Guide to Good Industry Practices

for Multicylinder LPG Installations

WLPGA

LPG
EXCEPTIONAL
ENERGY

Contents

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Chapter One - Background

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

The two WLPGA Guidelines - Good Business Practices and Good Safety Practices - have been used extensively globally during the last fifteen years 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 practices throughout the supply and distribution chain.

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

There have been many of these more prescriptive Guides published to date including *LPG Cylinder Management*, *Bulk LPG Road Transport* and *Bulk LPG Storage*.

This Guide, entitled *Multicylinder LPG Installations*, focusses on the issues involved in the design, installation, commissioning, operation, maintenance, and safety aspects of multicylinder installations. It is recommended that this Guide be read in conjunction with other Guides in the series that are relevant to multicylinder installations such as the Guide to Good Industry Practices for Cylinder Management, and the Guide to Good Industry Practices to LPG in Commercial Kitchens.

The information in this Guide has been gathered from globally recognised LPG Standards and Codes of Practice as well as using best practices from major LPG companies. It is essential that the information be applied in conjunction with any local laws or regulations to enhance the overall safety performance of the LPG business.

Chapter Two - Introduction and Scope

The majority of LPG in the world is supplied in cylinders that contain less than 20kg of product. For typical domestic consumers, this equates to around a month of stock and is adequate for their needs.

Where LPG consumption is greater than what a typical domestic cylinder set up can provide efficiently, multicylinder installations can be considered. Such applications may include food stalls, laundry shops, home-based businesses, etc. requiring higher flow rate of LPG than basic household appliances. For large LPG demand - such as in commercial and industrial applications - where consumption can reach several tonnes of LPG a day, bulk storage is the preferred installation.

Bulk storage facilities can have capacities ranging from a few tonnes to hundreds of tonnes of product. However, the safety requirements for bulk storage facilities are stringent and not all locations may be able to comply with the regulations. In such a situation, a multicylinder installation is also an option. Examples of such applications of multicylinder installations includes residential, commercial and small industrial applications such as apartment blocks, restaurants, hotels, shopping malls, and small factories, etc.

This *Good Industry Practice Guide for Multicylinder Installations* provides guidance for those wishing to consider using a permanent LPG multicylinder installation for residential, commercial, and industrial applications. It describes what a multicylinder installation is, and the general safety requirements and best practices for its design, construction, operation and maintenance. This document also discusses how multicylinder installations might be used to develop LPG demand where small bulk facilities may not be possible.

LPG marketers, engineers, LPG operators and consumers will find the information in this document useful when dealing with multicylinder installations.

This *Good Industry Practice Guide for Multicylinder Installations* does not cover LPG reticulation, liquid offtake installations and installations using vaporisers.

Chapter Three – Considerations and Layout

3.1 Key Considerations for Multicylinder Installations

Multicylinder installations serve as a convenient solution for LPG applications where demand is higher than typical domestic consumption and where a small bulk storage facility cannot be used due to either safety or economic reasons. The installation consists of several commercial size cylinders, linked together by a manifold, to increase the vaporisation capacity.

They are simple installations which can be constructed faster, and require less space, in comparison to bulk storage facilities. A multicylinder installation using vapour offtake may have a practical limit on how much LPG vapour it can supply and is typically used where consumption does not exceed 15 tonnes a month.

Before deciding to invest in a multicylinder installation, there are some key points to consider:

- Supply of commercial size LPG cylinders must be available in the area
  Cylinders used in multicylinder installations usually have capacities ranging from 45kg to 50kg though some locations may also offer other sizes of cylinders. It is important to check with the local LPG distributors if this type of cylinder is available in the area

- Space is available and suitable for the LPG installation
  Small multicylinder installations may not require much space and may even be placed beside a suitable concrete or brick wall. Bigger installations though may need a bigger space to ensure safety and may include hazardous zones around the cylinder in which all sources of ignition are prohibited. In most jurisdictions, there are regulations governing the storage of LPG cylinders which may require the prior application of a permit. Check the local regulations and ensure compliance with all requirements

- Projected consumption justifies investing in a multicylinder installation
  Determine that the projected consumption and/or flowrate is appropriate for a multicylinder installation. It should neither be too small that a single cylinder can easily supply, nor too big to be impractical for a multicylinder installation. A suggested maximum limit for vapour offtake multicylinder installation is around five million BTU per hour (1,465kW). See table below for more detail.

Category – cylinder size and LPG content	Diameter (mm)	"L" (mm) vessel length	"H" (mm) overall height	Water Capacity (kg)	Tare Mass (kg)	Vapourisation Capacity at 30% full MJ/hr (approximate); for varying temperatures			
						-7°C	0°C	15°C	25°C
4 kg exchange	260	229	310	9.5	5	14	17	23	28
9 kg exchange	310	372	481	22	8	23	28	39	46
13.5 kg exchange	375	450	550	32	13.9	30	37	52	61
18 kg exchange & forkliift	310	655	840	43	18	34	42	59	69
45 kg echange & insitu fill	375	1075	1235	108	33	65	80	110	130
90 kg – insitu fill	508	1210	1340	215	70	101	124	172	203
190 kg – insitu fill	760	1160	1350	450	125	165	204	282	332
210 kg – insitu fill	762	1260	1454	499	143	176	217	301	354

3.2 General Guidelines on Cylinder Location

The location of multicylinder installations should always conform to local regulations. In some jurisdictions, there is a maximum limit to the number of cylinders that can be installed beyond which it will be considered as a bulk installation. Contractors and consumers should check the local regulations before commencing work on the installation. In selecting a location for the multicylinder installation, ensure that the area is:

An example of a bad multicylinder installation

- Well ventilated and in open-air to facilitate quick and safe dispersion of any leaks which might arise
- Stable and has a level base which can bear the weight of the cylinders e.g., concreted, compacted, paved, etc.
- Well drained with no risk of flooding or water ponding
- Clear of combustibles and corrosive materials and weeds
- Accessible to delivery of cylinders and emergency response vehicles
- At least 3m away from sources of ignition and open flames (as much as possible)
- At least 2m away from windows and floor level openings where any uncontrolled vapour discharge might flow into

Where cylinders are allowed by law to be installed or used indoors, they must be in an isolated section of the building and ventilated to the outside air. This maybe in a parking area, the roof deck, or a dedicated storage room for LPG. It must comply with all other safety requirements prescribed by applicable local laws e.g. maximum quantity of cylinders, provision for leak detection devices, fire protection system, etc.

Locating multicylinder installations in unsuitable locations may cause accidents and lead to potential injuries and property damages. Some locations that must be avoided include:

- Any space below ground level e.g. basements, cellars or pits
- Near water drains or gullies, unless these are sealed to prevent entry of escaping vapour
- Along passageways, stairwells and emergency exits
- Areas with risk of vehicular impact

Where the multicylinder installation is located against a building wall, there should be no openings on the wall and it must be constructed of at least 60 minutes fire resistance rating. This applies to all parts of the wall up to a height of 9m and within the width of the cylinder store plus 2m on both sides.

Some recommended examples of cylinder locations are illustrated in Appendix Two.

3.3 Security

Wherever the multicylinder installation is located, consideration should be given to the immediate vicinity and the general security of the premises. Unless the installation is located within a wider security fenced area, it should be protected against tampering, theft, or vandalism by appropriate industrial type fencing.

Recommended design of the security fence should be as follows:

- At least 1.8m high and at least 1.5m between cylinders and fence
- Made of strong industrial wire mesh to allow ventilation e.g., 12-gauge chain link or 52 mm x 52 mm mesh welded panels

- Inclusion of at least two outward-opening escape doors, or one only if the area is less than 9.0m^2

- Provision of locked fence doors when unattended (not self-locking)

The fenced area should not be used as storage space for other materials or equipment.

3.4 Signage

The multicylinder installation area should be clearly identified, and notices displayed with the following information:

- Highly flammable LPG
- No smoking or naked lights
- No unauthorised entry
- Safety procedures in the event of an emergency and emergency service telephone numbers

A typical compound for storing LPG cylinders is illustrated in Appendix Three.

Chapter Four – System Components

The key components in a multicylinder installation are the cylinders, manifold, changeover device, supply line, regulator, and appliance.

4.1 Cylinders

While any cylinders can be manifolded together, the typical ones used in multicylinder installations are the 45kg to 50kg capacities. These cylinders have more content while still being portable and are the most widely used cylinders for this type of installation.

The number of cylinders installed should provide sufficient gas to meet the demand of the application. For cylinders operating in vapour offtake mode the LPG is generated by natural vaporisation of the liquid boiling inside the cylinder. This is known as the evaporative capacity and this depends on several factors such as:

- Cylinder size and shape
- LPG content (propane/butane or mixtures)
- Climatic conditions
- Type of off-take (continuous or intermittent)

The typical evaporative capacities of an LPG cylinder are indicated in the table below (in kg/hour/cylinder) and can be used for all sizes of cylinders. The capacities may be affected by type of usage, e.g., intermittent, continuous, and also weather conditions, so adjustments should be made as necessary. The evaporative capacities in the table below apply to steel cylinders only.

