bulk LPG Installations).

After the temporary requirement has been fulfilled, the ISO container can be retrieved from the site and shipped back to the terminal for other uses.

3.0 LPG ISO Container Design

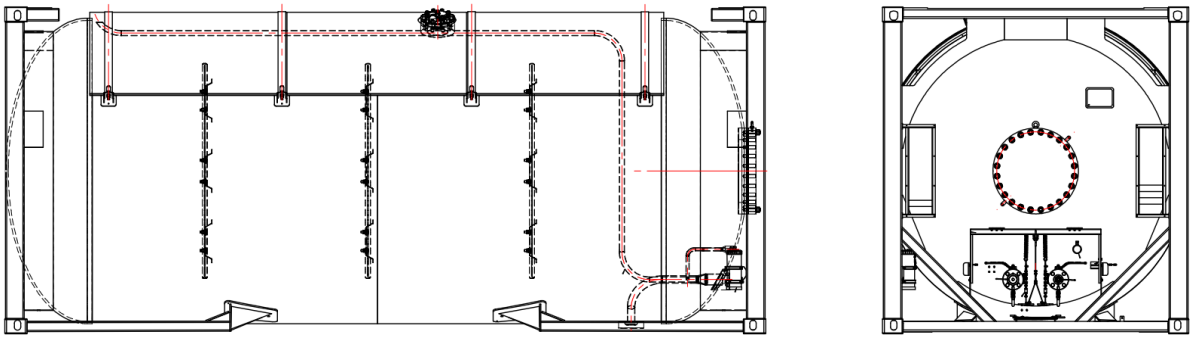


Figure 3 – Sample drawing of ISO Container (courtesy Fogas)

3.1 General

LPG ISO containers are intermodal containers used on ships, railways and road, and must be designed, manufactured and maintained in strict compliance with various codes and standards so that they can be used seamlessly across different modes of transport.

They are used for storing hazardous product under pressure and any uncontrolled discharge must be prevented. Tank failures due to poor construction can result in serious consequences. For this reason, the pressurised tank, as part of the LPG ISO container, should be designed and manufactured to a recognised code or standard to ensure their safety during transport and use while onsite. They must also hold necessary approvals to be accepted for transport on maritime shipping and/or rail networks as required in each jurisdiction.

3.2 Design Code

LPG ISO containers should be designed, manufactured, inspected and tested in accordance with recognised international design codes and standards that cover all aspects of unit (e.g. ISO 1496-3, ISO T50, ASME VIII, 49CFR etc.). Where local regulations require the use of national standards or alternative codes it is important to confirm that they at least equal the requirements of ISO T50, ASME VIII or the equivalent.

3.3 Design Pressure and Temperature

The design pressure of the tank should be based on the maximum vapour pressure developed by LPG at the applicable reference temperature. This is dependent on the grade of LPG to be carried. If the ISO container will be used for transporting different grades of LPG, the grade of LPG resulting in the highest vapour pressure should be used i.e. propane. Reference temperatures, specified under the UN Model regulations for the transport of dangerous goods, to calculate the vapour pressure of LPG developed inside the ISO container which is as follows:

- 50°C for tanks more than 1.5m in diameter with sunshield
- 60°C for tanks more than 1.5m in diameter without sunshield

LPG ISO containers should be designed for vacuum conditions developed by the product during operation or other operational conditions. As a minimum, this should be 0.4 bar gauge pressure unless local/regional regulations require full vacuum.

3.4 Construction

LPG ISO containers come in two configurations: 6.05m (20 ft.) and 12.19m (40 ft). The 6.05m ISO container has dimensions of 6.05 m (20 ft) length, 2.42m (8 ft) width and 2.60m (8.6 ft) height with a water capacity ranging from 24,000 litres to 24,600 litres. The 12.19m (40 ft) configuration has the same width and height but with length of 12.19m (40 ft) and water capacity ranging from 51,700 litres to 52,000 litres.

LPG ISO containers are cylindrical in shape and have semi-ellipsoidal ends. A 500mm diameter manhole is provided on one of the ends of the tank for internal access.

LPG ISO containers should be of welded steel construction. The steel used should have suitable properties, particularly with regard to impact resistance for operation over a range of temperatures between -20°C and +50°C.

LPG ISO containers commonly operate in a marine environment which is much harsher because of the saline conditions. This should be considered when selecting the type and size of the components and painting system used.

LPG ISO containers should be painted in a light colour, preferably white, to increase reflection and minimise the temperature rise of the contents from solar heat gain. They should also be suitably protected against corrosion arising from environmental effects.

3.5 ISO Container Frame

LPG ISO containers are built within a framed cage which is designed to facilitate lifting and stacking while they are in transit. The framework should comply with the relevant ISO tank standard i.e. ISO 1496-3, ISO 668, etc. to allow it to move seamlessly across the different modes of transport.

The dedicated earthing or grounding point is normally fitted to the tank frame.

Corner castings should be made of reinforced blocks with standard holes designed for locking mechanisms. Twist locks are made of standard rotating fasteners that secure the corner castings to ships, railcars or trailer beds. Corner posts are made of vertical steel pillars that can withstand stacking weight when containers are piled on top of each other.

Figure 4 - LPG ISO Container supported in a frame (courtesy Fogas)

3.6 Surge or Baffle Plates

LPG ISO containers should be fitted with surge or baffle plates if the liquid content is filled to between 80% and more than 20%. This is set laterally to limit any longitudinal surge of liquid LPG following sudden acceleration of the vehicle. The plates must be at least 2 mm thick and have a suitably sized manhole for full access through the tank. Openings must be provided at the top and bottom of each plate to allow for complete liquid and vapour transfer. The volume between plates should not be more than 7.5m^3.

A 6.05m ISO container will typically have three baffle plates while a 12.19 m unit may have more.

3.7 Sunshield

A sun shield installed on ISO containers reflects direct sunlight, keeps the LPG temperature cool and prevents dangerous pressure build up that may activate the pressure relief valve to discharge.

The shield is mounted approximately 10 to 15 centimeters (four to six inches) away from the actual tank shell. This creates a physical gap that allows air to circulate, naturally cooling the tank via convection. It usually covers only the top half or top two-thirds of the tank as this is the area most directly exposed to sunlight. The material used should be lightweight, corrosion resistant and highly reflective i.e. aluminum or stainless steel.

Figure 5 - ISO Container fitted with sun shield (courtesy Fogas)

3.8 Markings and Labels

LPG ISO containers are subject to strict international shipping and road transport regulations and are required to display specific markings and labels. The markings and labels should be permanent, visible, legible and indelible. If tags or plates are used, they should be securely fixed to the part to which they relate. Paper labeling should not be used as these may be destroyed in a fire.

Figure 6 - Showing tank markings (courtesy Fogas)

It is important to mention here that markings and labels are important even when LPG ISO containers are used as a temporary solution.

3.8.1 LPG Tank Design Data

The following design data is recommended to be shown on the tank labelling:

- Design code
- Maximum operating pressure
- Minimum operating pressure
- Maximum design temperature
- Minimum design temperature
- Date of manufacture
- Manufacturer's identity
- Serial Number
- Water capacity
- Date – month and year – of last pressure test
- Test pressure
- Inspection authority's identification

3.8.2 Operational and Capacity Markings

Similarly, the following operational and capacity markings are recommended to be shown on the tank:

- Maximum Gross Weight
- Tare Weight
- Maximum Load Weight
- Water Capacity

3.8.3 Product Hazard Labels

The following product hazard labels are also required:

- Primary Hazard Label
- UN Number
- 'Liquefied Petroleum Gas' or 'LPG' painted on both sides of the ISO container. If un-odourised LPG is being transported, it must also be clearly marked 'UN-ODOURISED' on both sides of the ISO container
- Emergency contact numbers

Figure 7 - LPG ISO container hazard labels
(*Courtesy of Elgas Australia*)

3.8.4 Other Labels and Markings

- Owner Code and Serial Number
- ISO size and type code
- Hazard Identification Number (23 for LPG)
- 'SV' (for safety valve) marking if operated under ADR

4.0 ISO Container Fittings

4.1 General

All valves and fittings on the ISO container should be suitable for liquid phase LPG at the anticipated operating pressures and temperatures. These should be installed or fitted in accordance with the manufacturer's instructions and recommendations.

Protection against mechanical damage must be provided by design, location or barriers against the dangers of collision or roll-over. Mechanical barriers should not be attached to pipework or valves which they are intended to protect.

Joints for pipework may be threaded for pipe sizes up to and including 50 mm nominal bore, or for proprietary items such as pumps, valves and meters up to 80 mm nominal bore. Larger sizes of pipe should either be welded or have welded flanges.

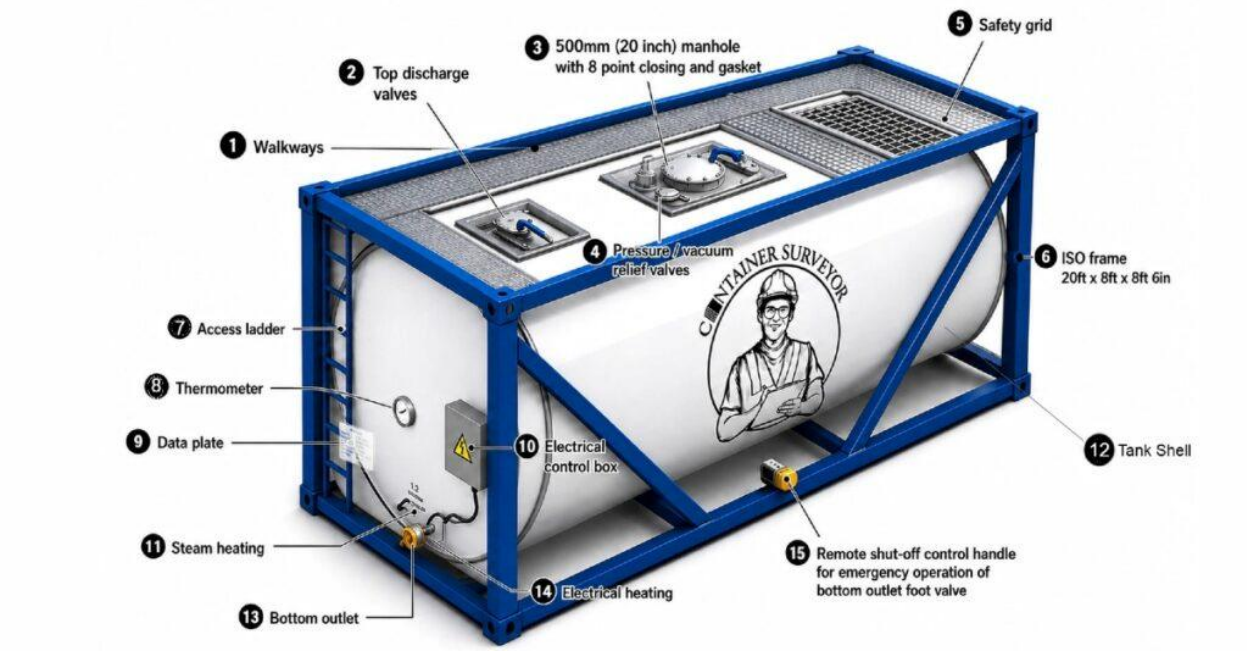


Figure 8 - LPG ISO container fittings
(courtesy: Liaquat Ali)

Threaded fittings should be forged carbon steel to BS 3799 or ANSI/ASME 16.11 and may require the use of heavy wall pipe. The thread on both the fitting and pipe should be tapered and of the NPT form.