	Capacities in 1000s of kcal/hr					
Number of cylinders required	Evaporative capacity – kg/hr/cylinder					
	0.5	1.0	1.5	2.0	2.5	3.0
1	5.5	11.0	16.5	22.0	27.5	33.0
2	11.0	22.0	33.0	44.0	55.0	66.0
3	16.5	33.0	49.5	66.0	82.5	99.0
4	22.0	44.0	66.0	88.0	110.0	132.0
5	27.5	55.0	82.5	110.0	137.5	165.0
6	33.0	65.5	98.0	131.0	164.0	196.5
7	38.0	76.5	115.0	153.0	191.0	229.5
8	44.0	87.5	131.0	175.0	219.0	262.5
9	49.0	98.5	148.0	197.0	246.0	295.5
10	54.5	109.0	163.5	218.0	272.5	327.0
11	60.0	120.0	180.0	240.0	300.0	360.0
12	65.5	131.0	196.5	262.0	327.5	393.0
13	71.0	142.0	213.0	284.0	355.0	426.0
14	76.5	153.0	229.5	306.0	382.5	459.0
15	82.0	164.0	246.0	328.0	410.0	492.0

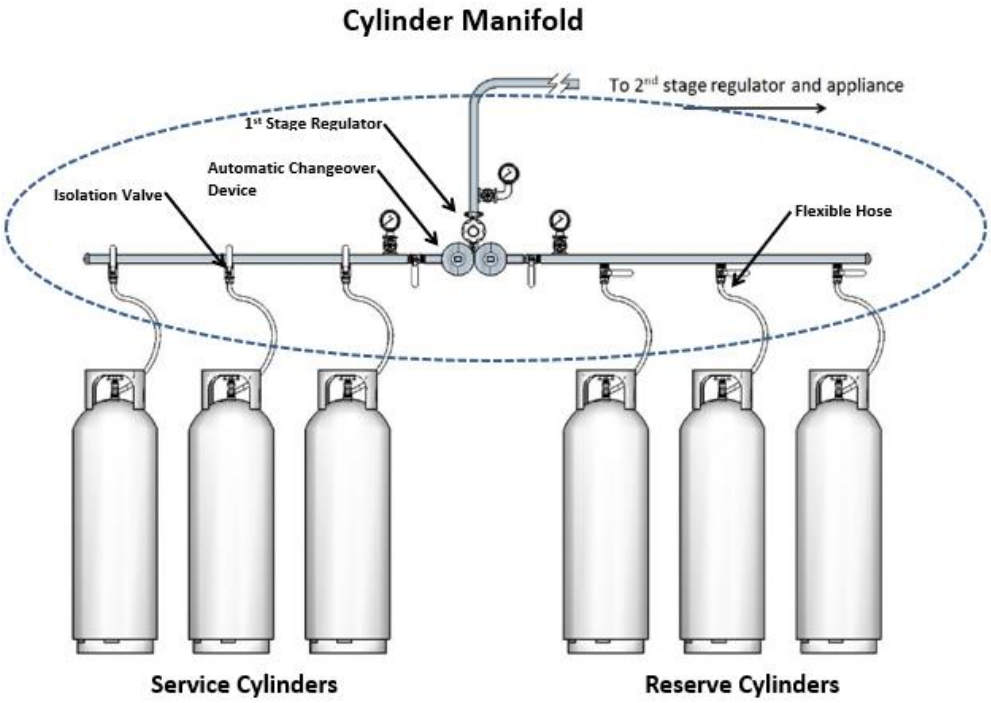
Evaporative Capacities of steel LPG Cylinder

Condensation or frost formation on the outside of a cylinder indicates the evaporative capacity of the cylinder has been exceeded. This is usually due to installing an insufficient number of cylinders which led to overloading, resulting in frost formation and eventual system failure. Too many cylinders on the other hand is not cost effective for anyone and increases the safety risk. Installing the appropriate number of cylinders will make the system operationally efficient and economical.

4.2 Manifold

The manifold provides the capability to expand the capacity of the installation by linking cylinders together. This can be just a few cylinders, up to tens of cylinders, depending on what the application requires and the limits of applicable local regulations. The manifold also allows empty cylinders to be removed, with the minimum escape

of gas and without disturbing the supply of LPG to the application. An example of a cylinder manifold is shown below.



The manifold can be constructed from a combination of flexible copper tube, steel, and reinforced rubber hoses. The pipe header is usually made of carbon steel pipe and fitted with high pressure LPG hoses to connect to individual cylinders.

The length of the high-pressure LPG hose should not exceed 1m. Depending on risk assessment, non-return valves may be provided for each hose to protect the system in the event of any hose rupture. The date of manufacture should be evident to facilitate replacement after five years or earlier if there are signs of defects.

To minimise any release of LPG during cylinder replacement, each individual cylinder connection must be provided with isolating valves. The individual isolating valves also permit the removal of each cylinder or replacement of worn out hoses without having to shut down the entire system.

It is common practice to design the manifold to have a group of cylinders in service duplicated on the other half of the pipe header for cylinders in reserve. In this way, the supply of LPG to the appliance will not be disrupted. The shift from one side of the manifold to the other when cylinders become empty is done manually, by opening and closing the respective isolating valves of each side of the manifold, or automatically. A manual changeover device can also be installed for this purpose. Alternatively, the transfer can be done automatically using an automatic changeover device. The latter will ensure continuous flow of LPG to the appliance.

Each side of the pipe header is provided with a pressure gauge as an indicator of when the cylinders need to be replaced. At the centre of the manifold is a pressure regulator where the LPG vapour is reduced to the desired operating pressure.

Never use a separate regulator on each cylinder. It is not possible to set all the regulators exactly at the same delivery pressure. The result will be that cylinders will not be evenly emptied, and liquid LPG will remain in some of the cylinders. The installation will be difficult and expensive to maintain.

The manifold should be pressure tested to at least 250psig ((1725 kPa) and be cleaned internally and externally to ensure there are no contaminants such as grease, oily deposits, and welding slag prior to use.

Manifolds, and their supporting structure, should be protected against corrosion especially in the highly corrosive environment of sea coastal areas.

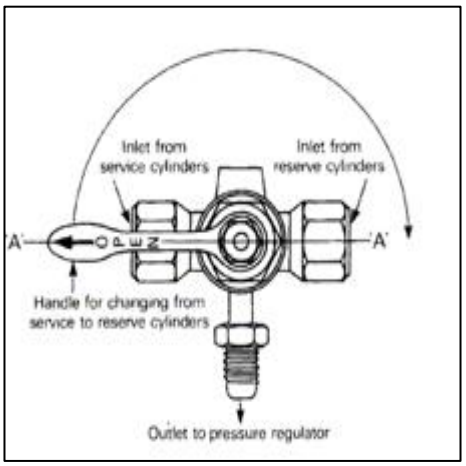
The manifold maybe mounted against a solid wall or a non-combustible structure at a suitable height using suitable bracketing and/or pipe supports.

Multicylinder installation showing isolating valves near manifold

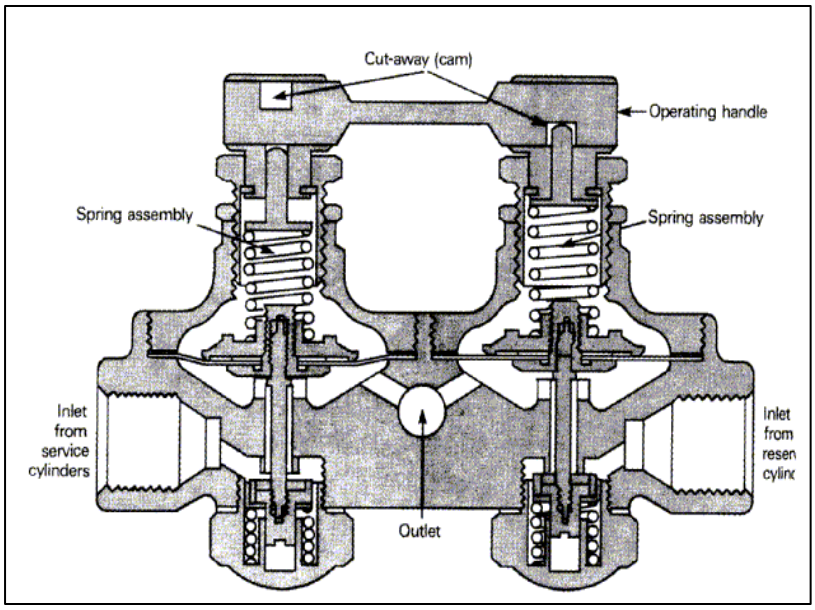
4.3 Changeover Device

Manual changeover is essentially a three-way valve. There are two inlet ports – one for service cylinders and the other for reserve cylinders - and a single outlet. It is used in lieu of installing two separate isolating valves on each side of the manifold and is used if a short interruption to the gas supply is acceptable.