All LPG ISO containers must be equipped with the following:

- Pressure relief valve
- Liquid valve
- Vapour valve
- Contents gauge
- Pressure gauge

Other fittings used on ISO containers may include:

- Maximum liquid level fixed ullage gauge
- Temperature gauge

4.2 Pressure Relief Valve

Unless prohibited by local legislation, all LPG ISO containers should be fitted with one or more pressure relief valves. The start to discharge setting shall not be greater than the tank design condition. The combined capacity of relief valves shall meet the requirements of ADR Chapter 6.7 or NFPA 58 Appendix E, E.2.2.

Pressure relief valves shall be spring loaded, flush-mounted, fully internal design and sited in the vapour phase of the tank which is on the top portion of the tank. They must be designed in such a way that limits the risk of a leak in the event of a transport accident.

Means must be provided to prevent water and solid particles from collecting in the outlet of the pressure relief valve.

4.3 Liquid Valve

The liquid valve can be used for filling and discharging the product from the ISO container. It is typically 50mm in diameter and consists of three components: an internal valve which must be remotely activated, a manual shut off valve and a 3¼" ACME coupling. Dry Disconnect Couplings can be used in place of ACME couplings to limit the release of LPG during loading/unloading of product. The liquid valve is normally located at the bottom portion of the tank ends and secured within a valve cabinet.

4.4 Vapour Valve

The vapour valve is used to maintain a balanced pressure between the source tank and the ISO container during filling. It can also be used as a vapour withdrawal valve when used as a temporary tank onsite. The vapour valve is typically 50mm in diameter and includes an internal valve which can be remotely activated, a manual shut off valve and a 2¼" ACME or Dry Disconnect Coupling. The vapour valve is also located at the bottom of the tank ends within the valve cabinet. The vapour valve extends inside the ISO container with an internal piping that terminates in the vapour space.

Figure 9 - Example of MannTek male adapter Dry Disconnect Coupling with Rego safety valve (courtesy of MannTek and Rego)

4.5 Contents Gauge

A float gauge is usually installed on the ISO container as a means to determine the level of the contents. Contents gauge may be a simple magnetic float gauge and indicates tank levels in percentage of water capacity.

4.6 Pressure Gauges

Pressure gauges, when fitted, should be installed directly into the vapour space of the LPG ISO container and easily readable from ground level. Pressure gauge connections should be protected either by a tapping reduced internally to a bleed hole not larger than 1.5 mm diameter, or by a suitable excess flow valve and shut-off valve.

5.0 Tank Commissioning and De-Commissioning

5.1 General

All LPG ISO containers must be inspected and pressure tested in accordance with the design code and standard before they are put into service. They must also be subject to a thorough inspection every 5 years with an intermediate inspection, and testing every two and a half years as required by applicable regulations.

An exceptional inspection and test must be done regardless of the date of last periodic or intermediate inspection and test if any of the following conditions exist with the LPG ISO container:

- Evidence of dents, corroded or abraded areas, leakage, or any other condition that might render it unsafe for use or transportation
- Involvement in an accident and has been damaged to an extent that may adversely affect its ability to retain LPG
- Out of service for a period of one year or more
- Modified from its original design specification
- Unsafe condition based upon probable cause

5.2 Purging and Commissioning

All ISO containers and associated fittings should be purged until there is insufficient oxygen inside to support combustion. To do so, the air should be either evacuated or replaced with inert gas or LPG.

- **Inert gas purging** – If inert gas typically nitrogen is used the oxygen content should be purged until it is less than 1% and the pressure should be 0.05Mpa. The inert gas is then removed from LPG ISO containers with vapour LPG, taking care to direct the purged gas/LPG mixture safely away from other tanks, ignition sources, boundaries, buildings or public places, or to a flare stack. Care should be taken during purging to ensure the safe dispersion of unignited purge gases. If purge gases are flared this should be done outside the normal separation distances

- **LPG vapour purging** – When LPG vapour is used to replace air, the LPG ISO container and fittings will, for a period of time, still contain a flammable mixture. A competent person should vent this to atmosphere in a safe manner. A flame arrestor should be fitted in the vent line to prevent flashback should the LPG/air mixture ignite

5.3 Initial Fill and Maximum Fill Quantity

Once the ISO container has been properly purged of air and inert gas and only vapour LPG is inside, it is now ready for initial filling. A competent person should be present and in control throughout the initial fill.

Before filling the LPG ISO container ensure all joints are properly connected and valves are in the correct open/closed positions and the ISO container is properly earthed.

Contents gauges should be checked for freedom of action/movement by observation during the initial fill.

LPG ISO containers can be filled by weight or by volume. An LPG ISO container must never be filled beyond its maximum safe quantity. This is to prevent liquid expansion of LPG inside the ISO container with temperature change leading to uncontrolled discharge of LPG through the pressure relief valve. The maximum safe quantity shall be such that the ISO container shall not be 97% liquid full when the LPG reaches its highest anticipated temperature or also referred to as reference temperature. The reference temperature depends on the climatic conditions of each locality and is normally prescribed by local legislation.

The maximum filling limit by weight of an LPG ISO container shall be in accordance with the filling ratios in NFPA 58 Table 7.4.2.2 which is reprinted below.

Table 7.4.2.2 Maximum Filling Limit by Weight of LP-Gas Containers (Percent of Marked Water Capacity in Pounds)

	Aboveground Containers		
Specific Gravity at 60°F (15.6°C)	0 to 1200 gal (0 to 4.5 m^3) Total Water Capacity (%)	>1200 gal (>4.5 m^3) Total Water Capacity (%)	Underground Containers All Water Capacities (%)
0.496–0.503	41	44	45
0.504–0.510	42	45	46
0.511–0.519	43	46	47
0.520–0.527	44	47	48
0.528–0.536	45	48	49
0.537–0.544	46	49	50
0.545–0.552	47	50	51
0.553–0.560	48	51	52
0.561–0.568	49	52	53
0.569–0.576	50	53	54
0.577–0.584	51	54	55
0.585–0.592	52	55	56
0.593–0.600	53	56	57

The maximum filling limit by volume of an LPG ISO container shall be in accordance with NFPA 58 Table 7.4.2.3 (b).