When the cylinders in service run out of gas, the user turns the lever on the changeover device to the opposite side, switching in the reserve cylinders to supply. An indicator on the device shows which bank of cylinders is on service and the empty cylinders can be replaced without interrupting the gas supply.



Manual Changeover Device



Regulator

An automatic changeover device operates the same function without human intervention. It is made up of two regulators positioned side by side and functions as a first stage regulator. They have separate inlets but a common outlet. They work on the principle of pressure differential i.e. the side with the higher pressure will flow into the device. When pressure in the service cylinders drops to around 5psig, the regulator automatically switches to the reserve cylinders. A visual indicator showing red will alert the user of the switch and the selection knob should be turned to the reserve cylinders to change the indicator back to green.

Automatic Changeover with telemetry

The position of the selection knob determines which of the two sides or regulators is in service, by the cut-aways (cams) incorporated in the handle assembly. The spring of one regulator will be compressed while the other is released. Turning the handle by half a turn, the position of the cams is reversed as well as the compression of the springs. As the spring pressure acting on the diaphragm determines the gas pressure at the regulator outlet, the regulator with its spring assembly compressed will deliver a higher gas pressure than the other.

For some automatic changeover devices, telemetry may be fitted to allow monitoring of the switchover from offsite. This is particularly advantageous for applications where LPG supply is managed directly by the LPG distributor.

4.4 Supply Line

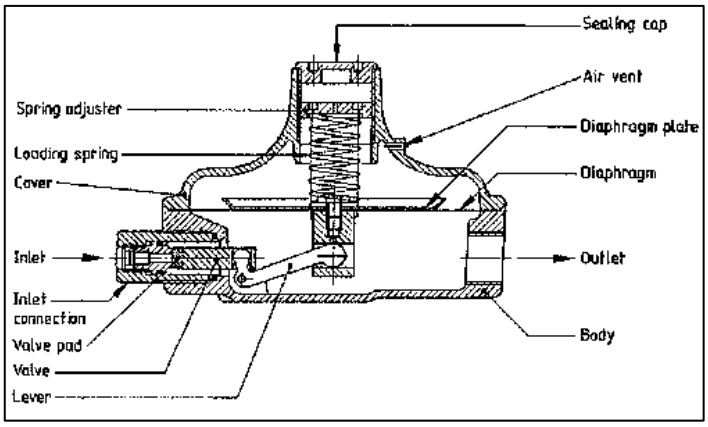
The supply line distributes LPG from the cylinders to all the connected appliances and gas equipment. This must be achieved at the correct operating pressure, in adequate capacity, and free of leakage. Suitable materials for the piping or tubing must be selected and installed correctly to ensure a safe, robust and durable system. A badly constructed supply line can give rise to problems for both LPG supplier and end user.

The supply line must be as short as possible, adequately supported to prevent unnecessary movement and provided with isolating valves at appropriate locations for ease of operation and maintenance. More details on the design and installation of supply lines are discussed in Chapter 5.

4.5 Regulator

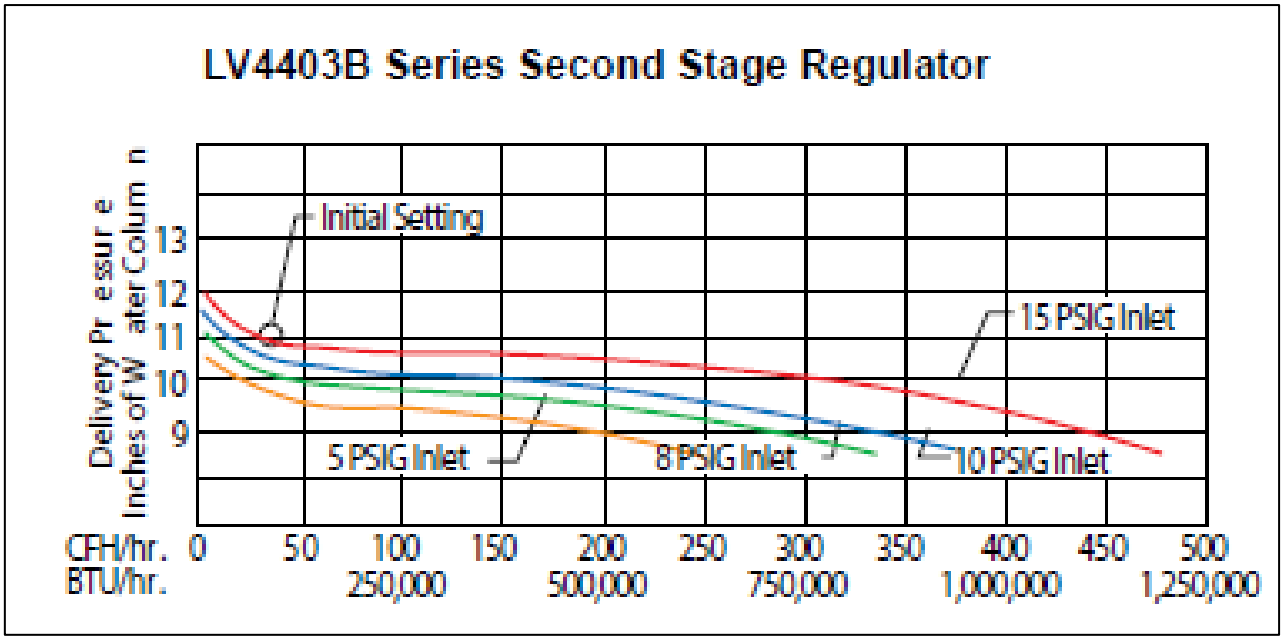
The regulator is the heart of the system. It converts a varying pressure inside the cylinders to a constant outlet pressure and controls the amount of LPG flowing to the appliances depending on the usage.

The vapour pressure of LPG inside the cylinder is affected by the surrounding temperature and is invariably higher than what is needed in the distribution system and at the appliance. Regulators must therefore be able to function effectively over a wide range of pressures - from as high as 200 psig to as low as 0.4 psig, or 300mm WC. For this reason, the selection of which regulator to install is critical for the safe and efficient operation of the appliances.



Typical Parts of a regulator

Regulators must be designed and constructed with materials to suit a full range of operating conditions and comply with a recognised standard. It is not possible to produce a single regulator to meet all conditions. Regulators are therefore designed with various outlet pressure settings and flow capacities. Refer to performance charts or tables when choosing which regulators to use.



Example of a regulator performance chart

Domestic regulators are usually available in 1 kg/hr capacity and 300mm water column (or 11 inches w.c.) outlet pressure setting. They are usually equipped with an excess flow limiter and are fitted directly at the cylinder valve outlet. Regulators for commercial and industrial applications have a wider range of settings and capacities to suit specific applications. They can basically be categorised into high-pressure and low-pressure regulators.

- High pressure regulators are used as first-stage regulators in a two-stage system. They reduce the tank pressure to an intermediate pressure, which is usually between 10psig to 20psig before the vapour enters a second stage regulator. They are also used when appliances require working pressures above 1psig. High pressure regulators are typically coloured red and have an adjustable

outlet pressure setting. Only qualified technicians are allowed to adjust pressure settings of regulators.

- Low pressure regulators are used as second-stage regulators in a two-stage system. They reduce the outlet pressure from a first-stage regulator to around 11 inches WC (28mbar – 30mbar) which is the required inlet pressure of most gas appliances. The outlet pressure setting of low pressure regulators are usually non-adjustable.

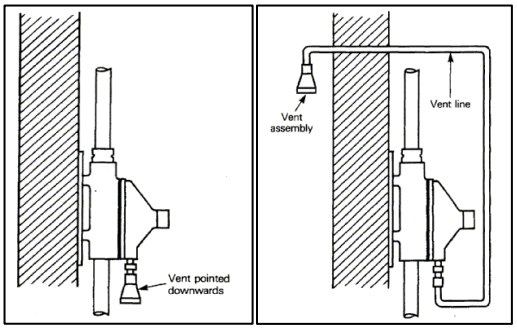
Integral twin stage regulators combined a first and second stage regulator into one and is commonly used for small commercial installations where piping is short.

Regulator with OPSO and UPSO

Regulators may also be equipped with over pressure shut off (OPSO) and under pressure shut off (UPSO) devices for additional safety. Refer to the manufacturer's product catalogue for more details when using such types of regulators.

Regulators should be installed outdoors and in well-ventilated locations. They are provided with vents for them to "breathe" to function properly. The vent must not be blocked by dirt, nor be exposed to rain and/or immersed in flood.

The regulator vent also serves as a relief in case of excessive pressure. When regulators are installed indoors, it is essential to extend the vent with suitable fitting and tubing to the outside air to allow any lost LPG to dissipate outdoors.



Outdoors *Indoors*

4.6 Appliance

Multicylinder installations can be used to supply LPG to a wide range of equipment for domestic, commercial and industrial applications. These may include simple heaters to boilers. The most common LPG-fueled equipment is cooking appliances e.g., stoves, ovens, grillers, fryers, rice cookers, etc.