ISO containers must never be filled beyond its maximum allowable capacity to prevent dangerous surge forces that may destabilise the transport vehicle during braking and to allow space for thermal expansion.

5.4 Decommissioning

ISO containers must be decommissioned if they are due for internal inspection and/or undergoing repair work.

This will require the removal of as much liquid LPG from the LPG ISO container as possible prior to de-commissioning via normal use or through controlled transfer to other tanks or vacuuming by a gas compressor until remaining LPG content is less than 4%.

Vent or flare the residual LPG inside the ISO container following the safety precautions indicated above. Purge with inert gas until all LPG vapours are cleared out. Displace the inert gas with clean water or other suitable methods. If clean water is used it should be correctly disposed of.

Care should be taken to ensure that no flammable vapours are generated from residual heavy ends.

5.5 Protection against Damage from Vehicles

Do not site LPG ISO containers, pipes and associated equipment in areas used by vehicles. If this cannot be avoided, install strong bollards or crash barriers appropriate to the size and weight of vehicles that are likely to use roads in the area. Never rely simply on the security fence or the use of warning signage or road marking.

Designating a parking area for vehicles away from the LPG ISO containers can reduce the risk of vehicular damage. Classify the parking areas according to the type of vehicle being parked i.e.

- Vehicles controlled by the site operator should be parked no closer than three metres, providing that ventilation around the tank is not obstructed

- Vehicles not controlled by the site operator (e.g. driven by the public), should not be parked any closer than three metres, or the specified separation distance, whichever is the greater

6.0 Lifting, Handling, Transport and Storage

6.1 Pre-lifting Inspection

Before attaching any lifting machinery, operators must verify both the physical integrity of the frame and the ISO container's stability.

Ensure the Container Safety Convention (CSC) and statutory pressure test certificates are valid. LPG ISO containers require strict two and a half year intermediate and five year periodic inspections.

Inspect all four corner posts, top and bottom side rails, and corner castings for deep dents, fractures, or severe corrosion that could compromise structural integrity under load.

Ensure the valve cabinet door is closed, locked, and secure. Never lift an LPG ISO container with the valve cabinet open or with loose hoses attached.

Check the cabinet's pressure and temperature (if available) gauges to verify that internal ISO container parameters are within safe operating limits before movement.

6.2 Lifting and Handling Operation

Lifting operations should strictly be designed and executed by a competent, certified rigging professional. Only approved lifting equipment should be used for lifting operation. The recommended lifting equipment is a top-lifting container spreader that locks directly into all four top corner castings.

Never use angled slings hooked into the top corner castings of a loaded LPG ISO container. The compressive, inward horizontal forces can bend or snap the ISO container frame posts. Angled slings are only permitted on completely empty, depressurized tanks - and even then, the angle of the sling leg must never be less than 45° to the horizontal.

If lifting from the bottom corner castings, a specialised lifting lugs combined with a transverse cross-beam/spreader is used to ensure the slings pull vertically and do not crush the tank's sunshield.

Forklift pockets (if present) are generally intended for empty handling only. A loaded LPG ISO container exceeds standard forklift safety margins and risks uneven center-of-gravity tilting.

Always conduct a short, 100mm 'trial lift' to check the balance, center of gravity, and brake holding capacity of the crane before fully hoisting the tank.

6.3 Transporting LPG ISO Containers

Transporting LPG ISO containers must be done in strict adherence to international maritime (IMDG) and road (ADR/DOT) regulations and other LPG safety practices to prevent gas leaks or discharge leading to an accident.

ISO containers must be mounted on approved container chassis trucks or rail cars that matches their physical configuration and maximum gross weight and also be compliant to international maritime (IMDG) and road (ADR/DOT) regulations and other LPG safety practices.

The bottom four corner castings must be used for simultaneous support and locked firmly using all four twist locks. It is important that no other parts are in contact with the vehicle apart from the four bottom castings. Lashing or strapping a tank down without twist locks is strictly prohibited.

Figure 10 - ISO containers ready for road transport (courtesy Liaquat Ali)

As was mentioned earlier, ISO containers must never be filled beyond their maximum allowable capacity to prevent dangerous surge forces that may destabilise the transport vehicle during braking and to allow space for thermal expansion.

6.4 Storage

Ensure there is flat hard ground for storing LPG ISO containers, equipped with smooth drainage systems. If stacking containers, ensure the loading requirements can be met. The loading requirements must be supported by only the four corner castings. Ensure the bottom end rails and bottom longitudinal rails are not in contact with the ground

If the LPG ISO containers are multi-stacked the corner castings must be aligned. If there are heavy winds forecast, ensure the containers are fixed. The number of LPG ISO containers being stacked, and methods of securing them, must comply with the relevant local requirements

7.0 Filling and Discharging of LPG ISO Containers

7.1 Safety Precautions

The following safety precaution measures apply for both filling and discharging operations for LPG ISO containers and must be in place before any product transfer operations commence.

If the containers are going to be used in rail transport they may require specific certification e.g. in the USA the Association of American Railroads [Home - Association of American Railroads}.

Drivers and other personnel involved in LPG bulk road transfer operations must never leave the ISO container unattended during loading or unloading.