All gas appliances require fresh air for proper combustion and the products of combustion must be dispersed outside. Gas equipment should be installed in a well-ventilated space with a constant supply of fresh air. If the supply of fresh air is diminished, it will impair the performance of the appliance and affect the health and safety of the occupant.

Gas appliances and equipment installed should be manufactured to standards and equipped with basic safety features such as flame failure device. They are designed for a specific inlet LPG pressure and a rated consumption. It is the responsibility of the LPG distributor to install an LPG system that is compatible with these requirements.

Installers of gas appliances for fixed installations must satisfy themselves that the appliances they install are safe and have been installed in accordance with the manufacturer's instructions, the relevant local standards of installation specifications, and building regulations.

Chapter Five – Piping Design

5.1 Pipe Sizing

It is important to not over size, or under size the piping when designing the LPG supply system. Over sizing is not cost effective and may jeopardise the investment case. Under sizing creates large pressure drops which can extinguish the appliance flame, lead to gas accumulations, and serious safety consequences.

The first step in designing the pipe size is to determine the total energy load of the system. This is done by adding all the rated consumptions of the connected appliances or gas equipment. This information can be obtained from the manufacturer's product manual and is typically expressed in BTU per hour or kWh.

Once the total load is established, the installer should decide how many stages of pressure settings is optimal for the application. Single stage systems are allowed only for domestic applications. For commercial and industrial applications, it is recommended to have at least two stages of pressure settings, normally referred to as first and second (or final) stage. A more complex piping layout may have 3 stages of pressure setting.

Dividing the piping system into several stages minimises the risk of regulator malfunction and allows for more economical piping cost. The higher the operating pressure the smaller the pipe diameter required to deliver the same amount of gas. The maximum operating pressure should however not exceed that prescribed by local regulations. In vapour distribution systems, the operating pressure must also be limited to levels below that at which recondensation may occur at the lowest foreseeable temperature. Where higher pressures are necessary for the application, precautions need to be taken to prevent recondensation, e.g., by using insulation/heat tracing.

In the commonly used two stage system, the first stage regulator is installed at the cylinder manifold with the outlet pressure set anywhere from 10psig to 20psig. The second or final stage regulator is installed near the appliance, or point of entry to the building, and supplies LPG at the appliance's required inlet pressure.

The length for each stage of the piping is the final information needed to determine the pipe size. Sketch the pipe route from the manifold to each individual appliance and measure the distances. Pipe sizes can be calculated using gas flow formulas or using LPG pipe sizing charts and tables. This is available from engineering handbooks and/or equipment manufacturer's manual. NFPA 58 and 54 has very useful pipe sizing tables. As an example, a sample pipe sizing chart from REGO LP Gas Servicemen's manual is shown below.

First Stage Pipe Sizing

10 PSIG inlet with a 1 PSIG Pressure Drop

Maximum capacity of pipe or tubing, in thousands of BTU/Hr of LPG

Size of Pipe or Copper		Length of Pipe or Tubing, Feet*									
Tubing, inches		10	20	30	40	50	60	70	80	90	100
Copper	3/8	558	383	309	265	235	231	196	182	171	161
Tubing	1/2	1387	870	700	599	531	481	443	412	386	365
(O.D.)	5/8	2360	1622	1303	1115	988	896	824	767	719	679
	3/4	3993	2475	2205	1887	1672	1515	1394	1297	1217	1149
Pipe Size	1/2	3339	2295	1843	1577	1398	1267	1165	1084	1017	961
	3/4	6982	4799	3854	3298	2923	2649	2437	2267	2127	20009
	1	13153	9040	7259	6213	5507	4989	4590	4270	4007	3785
	1 1/4	27004	18560	14904	12756	11306	10244	9424	8767	8226	7770
	1 1/2	40461	27809	22331	19113	16939	15348	14120	13136	12325	11642
	2	77924	53556	43008	36809	32623	29559	27194	25299	23737	22422

Sample pipe sizing chart

Pressure losses will also occur when LPG flows through pipe fittings, elbows, tee junctions, or when there is a change in flow direction. This pressure drop must be accounted for in the design by converting each fitting to their equivalent length of pipe having the same pressure loss. Refer to the engineering handbook for conversion tables on equivalent pipe length for friction loss.

5.2 Pipe Routing

The piping layout should be designed to reduce any potential hazards by making it as short as possible to minimise pipe content, and routing through locations that have minimal risks. The chosen pipe route should avoid the following:

- Elevator shafts, chimneys, flues, air, or ventilation ducts
- Areas with risks of vehicle impact (protect with bollards if this cannot be avoided)
- Exposure to extreme heat or cold temperatures

Piping should preferably run above ground to facilitate visual inspection, leak testing, and maintenance. If this is unavoidable, piping can be buried underground at a minimum depth of 500mm. MDPE pipes are most suitable for use underground due to their inherent anti-corrosion properties. Steel pipes buried underground should be protected against corrosion by a suitable anti-corrosion coating, overwraps, or by cathodic protection.

Where any kind of superimposed load may occur, the pipe affected should be protected with covers or well-supported load-bearing slabs. A warning tape should be laid half-way way between the pipe and the surface to indicate the existence of the buried LPG pipework. Isolation valves should be fitted at both ends of the underground pipe to permit testing and maintenance.

Pipes carrying flammable or inert liquids may be laid in the same trench as LPG piping but NOT pipes carrying toxic or corrosive materials. Electrical cables must be separated at least 300mm from LPG pipe in the same trench.

When an LPG pipeline passes through a concrete construction (e.g., wall, ceiling etc.) it must run through another pipe (sleeve) of a larger diameter that will stand out on both sides of the concrete construction. The space between the sleeve and gas pipe should be sealed to prevent gas ingress.

5.3 Pipe Support

Piping should be adequately supported with enough flexibility to safely absorb piping movements due to thermal expansion and building settlement. This can be done with pipe hooks, metal pipe straps, bands or hangers located at proper intervals. Supports should be so designed that under the maximum expected design load of the piping the support deflection is limited to 15mm. The following table provides guidance on spacing of supports.

Nominal size of pipe in mm	Maximum interval between pipe supports in metres	
Copper pipes	**Vertical**	**Horizontal**
8	1.2	0.6
10	1.5	0.9
15	1.8	1.1
20	2.4	1.8
Steel pipes		
10	1.8	1.2
15	2.4	1.8
20	3	2.4
25	3	2.4
40		3.8
50		4.5
80		5.4
100		6.8
150		7.9

Distances between Supports for Steel Pipe

The pipework should be protected against stress from further movement by providing ample bends, allowing the pipe to flex without excessive stress.

5.4 Pipework and Tubing Materials

Pipework and fittings used must comply with the relevant standards and be of a material suitable for LPG, the expected conditions of service and the range of pressures and temperatures likely to be encountered.

LPG pipework is available in various materials and the choice is usually dictated by the size and cost of pipe, and tools and fitting skills available to the installer.

Materials commonly used in LPG pipework for multicylinder installations are:

- Carbon steel – Seamless pipe to an acceptable thickness or galvanised heavy/medium weight welded seam pipe. Carbon steel pipe are joined by welding and flanges or through the use of screwed fittings. For screwed connections particular care should be taken to ensure that mating screw threads are of the same type, form and designation. Carbon steel pipes maybe installed aboveground or underground with suitable anti-corrosion protection. Jointing compounds for screwed connections, flanged gaskets and any other component parts should all be suitable for use with LPG.

  Cast iron fittings are not suitable for use with LPG

- Copper - Half hard or annealed solid drawn copper. Copper tube is typically used for short piping lengths and can be bent, but means must be employed to prevent the possible flattening of the pipe during the installation and operation. The risk of work hardening should also be considered. Copper tube can be joined by flare fittings, but for design pressures above 37mbar, brazing should be carried out with a filler material having a melting point above 600°C. Copper pipes or tubes are not suitable for pipework carrying liquid LPG.

- Polyethylene (PE) – Applicable for LPG vapour and should be installed underground and outdoor. There are two types of PE – high density PE (HDPE) and medium density PE (MDPE). The latter is preferred and is suitable for pressures up to 4 bar and a temperature range of minus 20^{o}C to 40^{o}C. PE pipes are joined by fusion.

  Where PE pipes are brought above ground, the exposed pipework should be shielded from mechanical, or ultra – violet damage, by sleeving. They should normally be limited to no more than 2m in length, but in any case, kept as short as practicable. Alternatively, a suitable fitting may be used below ground to achieve the transition to metal pipework on either or both terminal transitions.

- Multilayer Pipe – made of a combination of polyethylene and aluminium, this is used mainly for low pressure applications i.e., 550mbar or lower. They are generally manufactured in small diameters and supplied in rolls which makes installing long piping more expeditious. Multilayer pipes are available with different jointing methods depending on their manufacturer e.g., crimping, screwed, etc. and often local regulations will apply to use inside and outside of buildings as well as underground.