All personnel must wear appropriate personal protective equipment (PPE) during the transfer operation. This may include the following:

- Goggles or full-face visors
- Gauntlet design hand gloves
- Protective footwear
- Safety helmet in areas prescribed by risk assessment
- Long sleeved clothing made of 100% cotton
- High visibility jackets/vests if there is risk of not being seen by other moving vehicles
- Smoking and naked flames must not be allowed throughout the filling/discharging operation.
- All other electrical equipment not rated for the hazardous zone should be switched off
- Transfer hoses used must be visually examined for kinks, wear or any damage and must be within its inspection/test period
- Couplings and seals should be similarly examined to ensure compatibility and checked for the presence of any dirt etc. before connection
- The grade of LPG to be loaded and unloaded should be correctly identified and the receiving container must be suitable and have sufficient ullage for the intended load
- The quantity required to be filled and discharged must not exceed the maximum safe fill capacity of the receiving container
- On no account should any overloading be allowed. If the ISO container is inadvertently overloaded, technical/ supervisory assistance must be obtained by the driver or operatives involved to resolve the situation
- The ISO container must not be standing on public roads during the transfer operation. If there is no other solution, a risk assessment must be carried out. In space restricted areas the road tanker must be able to easily drive out without reversing
- The ISO container must be correctly positioned, e.g. beneath water sprays, adjacent to loading/unloading connections, facing in the direction that will permit easiest exit in the event of an incident
- Transfer operations should not be undertaken during hours of darkness without adequate (flameproof) lighting

7.2 Filling Procedure

Inspect the ISO container and vehicle to ensure it is in an acceptable condition for safe loading. It is recommended that the operators of supply terminals identify and keep a record of each ISO container and vehicle following an initial examination of major safety aspects. Periodic spot-checks are recommended for subsequent entries.

Position the vehicle carrying the ISO container at the designated loading area and engage the brake interlock. Make sure the vehicle is immobilised for the duration of the loading operation. Wheel chocks and barrier installations must be used when there is no interlock system provided on the road tanker.

Ensure that the twist locks are securely fastening the ISO container onto the vehicle.

Connect the earthing cable between the ISO container and the gantry structure and ensure the ISO container is properly bonded.

Connect the transfer hoses/loading arms. Ensure the couplings are properly connected without use of undue force before loading and check for any sign of leakage before and during loading.

When filling by volume monitor the level of the ISO container throughout the loading operation. Periodic level checks and observation of the ISO container pressure during loading will help in identifying if the vapour return line excess flow valve has inadvertently closed. Should this occur, the operation should be stopped and the condition rectified.

Reduce the filling rate as the maximum fill level in the ISO container is approached to avoid overfilling.

Stop the loading immediately when the maximum fill level in the ISO container has been reached.

If the ISO container is accidentally overfilled the excess LPG should be removed in a safe and approved procedure as soon as possible and before leaving the facility.

ISO containers filled using a level gauge may need to be weighed after loading to ensure that they are not overloaded based on gross weight.

Conduct a final check after disconnecting the loading lines and earthing connection to ensure all ISO container valves are properly closed and secured and that the vehicle is in a fit and safe condition to be driven away.

7.3 Discharging Procedure

The discharging of LPG from ISO container follows the general principles applicable to filling with the following additional procedures to be taken.

Park the vehicle carrying the ISO container on a flat, firm ground within easy reach of the transfer connection. Engage the parking brakes and place the wheel chokes to eliminate any movement.

Ensure there are no open flames or any ignition sources around the ISO container unloading area. If the ISO container is used as a temporary storage installation at the site, it should comply with the required separation distance prescribed by NFPA 58 Table 6.3.1.

Take out and position the fire extinguishers in such a manner that they are easily accessible in case of emergency.

Carry out a pre-unloading check of the receiving tank if delivering to a customer site to ensure the facility is in order. This should include a visual check of the surroundings for any unusual or dangerous situation.

Connect the earthing cable of the ISO container to the receiving facility's earthing point.

Connect the hose at the receiving gantry to the ISO container liquid discharge valve. Connections should be properly made without use of undue force before unloading and checks made for any sign of leakage before and during unloading. Any leakage shall be rectified before proceeding

Hoses should not be located across a public footpath or pavement for unloading unless there is no alternative, and where consideration of likely public activity during the time of unloading indicates it will not constitute a significant hazard. In such cases, before and during unloading, warning notices shall be prominently displayed at the front and rear of the vehicle and should state: 'LPG delivery in progress. No smoking or naked flames'.

At the completion of discharging, the following steps should be taken:

- Close all isolating valves on the ISO container
- Close all pertinent isolating valves on the liquid fill and vapour return lines on the receiving gantry
- Disconnect and stow or, reel in, the delivery hoses. Any protective caps should be re-connected
- Disconnect the earthing cable after the hoses have been removed
- Stow the fire extinguishers and warning notices back into the road tanker
- Remove the wheel chocks and disengage the parking brake after confirming that the ISO container vehicle is safe to move away

8.0 Inspection and Maintenance

8.1 General

LPG ISO containers must be subject to periodic inspection and maintenance to be legally compliant. This should be carried out in accordance with the design code and standards used during fabrication i.e. ISO 1496-3, ISO T50, ASME VIII, IMDG, ADR/ RID, US DOT, etc.

The five year periodic inspection shall include all two and a half year tests, plus internal inspection and a rigorous hydrostatic pressure test (filling the tank with water and over-pressurising it) to its designated test pressure to check for leaks and deformations. Non-destructive tests to be carried out includes magnetic particle test or dye penetrant tests to check for micro fractures on the weld areas and ultrasonic thickness test to check for internal corrosion and metal thinning.

The scope of the inspection and maintenance should include the frame, pressure vessel and all associated tank fittings and equipment. This work should be carried out to a written scheme of examination prepared by a competent person.

Only trained and experienced personnel under the appropriate supervision of a competent person should be allowed to carry out all maintenance work on an LPG installation.

A detailed report should be issued after an examination and kept on record. The inspection and test should be witnessed and stamped by an authorised body i.e. Bureau Veritas, SGS, etc.

8.2 Frequency and Scope

LPG ISO containers must be subject to a rigid five-year periodic inspection and an intermediate two and a half year inspection regimen. They should also comply with the local regulations where they are applicable and more stringent.