- Corrugated Stainless Steel – Proprietary brands of flexible stainless-steel pipe may be used for underground liquid LPG service at Autogas forecourts and similar installations

- LPG Hoses – should be suitable for the required operating pressure and must comply with relevant design codes. In addition, they must be:

- Marked accordingly
- As short as possible and not to exceed 1.5m
- Suitably crimped with required fittings if used on manifold
- Tightly clamped at the hose connection fitting of appliances

- Hoses attached without proper hose clamps are potentially dangerous. Furthermore, they should not be exposed to heat more than 50^{o}C. When connecting to appliances, hoses should be kept well below the level of the open burners and well clear of the oven vent or flue outlet.

Chapter Six - Installation and Commissioning

6.1 Good Piping Practices

Installing a multicylinder installation and piping system requires careful planning and good workmanship. Faulty workmanship can create a serious hazard. For this reason, only experienced, qualified - and in some jurisdictions - licensed LPG technicians should be allowed to work on LPG installations.

There are three basic objectives which should be achieved as far as the piping part of the installation is concerned and these are:

- Neatness of appearance - When the installation is finished, it should show evidence of painstaking effort. Neatness will not make the system work any better, but if the piping job is pleasing to the eye, it will contribute to the satisfaction of the customer

- Adequate capacity - The gas lines must have sufficient capacity to supply the appliances. Inconvenient and hazardous operations may result if undersized piping is installed

- Gas tightness - The most important requirement of all is that the piping system must be absolutely gas tight. Where human life is at risk, carelessness or ignorance is inexcusable

Some guidelines on good piping practices are as follows:

- LPG pipelines must have as few fittings (e.g., flanges, mechanical couplings etc.) as possible as each constitutes a possible leak point. Underground pipelines must not have any connection fitting (e.g., flange, mechanical coupling etc.) or any device (e.g., valve, regulator, pressure relief valve etc.)

- Screwed joints are recommended for used on pipework with nominal diameters of less than 50mm while those 50mm and larger should preferably be welded

- LPG pipework passing through concealed locations should be protected against inadvertent damage (from nails, drills, etc.) either by location, type of materials, or by protective sheathing

- Piping should be free internally from cutting burrs, loose scale, dirt, dust and other foreign particles when the installation is completed. Foreign particles left in the pipeline may damage the regulator and appliance

- Isolating valves should be provided to allow sections of the piping to be shut off for repair without the need to shut off the whole installation. Individual appliances/equipment should likewise be provided with isolating valves

- Where required, meters should be installed as close as possible to the entry point. If located outside the building the meter should be housed, together with the emergency valve, in a suitably protected and accessible housing. Meters must be of a type approved by the authorities as suitable for use in gas distribution systems

- Emergency shut-off valves should be fitted externally at the point where the LPG piping enters the premises. The valve should be clearly identified, and its direction of closure indicated

- All unused pipe ends should be protected by plugs or caps and flange facings fitted with blind flanges before the system is commissioned

Multicylinder installation with meter

- LPG piping should be painted yellow and marked with 'LPG' for identification

- A plan should be made to record the pipe layout, and this should be included in building layout drawings for future reference. Any subsequent changes should be recorded

6.2 Leak Testing

The complete installation must be pressure tested to check for leaks before introducing LPG into the system. Pressure testing is done by introducing air, inert gas, or LPG itself, into the piping and observed for a drop in pressure over a period with all appliance valves closed. Oxygen must never be used for leak testing. If an inert gas is used, care must be taken to see it vented clear of any surrounding occupied workspace.

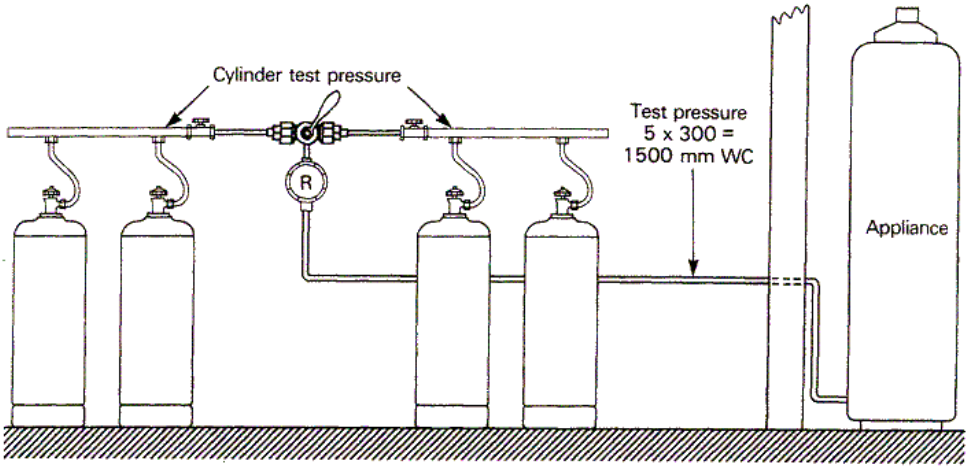
All connected equipment e.g. regulator, gas meter, etc. that might be damaged during the testing should be removed and reinstalled after the test has been completed. The tightness of the reconnected joints can be leak tested at its normal working pressure.

The leak test must include testing the part of the system subject to, and tested to, full cylinder pressure. The intermediate and low pressure system should be tested to at least five times the operating pressure.

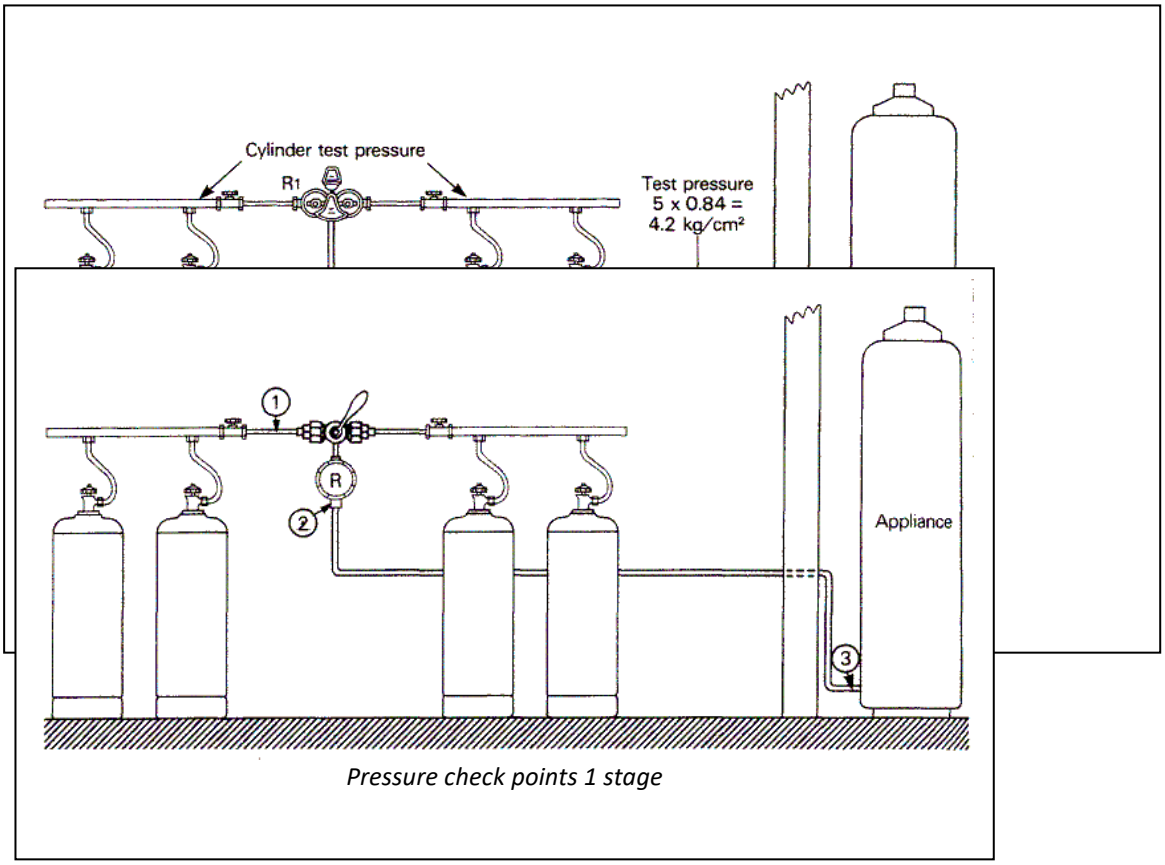
Depending on the length and complexity of the pipeline, the duration of the test maybe a few hours to up to 24 hours. If there is no drop in pressure, the piping is leak free. If there is a pressure drop, leak detection fluid or soapy water can be applied to determine leaking joints. A match or other open flame should never be used to test for leaks. If a sizable leak exists, the use of flame would be extremely hazardous

After any leaking joint has been repaired, the piping must be leak tested again to confirm that it is now free of leaks.