The scope of the two and a half year intermediate inspection includes an external visual inspection, leak test, and functionality checks of all valves, fittings and pressure relief devices. The ISO frame, corner castings and twist locks should be inspected for signs of corrosion, twisting or cracks to ensure safe stacking on ships and during transport.

Pressure relief valves shall be replaced every five years with new or reconditioned units set at a pressure not less than the tank maximum working pressure but not above the tank design pressure. Capacity of the pressure relief valve should meet design requirements (refer also to 4.2).

Inspection of shut off valves, including remotely operated types and other tank fittings for effective operation, corrosion or damage or replacement. Shut off valves and other tank fittings should be replaced when they reached 20 years of service regardless of condition.

8.3 Repair Standards

The standard of any modifications or repair work should be at least equivalent to the original design and manufacturing standard. If installation integrity may be affected by such work, it should be supervised and certified by a competent person, who should endorse or revise the safe operating limits.

Any repairs of the LPG ISO container should only be carried out by the organisation having the relevant manufacturing qualifications license (ref AP519).

Repairs should preferably be carried out by the original manufacturer. All repairs should adhere to the original design drawing. Any changes undertaken by parties other than the original manufacturer should be approved by them, and the local authorised body.

Appendix One - LPG Properties and Hazards

1.1 **LPG** comprises commercial propane, commercial butane, propylene and butene and mixtures thereof. They are hydrocarbon gases that can be changed into a liquid and changed back into a gas by the simple application and release of pressure.

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

1.3 **Cooling effect** – LPG liquid vapourises and cools rapidly; it can therefore inflict severe cold burns if it comes in contact with bare skin

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

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

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

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

Table A1 overleaf shows some typical physical properties of LPG

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

Table A1 - Typical Characteristics of Propane and Butane

Appendix Two - Written Scheme of Examination

A Written Scheme of Examination (WSE) should be prepared prior to the commissioning of any LPG installation. The scheme for customer installations may be generic, i.e. one WSE describes the method of assuring the integrity for all of this class of installation. At depots, terminals and plants a specific written scheme of examination should be prepared which covers the following:

- Identification of the items of plant or equipment within the system
- Those parts of the system which are to be examined
- The nature of the examination required, including the inspection and testing to be carried out on any protective devices
- The preparatory work needed for the item to be examined safely
- Where appropriate, the nature of any examination needed before the system is first used
- The maximum interval between examinations
- The critical parts of the system which, if modified or repaired, should be examined by a competent person before the system is used again
- The name of the competent person certifying the written scheme of examination
- The date of certification

To prepare a WSE:

- The system design criteria should be established, i.e. what pressure should each part withstand
- A drawing of the system should show the items of equipment that are under pressure and number them for reference in an equipment list
- The list of equipment should show the pressure ratings of the equipment and test certificates for each item should be held in a system integrity file
- Where the history of the installation has led to the loss of certificates for components of the LPG system, the integrity can be verified by reference to markings on the items and by a pressure test at which point the integrity of the system can be certified

A competent person should decide:

- Which parts of the system are going to be inspected and /or tested
- What inspection/testing is to be done
- How the system is to be safe while the inspection/testing is done
- How often the parts of the system are to be inspected/tested and how it is to be done
- What independent inspection is required from a notified body

A defined person should be responsible for each LPG system and for ensuring that the WSE is applied and that records are kept for the design, and maintenance of the system integrity. He should appoint or may be the competent person who creates the WSE. A competent person should have the necessary knowledge, experience and independence to undertake the functions required of them.

The WSE should be periodically reviewed for suitability by a competent person.

Appendix Three - Example of Operating Procedures

The following example of operating procedures has been extracted from guidance notes issued by one of the manufacturers of LPG ISO containers and should be adjusted to take into account actual operating conditions.

- Ensure no pressure or residual products remain in the connection hose before removal
- Loading/unloading operations should only be carried out when safe to do so and preferably be separated from other traffic movement. Diversions for passing vehicles and pedestrians (e.g. barriers, warning signs) should be used
- Operations should not be carried out during the hours of darkness unless adequate artificial lighting suitable for hazardous areas is used
- Ensure that any customs seals have been fitted in accordance with international customs requirements as appropriate
- When dismantling or installing valves ensure the tank is not under pressure and has been cleaned and provided with an internationally recognised cleaning certification
- When fitting or dismantling blank flanges a torque wrench must be used with the torque settings advised by the valve and gasket suppliers
- In some cases, the hoses used to unload the vehicle will already be attached to the plant bulkhead and must simply be connected to the appropriate vehicle fittings before unloading. In others, it may be necessary to use the hoses stored on the vehicle to make the required connections. In the latter case, connections must be made, inspected, and tested at both ends of the hose. In either case, however, the same precautions should be observed and the same procedures followed when making and testing hose connections
- Verify operation of the emergency shutdown valves (ESV's) installed in the plant. Be sure to check all the remote operators and all fusible links. If the ESV's do not operate properly, do not continue the transfer operation. If possible, correct the problem. Otherwise, notify the supervisor
- Verify the presence of a strainer or screen at the unloading bulkhead to prevent debris or foreign material from entering the piping system and impeding the action of valves and other components
- Check the manual shutoff valves on the vehicle liquid and vapour connections to be sure they are fully closed. Then remove the dust caps slowly. CAUTION: LPG may vent from the connection. Wear heavy impervious safety gloves to protect hands
- Remove the dust caps from the connectors on the transfer hoses. Check that the connectors/ couplers are clean. Check the O-rings on the valve connectors to be sure they are in good condition

- If necessary, clean the connectors with a rag and replace worn, flattened, or damaged O-rings before making connections to the vehicle. If couplers other than ACME couplers are used, such as camlocks, use safety pins, Velcro straps, or another approved securement devices before making connections

- When using a rubber hose for transferring LPG use only hoses marked 'LPG' and approved for LPG use. They must be rated for a working pressure of at least 350 psig, and a burst pressure of at least 1,750 psig, and be chemically resistant to the LPG being transferred. They should not be used where temperatures can exceed 50 °C. The hose connections must be capable of withstanding test pressures of at least 700 psig