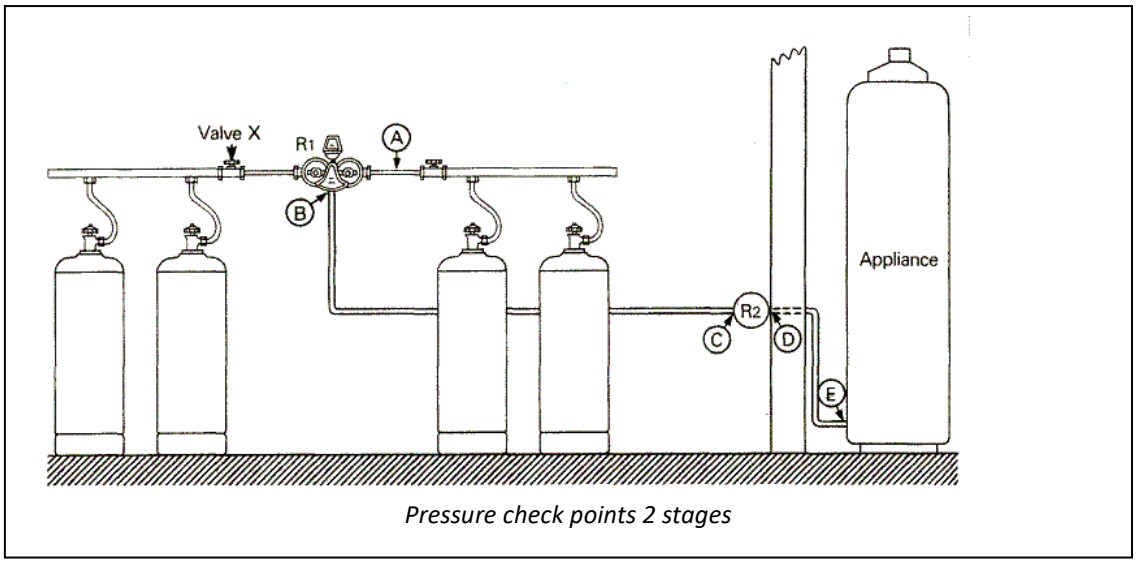
Leak testing should be conducted prior to painting of the piping and/or application of any anti-corrosion coating or wraps. Paint and other surface coatings will hinder the detection of leaks.



Pressure test - One stage



Pressure check points 1 stage



Pressure check points 2 stages

6.3 Purging and Commissioning

The piping should be purged of any air or inert gas used during testing with LPG vapour for the appliance to function properly. This will be the first time the pipeline will be injected with LPG and is a very critical procedure. This should be undertaken only by experienced LPG technicians.

Purging is done by opening the burner at the farthest end of the piping to let LPG vapour push out all the air/inert gas. Care must be taken to prevent accumulation of air-gas mixture inside premises or confined spaces.

When purging through individual appliances a source of ignition shall be held adjacent to the burner to ensure immediate ignition when the air-gas mixture is rich enough. If there is more than one branch, there may be a need to purge at a burner on each end of the piping. Steps shall be taken to ensure no other source of ignition are present and to prevent inadvertent operation of electric switches or appliances and to prohibit smoking or naked lights in the vicinity of the purge point.

Purging is completed when all appliances connected to the piping is functioning properly.

6.4 Checking Delivery and Lock Up Pressure

A final step before handing over the installation to the consumer is to check the delivered pressure at the appliance as well as the lock up pressure. The delivery pressure must not fall below that required for efficient performance of the appliance with all the burners and/or appliances operating.

- Lock-up pressure is the pressure of the gas between the final stage, or low-pressure regulator, and the appliances when all outlets are closed and there is pressure on the container side of the regulator. Lock up pressure which is more than twenty percent of the regulator outlet setting indicates a problem with the regulator.

Both tests are be done by attaching a manometer or low-pressure gauge at a point near the appliance and observing the pressure reading. Corrective actions should be taken if the readings fall outside the recommended limits of the delivery and lock up pressures.

Chapter Seven – Operation and Maintenance

7.1 Operation

Everyone involved with using LPG must be aware of its basic characteristics and safe handling procedures to avoid bad practices that may lead to accidents. It is the responsibility of the LPG distributor to provide this information to all their customers and end users. They must be instructed on the following:

- How to recognise LPG leaks
- Action to be taken in case of leakage
- Action to be taken in case of fire
- Action to be taken in case of damage to or failure of any part of the installation
- When to reorder LPG
- How to change LPG cylinders

Some tips on the safe operation of the LPG system include:

- Appliances and gas equipment should always be used in accordance to the manufacturer's instructions
- Gas valves should always be shut off when appliances are not being used
- When LPG is not being used for an extended period of time, the main isolating valves on the manifold and cylinder valves should be shut off for safety reasons
- Check for signs of leakage before using the appliance or gas equipment. Do not operate the appliance or gas equipment when a leak is suspected
- Never leave cooking appliances unattended when the flame is on
- Cylinder storage areas must always be kept clear of any combustible materials
- Ensure that cylinders delivered are in good condition and within requalification date. Cylinders due for requalification must not be used
- Confirm that the cylinders being replaced are indeed empty
- Check the connections between the cylinder and flexible hose on the manifold for vapour tightness during every delivery

7.2 Maintenance

The multicylinder installation and piping system will deteriorate in time and with constant usage. It is therefore important that the LPG system is regularly inspected and maintained to keep it in a safe working condition. Failure to do so will increase the risk of an accident occurring.

Maintenance should cover the entire LPG system. This includes cylinders, piping and tubing, regulators, and all other LPG accessories installed on the system. The responsibility for carrying out the maintenance may either be with the LPG distributor or the end user depending on contract stipulations. Whatever the case, only trained technicians should be allowed to work on the LPG system.

The parts of the LPG system should be subject to the following maintenance:

- Cylinders – the LPG distributor will collect empty cylinders and replace them with full ones. When the cylinder returns to the cylinder filling plant it will be subjected to a series of checks and procedures including washing, visual inspection, repairs and painting, leak detection etc. There is no need for any maintenance of cylinders at the site of the multicylinder installation other than keeping them clean and ensuring they are not subjected to any impact damage

- Pipework - visual inspection and leak testing on the pipework should be done at least once a year. For short and exposed pipework, this can be done by simply applying a soapy water solution on all the joints with the system under its normal operating pressure. For longer and complex piping systems, this should be pressurised and observed for any pressure drop overnight. Any pressure drop should be traced by applying soap solution on joints and weldments. The piping should also be checked for signs of corrosion (if steel is used) and repainted accordingly

- Regulators – are subject to wear, damage, ageing, and possible contamination from 'heavy end' build up. They should be inspected for any signs of damage or malfunction annually. Regulators are sealed at the factory and are not designed to be repaired. They should be replaced if they are observed as defective which can be manifested by unstable outlet pressure or frequent venting. They should also be replaced regardless of condition when they have been in service for 10 years

- LPG Hoses – should be inspected for signs of any damage or cracks annually and replaced accordingly. The recommended service life of LPG hoses should not exceed 5 years from date of manufacture and should be replaced regardless of condition. Hoses subjected to aggressive operating conditions will have shortened lifespan. Hoses should be kept clean of food to avoid possible vermin damage

- Valves – all valves installed should be checked annually for proper function and leak-free condition

- Appliances – burners should be kept clean and tidy daily

A record of the inspection and maintenance carried out including the remedial actions taken should be kept.

Chapter Eight – Appliance Safety

This chapter provides safety guidelines on the installation and utilisation of some LPG appliances and equipment.

- LPG appliances that are in use and burning gas consume oxygen and in enclosed or restricted spaces this will cause the depletion of oxygen content of the available air.

- Although the exhaust gases from an LPG burner (Nitrogen, water vapour, Carbon Dioxide) are clean and non-toxic, they can cause heavy water condensation inside a room if the ventilation is inadequate. Too much carbon dioxide in the air may disturb the performance of the LPG appliance and lead to formation of Carbon Monoxide, which is highly toxic and can quickly lead to death.

- All appliances that are likely to need a flue have connections for a flue pipe. In most cases the appliance will incorporate a draught inverter, the purpose of which is to prevent downdraughts that might cause the accidental blowing out/extinguishing of the burner flames.

- If instantaneous water heaters are fitted in bathrooms, adequate and permanent ventilation has to be ensured because of the high gas consumption rate of the appliance, the small size of normal bathrooms, and the tendency of most users to keep air entry into a bathroom to a minimum. Only room sealed appliances may be installed in bathrooms or shower rooms as these appliances take air from the outside and push comustion products outside of the bathroom/shower room.

- In domestic garages or similar premises, only room sealed appliances should be used. Cabinet heaters or other forms of flueless or open flued appliance should not be used in garages or other inside locations in which flammable liquids or gases are used or stored, as petrol vapour may be present. Only room sealed appliances should be used in these premises.

- Flueless space heating appliances are not considered suitable for use in bedrooms and hairdressing salons.

- The incorrect installation or use of LPG appliances in buildings can give rise to variety of hazardous condition as build-up of unburnt gas, high concentration of carbon monoxide and the depletion of oxygen.