- Connect hoses between the vehicle and the bulkhead. When using ACME connectors, spin on the connectors until they are hand tight. As the connectors are tightened, move the hose or hose end valve up and down slightly to prevent the threads from seizing. When each connection is hand tight, tighten it an additional ¼ turn with a hook spanner

- When using Dry Disconnect Couplings:

    - One single action, a straightforward push and a clockwise turning motion connects and open the valves of the Dry Disconnect Couplings for the loading and offloading

    - A counter-clockwise turning and pull action closes the valves and disconnect the couplings:

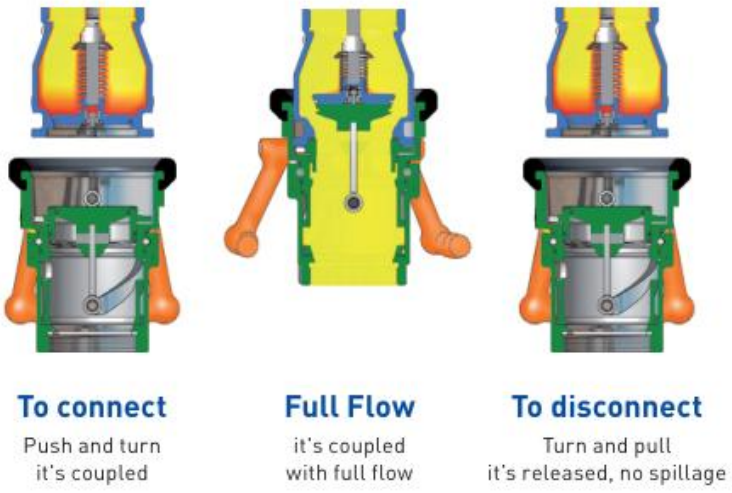


Diagram courtesy of ManTek

- Do not hit the connector with the dust cap, a hammer, or other device. If using camlocks, connect the male and female coupler ends and secure the connection by pulling the camlock ears down to the closed position. Secure the camlock ears by inserting safety pins, securing the camlock ears using a Velcro strap, or other approved securement device. Once the camlock ears are secure, test that the camlock ears will not open by slightly pulling on the ears

- Check each connection for leaks by isolating it from the system and charging it with LPG. The proper procedure for checking the connection depends on the equipment being used. If, for example, a bulkhead hose has been connected to the pump discharge on the vehicle, the connection will be isolated so long as the ESV at the bulkhead and the shutoff valve in the pump discharge line are closed

- The connection can be checked for leaks by slowly opening the hose end valve at the connection to the vehicle. Other connections must be tested in an equivalent manner. If any connection leaks, close all valves and retighten the connection. If the leak persists, notify the supervisor

- A qualified person must be present during the entire transfer operation to handle emergencies and monitor the condition of the transfer system

- If a leak or fire develops at any time during the operation, close all ESV's immediately and stop the transfer operation. Be alert throughout the operation for signs of erratic pump operation. If a problem develops, shut down the operation, notify the site supervisor, and correct it before continuing

- If there is not enough room in a single LPG ISO container for the entire load of LPG, monitor the liquid level gauges in the container carefully during the operation. When a container reaches its maximum permitted filling level, stop the pump and adjust the valves and piping to route the remainder of the load to another container

- If possible, equalise the pressure between the vehicle and the destination container

- If the pressure in the unloading vehicle is higher, equalise the pressure by opening all valves in the liquid line, starting at the vehicle and working towards the destination storage LPG ISO container. This will allow the higher pressure in the vehicle tank to force some LPG through the liquid line before the pump is started

- When the pressure between the two tanks has equalised, the valves may be opened in the vapour equalisation line

  NOTE: If the vehicle is equipped with an internal valve that opens only on pump pressure, it will be impossible to equalise pressure through the liquid line. In that case, equalise pressure through the vapour line. If pressure in the LPG ISO container is higher, equalise pressure by slowly opening all valves in the vapour line first

- Slowly open the remaining vapour and liquid valves on the vehicle and in the transfer piping. When all valves are fully open, start the pump. Listen carefully for sounds of erratic pump behaviour and check the sight gauge or flow indicator to be sure liquid is flowing through the system. CAUTION: If an excess-flow valve suddenly shuts, stop the pump. Then, reopen the excess-flow valve by equalising pressure across the valve before continuing

- When the destination LPG ISO container reaches its maximum permitted filling level, or if the vehicle tank is empty, close all liquid and vapour lines involved in the transfer operation and stop the pump immediately

- Bleed down and disconnect the hoses. Store them away as necessary. CAUTION: Never disconnect any hose until the material trapped in the connection has been safely bled off. This should be done through either the bleeder valve on the hose end valve or a pipe-away adapter in the vehicle or bulkhead connections

- Replace all caps on hose-end valves and on vehicle and plant liquid and vapour connections

- To prepare the vehicle for departure:

    - Check to be sure that all bulkhead or vehicle hoses have been disconnected and securely stored and that all valves are tightly closed and capped
    - Ensure that all Emergency Shut Valves are in the closed position. Walk completely around the vehicle to be sure there are no obstacles in its way
    - When everything is in order, remove the chock blocks from the tractor wheels and store them away as necessary

- Safely direct the vehicle out of the plant area

Appendix Four: Sample Pre-Transfer Checklist

A sample pre-transfer checklist might include:

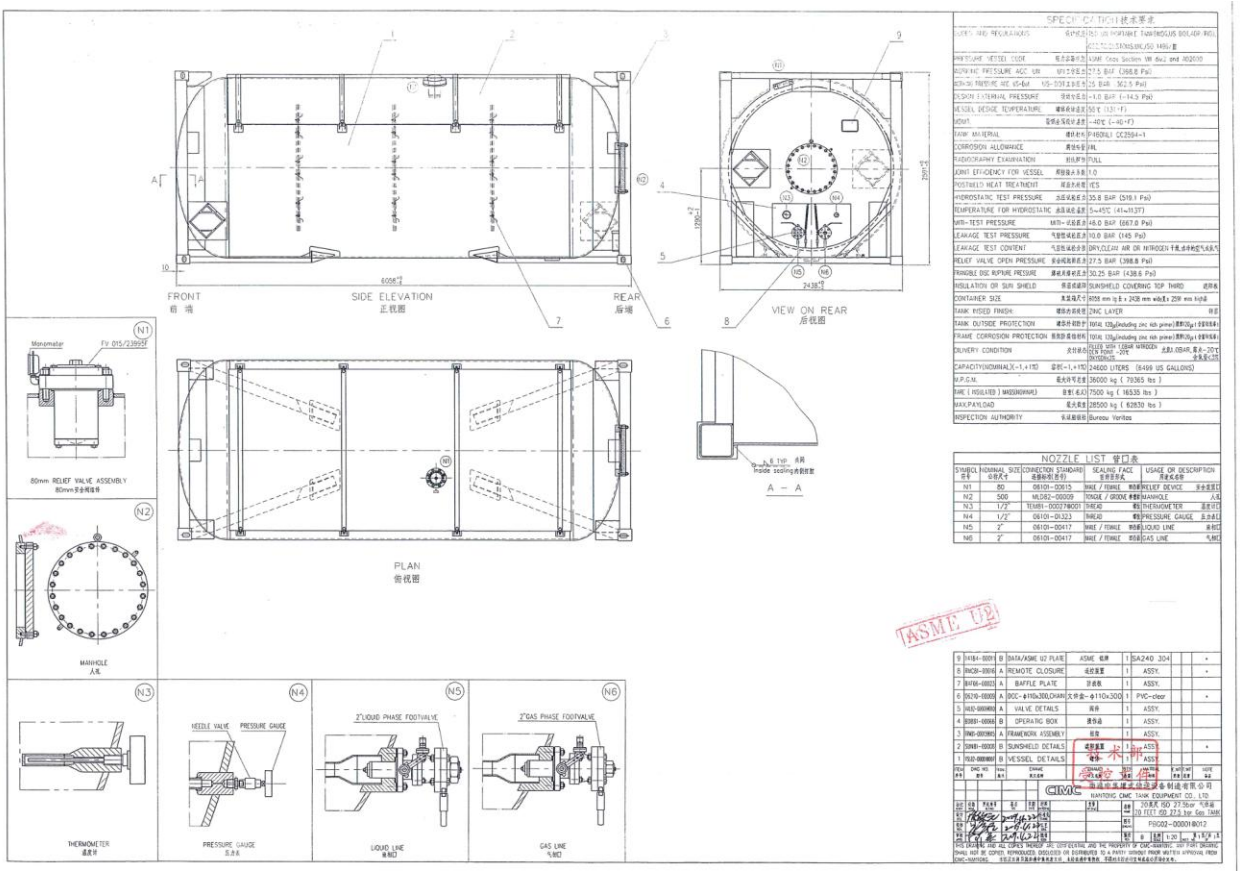
Task	Status
Permit To Work issued and verified	
Personnel assigned and trained	
Risk assessment reviewed	
Environmental conditions checked	
LPG ISO container certification verified	
Container visually inspected	
Valves, pressure relief valves, gauges inspected	
Hoses checked and positioned	
Grounding and bonding confirmed	
Emergency systems checked	
Vehicle positioned and secured	

All checklist items must be completed and signed off by the operator and supervisor before starting the transfer.

Appendix Five: Do's and Don'ts

The following is an example of a simple chart that might be used on site to remind operatives of key instructions.

Appendix Six: Example of an LPG ISO container drawing



Definitions

Competent person: A person with knowledge, training and ability to carry out their work safely and with the necessary proficiency to ensure the subsequent safe operation of the equipment.

LPG ISO container: A container or vessel designed with over 20,000 litres water capacity and manufactured to a recognised pressure vessel code.

Maximum Gross Weight: The maximum permitted total weight of the loaded container, including the container, product, and all equipment

Maximum Load Weight (Payload): The maximum weight of cargo that can be safely loaded into the container. It is calculated by subtracting the tare weight from the maximum gross weight

Remotely operated emergency shutdown valve: A shut-off valve that can be activated remotely to automatically shut when engulfed by fire, deprived of actuating power or some other hazardous condition is detected

Surge or baffle plates: Internal plates fitted inside some tanks to reduce the movement (surge) of liquid during transport, improving vehicle stability

Separation distance: The horizontal distance between a specified feature and the nearest part of a storage tank

Tare Weight: The weight of the empty ISO container, including all permanently fitted equipment but excluding the cargo

UN Number: A four-digit number assigned by the United Nations to identify hazardous materials during transport. For example, **UN 1075** identifies LPG

Water capacity: The water volume (in litres of water) that will completely fill a tank

References

NFPA 58 Liquefied Petroleum Gas Code 2008 Edition.

AS/NZS 1596:2014

AP 519

BS EN 13175:2019 + A1:2020 - LPG equipment and accessories. Specification and testing for Liquefied Petroleum Gas (LPG) pressure vessel valves and fittings (including Dry Disconnect Couplings)

LGUK CoP 1 part 1 - Bulk LPG Storage at Fixed Installations: Design and Installation (2017)

LGUK CoP 1 part 3 - Bulk LPG Storage at Fixed Installations: Examination and Inspection (2020)

LGUK CoP 1 part 4 - Bulk LPG Storage at Fixed Installations: Buried/Mounded LPG Storage Vessels (2021)

LGUK CoP 7 - Storage of full and empty LPG cylinders and cartridges

LGUK CoP 20 - Liquid LPG Dispensing Facilities (2025)

LGUK CoP 22 - Design, Installation and Testing of LPG Piping Systems (2025)

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