- The sufficient ventilation is of vital importance and the warnings and recommendations of the appliance manufacturers installation brochures must be respected.

Example of installed cooking appliances in a restaurant kitchen

- It is the responsibility of the installer to ensure that there is an adequate and permanent supply of air for combustion and for the comfort and safety of the occupants.

- When siting the appliance regard should be paid to the convenience of use, protection/shelter from draughts that are strong enough to extinguish the burners while set on “low” flame, protection of damage, and layout of the gas piping system.

- Appliances should be sited in a room where there is no danger of setting fire to furnishings. For example, a gas stove set below a combustible shelf, where curtains could be near a cooking top, or in case of a hotplate, open underneath. Appliances should be installed on combustible resistant surfaces.

- Appliances should be installed on a firm and level base (especially with refrigerators which require checking with a spirit level during installation). The support (floor, table or shelf) should be large enough to accommodate the appliance and to prevent the appliance form slipping off the support. It has to be strong enough to carry the appliance/s and all superimposed loads.

- Where inevitably combustible or ignitable material is liable to attain ignition temperature or be exposed to heat damage, the material has to be protected by mounting on a sheet of metal or other non-combustible material between it and the appliance as to provide a ventilated air space of width at least 15mm.

- If several appliances are connected to a system, the nearest appliance to the gas supply point has to be the one(s) with the higher rate of consumption. Alternatively, the supply point should be brought as close as possible to the high-intake appliances. Water heaters have to be placed as close as possible to the sink or bath they serve to minimise the heat loss.

- Each gas supply point should allow a convenient coupling to the appliance. Until connected each point should be securely capped or plugged and marked to indicate that it is a gas point.

- Each point intended for connection to a portable appliance should have a shut-off valve.

- Once connected to the pipework the appliance has to be rigidly fixed. If it is to be moved for cleaning it has to be connected with flexible hose and to have a restraining mechanism of a length shorter than the hose. All undue strain on the pipework and fittings has to be eliminated.

Customers should be instructed on the operation of the complete installation and how to shut off the gas in case of an emergency. Any changes contemplated should be undertaken only by authorised personnel and under no circumstances should customers do it themselves.

Appendix One - LPG Properties and Hazards

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

1.2 **Density** – LPG vapour is heavier than air and tends to gather at low areas such as drains, pits, cellars and other depressions. A flammable cloud of LPG in air may remain undispersed and therefore hazardous for several days if not disturbed. 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 vaporising.

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

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

1.5 **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.

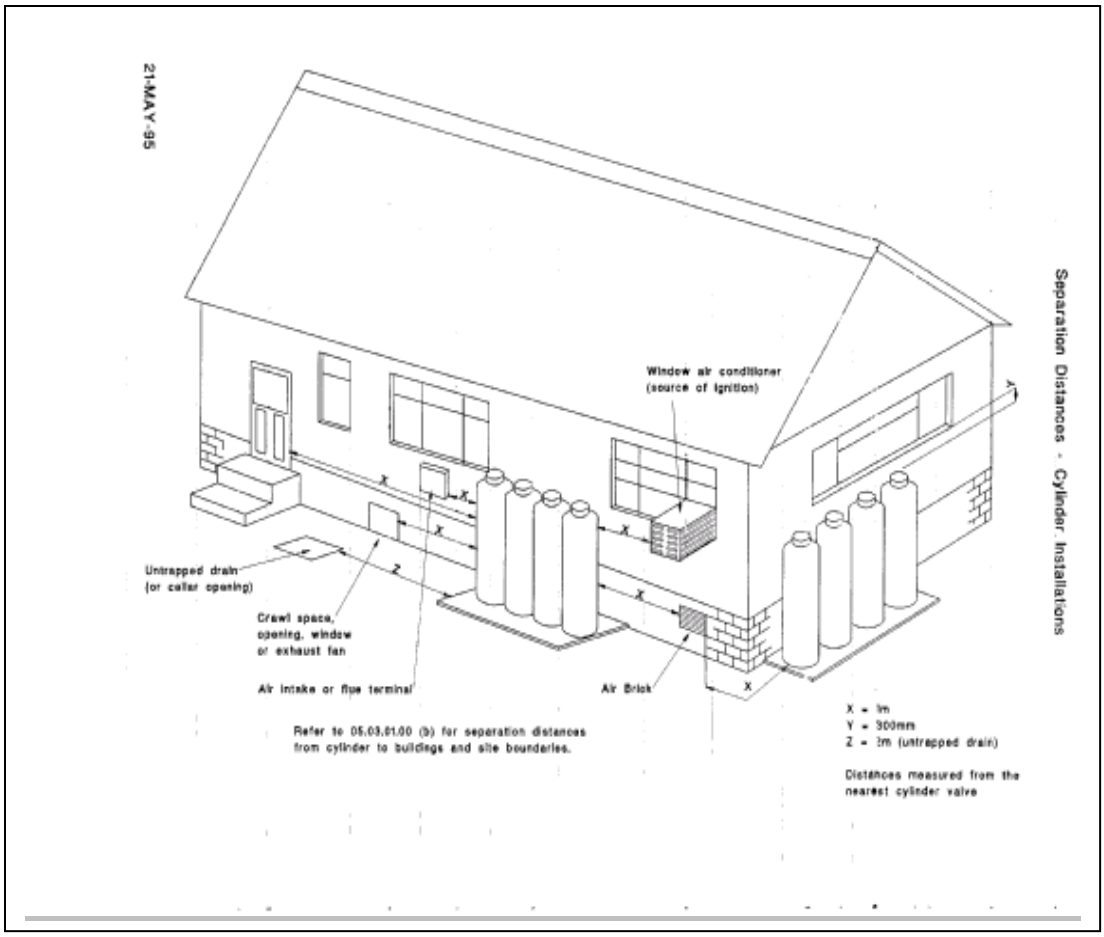
1.7.1 **Liquid Expansion** – LPG liquid has a high coefficient of expansion. Tanks, cylinders, pipelines and equipment must be protected against the high pressure resulting from liquid expansion with temperature rise.

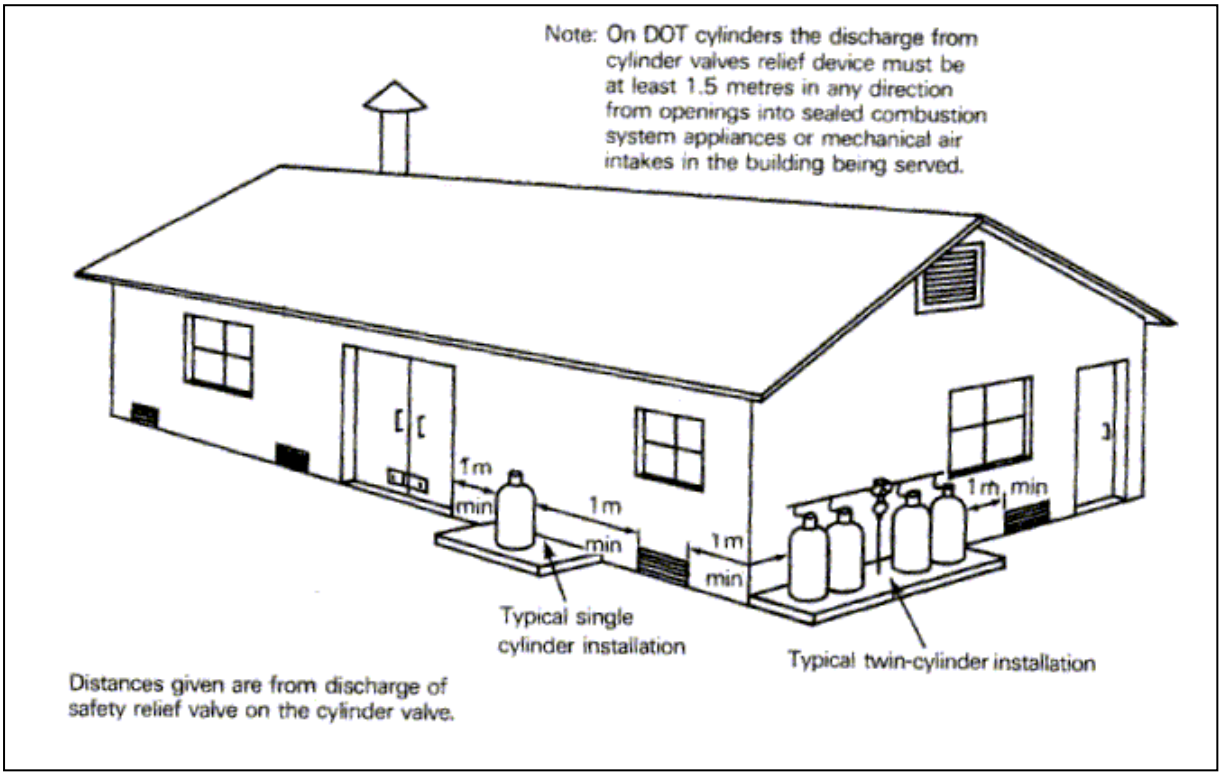
Table One overleaf shows some typical physical properties of LPG

Table One

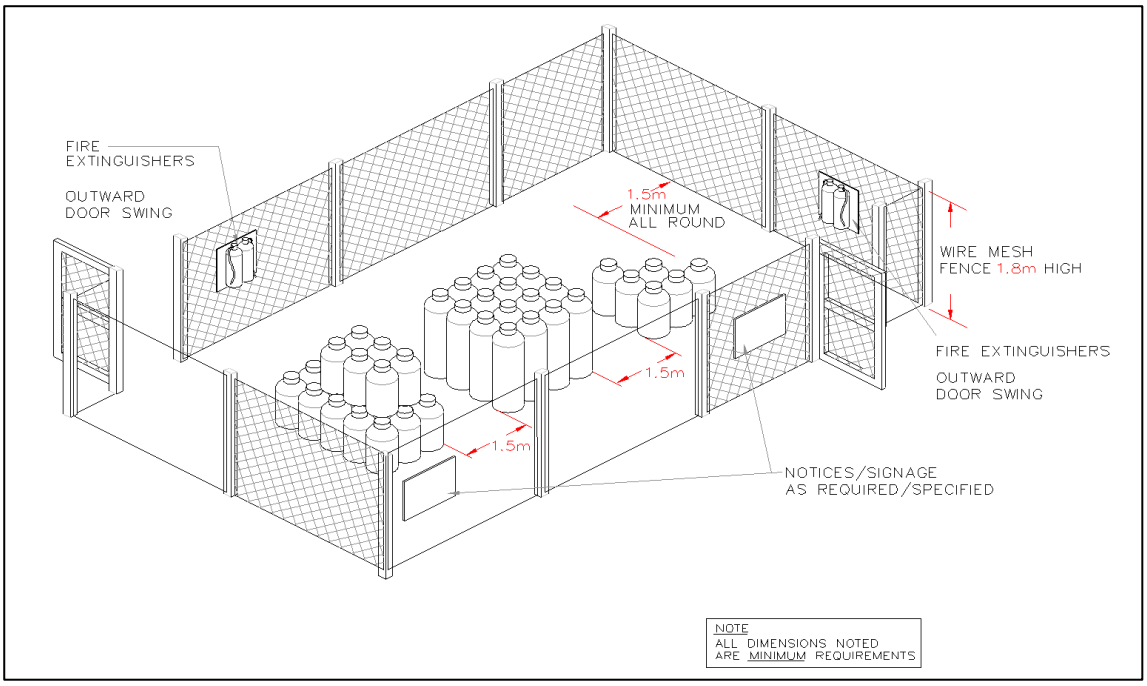
Typical Characteristics of Propane and Butane **PHYSICAL PROPERTY**		**COMMERCIAL PROPANE**	**COMMERCIAL BUTANE**
Litres/tonne of liquid at 15^{O}C Litres/ton of liquid Litres/kg of liquid US barrels/tonne		1,965 – 2,019 1,996 – 2,051 1.96 - 2.02 12.4 – 12.7	1,723 – 1,760 1,750 - 1788 1.72 - 1.76 10.8 – 11.1
Relative density (to water) of liquid at 15^{O}C		0.50 - 0.51	0.57 - 0.58
Ratio of gas to liquid volume at 15^{O}C and 1015.9 mbar		274	233
Relative density (to air) of vapour at 15^{O}C and 1013.25 mbar		1.40 - 1.55	1.90 - 2.10
Volumes of gas/air mixture at lower limit of flammability from 1 volume of liquid at 15^{O}C and 1015.9 mbar		12,450	12,900
Boiling point ^{O}C		Minus 45	Minus 2
Vapour pressure at 0^{O}C	barg	4.5	0.9
Vapour pressure at 15^{O}C	barg	6.9	1.93
Vapour pressure at 38^{O}C	barg	14.5	4.83
Vapour pressure at 45^{O}C	barg	17.6	5.86
Upper limit of flammability,	% v/v	10.0	9.0
Lower limit of flammability,	% v/v	2.2	1.8
Gross calorific value	MJ/m^3 dry	93.1	121.8
	BTU/ft^3 dry	2,500	3,270
	MJ/kg	50.0	49.3
	BTU/lb	21 500	21 200
Net calorific value	MJ/m^3 dry	86.1	112.9
	BTUu/ft^3 dry	2,310	3,030
	MJ/kg	46.3	45.8
	BTU/lb	19,900	19,700
Latent heat of vaporisation Latent heat of vaporisation	kJ/kg at 15 °C BTU/lb at 60 °F	358.2 154	372.7 160

Appendix Two – Suggested Cylinder Locations





Appendix Three – Typical Compound for Storing LPG Cylinders



Appendix Four – Typical Example of a Maintenance Check List

ANNEXURE - II

LOCATION

MULTI CYLINDER INSTALLATION INSPECTION

Consumer No. _____ Date of Last Inspection ____

Address:_____

_____

Phone No. _____

End Use _____

Name of Dealer_____

Address _____

_____

_____

Others _____

Phone No. _____

Installation Supplied by: _____

Type of Establishment: Hotel Industry
Laboratory: Hospital/ Nursing Home

Educational Institution _____

Others Specify _____

Sanctioned Qty:_____

Period_____

Vide letter No._____

1	**Cylinder Location:**	
a	Installed Indoors	Yes/No
b	If so, floor area as per norms	Yes/No
c	Adequate ventilation at low level to directly outside air provided	Yes/No
d	Minimum distance of 3m is maintained between installation and any building public place, roadway and other surroundings provided.	Yes/No
e	Installation is protected from excessive weathering from sun, rain etc.	Yes/No
2	**Position of Cylinder to facilitate**	
a	Changing and quick removal	Yes/No
b	Access to connection and regulating device	Yes/No
c	Operation of cylinder valves	Yes/No
d	Cylinder installed upright	Yes/No

e	Cylinder installed on ground level	Yes/No
f	Cylinder are not installed where they may get over heated (3 m away) (Close to steam pipe, boiler, open flame etc.	Yes/No
g	Cylinders are not causing an obstruction	Yes/No
h	Cylinder raised in case of outdoor installation (on a concrete or brick platform)	Yes/No
i	Cylinders are 1m away from entrances of openings (from culverts, depressions, opening leading to below ground level compartments and drains)	Yes/No
j	Smoking is completely forbidden within 3m while connecting and disconnecting	Yes/No
k	If mounted on trolley, the trolley is stable	Yes/No
3	**Cylinders Manifold:**	
a	All joints between manifold header and cylinder connection are readily accessible	Yes/No
b	All materials, fittings etc., used in cylinder manifold comply with BIS stipulation.	Yes/No
c	In case of pressure regulator and automatic change over device connected by semi flexible connectors and are rigidly supported.	Yes/No
4	**Pressure Regulators:**	
a	PR comply BIS stipulation (IS:4786-2014)	Yes/No
b	PR fitted with a relief valve and positioned to avoid hazards	Yes/No
c	PR and other control devices adequately supported	Yes/No
d	PR manufactured by _____	
5	**Piping, Tubing and Fittings:**	
	All piping, tubing and fittings comply BIS stipulation (IS:2501-1963 – Copper Tubes) (IS:3601-1966 – Steel Tubes) (IS:1239 - Part I) – 1968 mild steel tubes)	Yes/No
6	**Flexible Hose/Piping:**	
a	Cylinder and the appliances are in same room	Yes/No
b	Length of hose does exceed 2m.	Yes/No
c	Appliance connected portable	Yes/No
d	Accessible for inspection	Yes/No

e	Not twisted - looped or kinked	Yes/No
f	Joints are accessible for inspection	Yes/No
g	Piping and electric wiring are at least 60 mm away and is fixed below electrical wiring	Yes/No
7	**Leak Testing:**	
a	Naked flames are not used for checking gas tightness of the installation	Yes/No
b	Soap solution is used to detect leak	Yes/No
c	Defective pipes or fittings replaced and not repaired	Yes/No
d	Consumer knows the action to be taken in case of leakage	Yes/No
e	Consumer knows the action to be taken in case of fire	Yes/No
f	Consumer knows the action to be taken in case of damage to or failure of any part of installation	Yes/No

Action to be taken:

Inspection Officer Signature _____

Regional Office _____

References

WLPGA – Guidelines for Good Safety Practices in the LPG Industry

WLPGA – Guidelines for Good Business Practices in the LPG Industry

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

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

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

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

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

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

EN 1440 - LPG equipment and accessories - Transportable refillable welded steel cylinder for LPG -- Periodic requalification,
European Committee for Standardisation

Liquid Gas UK (LGUK) - Code of Practice 25 2018 LPG Central Storage and Distribution Infrastructure for Multiple Consumer

LGUK - Code of Practice 32 2020 LPG systems in Leisure Accommodation Vehicles and Road Vehicles with Habitation – Post Delivery Inspection, Commissioning and Maintenance

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All photographs sourced to Mr V Marinas, ITO Europe and Mr D. Tyler.