

MRA DRAFT FOR CONSULTATION PURPOSES - NO LEGAL VALUE

MRA LPG

Code of Practice A4:2008

Bulk Vessels

Purging LPG Vessels and Systems

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This Code has been prepared by the Malta Resources Authority in consultation with the Malta Environment and Planning Authority (MEPA), the Malta Standards Authority (MSA), the Occupational Health and Safety Authority (OHSA), the Civil Protection Department (CPD) and Enemalta Corporation (EMC).

Before publication, the contents of this document were sent out for wide consultation to all stakeholders with an interest in the transportation, storage or use of L P Gas. Many of the comments received have been incorporated in the document.

The aforementioned Authorities believe that the contents of this Code demonstrate good practice in the L P Gas Industry and commend its use.

The MRA LPG Code of Practice A4

Purging LPG Vessels and Systems

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Section 1: Introduction, Scope, Definitions and References

1.1 Introduction

Safe cleaning, repair, internal inspection, commissioning and decommissioning may all require LPG storage vessels to be purged of LPG. Any hot work on an LPG storage vessel will also require the vessel to be purged of its flammable contents and rendered safe.

Purging of LPG vessels and systems falls within the scope of, amongst other Work Equipment Regulations L.N. 282/2004, General Provisions for Health and Safety at Work Places L.N. 36/2003, Work Place (minimum Requirements for Work) (Confined Spaces and Spaces having Explosive Atmospheres) Regulations L.N. 41/2004, and Protection of the Health and Safety of Workers from the Risks related to Chemical Agents at Work Regulations L.N. 227/2003. These require that employers, self employed and/or the responsible person must:

- carry out a risk assessment of any work activities involving dangerous substances;
- provide measures to eliminate or reduce risks as far as is reasonably practicable;
- provide equipment and procedures to deal with accidents and emergencies;
- provide information and training to employees;
- classify places where explosive atmospheres may occur into zones and mark the zones where necessary.

In this Code the term LPG includes commercial butane and commercial propane in accordance with BS 4250:1997 or equivalent and mixtures thereof, as defined in Appendix A.

- Further relevant Codes and Standards are listed in Appendix B.
- This Code of Practice adopts the recommendations of MSA EN, BSI, CEN and ISO for the presentation of numeric values. The thousand separator is therefore a space (e.g. One million is represented as 1 000 000) and the decimal separator a comma (e.g. one point five is represented as 1,5).

Where access is required to connections on top of the vessel work may fall within the scope of the Work Equipment Regulations L.N. 282/2004.

1.2 Scope

This Code gives guidance on the purging of LPG bulk storage vessels and systems into, and out of, service and their preparation for entry.

It describes the most common method of purging LPG vessels by the use of nitrogen as intermediate inert gas.

Note: CO₂ purging is not recommended for purging LPG storage vessels.

Alternative methods of purging by the use of water, steam and vacuum are also described.

1.3 Definitions

1.3.1 **Purging:** the sweeping of gas from a gas vessel or pipework installation with another gas.

1.3.2 **Purging into service:** the removal of air in a closed system and the replacement by combustible gas, vapour or liquid.

1.3.3 **Purging out of service:** the removal of the normal LPG content of a closed system and its replacement by a non-combustible gas.

1.3.4 **Endpoint:** the attainment of such a concentration in % by volume of inert substance in the closed system being purged, that subsequent admission of air if purging out of service, or of gas or vapour if purging into service, will not result in the formation of an explosive mixture.

1.3.5 **Competent person:** as defined in Bulk LPG (Installation and Use) Regulations (Still in draft).

1.4 References

This Code of Practice incorporates by dated or undated reference, provisions from other publications. These references are cited at the appropriate places in the text and the publications are listed in Appendix B. For dated references, subsequent amendments to or revisions of any of their publications apply to this Code of Practice only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

Section 2: Purging with Nitrogen

2.1 Basic Methods

Liquid phase LPG and as much vapour as possible should be removed by uplift (for example using a vapour compressor) or flaring before any purging takes place.

Two basic methods of purging may be used, ram purging or pressure and vent.

In practice it is common for a combination of the methods to be used, ram purging to start followed by pressure and vent to achieve the required dilution level.

Venting may be to atmosphere or to a flare burner depending whether or not flammable mixture is being expelled.

It may be permissible to vent the vessel vapour contents to atmosphere without the use of a flare burner, when the vent point is located within a controlled area. Permission should only be granted after a competent person has given careful consideration to the hazards involved in accordance with a written work instruction.

2.1.1 *Ram Purge*

Purge gas is continuously fed into one end of the vessel (or system) and is allowed to flow through to the other end, thereby expelling any LPG or air that exists. For maximum efficiency with a ram purge, it is essential to achieve stratification between the purge gas and the LPG or air to be expelled.

When delivery pressure to the flare-off burner drops, the introduction of purge gas in a ram purge manner may enable the pressure to be maintained and reduce time taken for flaring off.

As nitrogen (relative density 0,97) is lighter than propane vapour (relative density 1,5) and will tend to float on top of propane, it is best to admit nitrogen slowly onto the top surface of the propane vapour and take the vapour to the flare burner from a bottom connection.

A ram purge should not be used where the design of the vessel/system includes dead legs or blind holes which could still contain flammable vapours even after the purge is apparently complete.

2.1.2 *Pressure and Vent Purge*

Purge gas is introduced into a vessel (or system) and the pressure is allowed to rise. The purge gas will mix with the LPG or air already in the vessel and at a chosen pressure the vessel is vented. This will leave the atmosphere within the vessel a mixture of purge gas and the original LPG or air. This procedure is repeated until the desired dilution of the original contents is achieved.

Note 1: Venting may be to atmosphere or to a flare burner depending whether or not flammable mixture is being expelled.

Note 2: It may be permissible to vent the vessel contents to atmosphere without the use of a flare burner, when the vent point is located within a controlled area. Permission should only be granted after a competent person has given careful consideration to the hazards involved in accordance with a written work instruction.

2.2 **Potential Hazards**

2.2.1 *Health Hazards*

Nitrogen is an asphyxiant and can cause injury or even death. Liquid nitrogen can cause frost burns if in contact with the skin.

2.2.2 *Low Temperature Embrittlement*

Liquid nitrogen is stored semi-refrigerated and under pressure, at a temperature at which most carbon steels experience low temperature embrittlement. It is important that when liquid nitrogen is to be used suitable vaporising equipment is employed which will ensure that only warm gas (i.e. at a temperature greater than -10 °C) enters the vessel.

A temperature gauge or some means of warning of excessively low temperature should be provided.

Note: Flash vaporisation of liquid phase LPG entering a vessel can also lead to low temperature.

2.2.3 *Over Pressurising*

Liquid nitrogen vaporises to 683 times its volume. Care must be taken to ensure that suitable control and/or relief devices are fitted to the purging equipment

2.2.4 *Supplies from cylinders*

Where nitrogen is provided from cylinders suitable two stage regulation should be employed. The maximum outlet pressure of the regulation system should not be greater than the design pressure of the vessel (or system).

- In practice a pressure of approximately 0,4 bar is used.

2.2.5 *Low Pressure Supplies*

Nitrogen may be derived from a low pressure source such as an inert-gas generator. In such case a non-return valve should be located at the inlet to the LPG vessel to prevent inadvertent reverse flow.

2.2.6 *Nitrogen Filled Vessels*

If a vessel capable of being entered is to be left for any length of time filled with nitrogen, then the flammable signs should be covered or removed, and the vessel re-labelled with text of the form: "NITROGEN PURGED. DO NOT ENTER".

Typical Label



2.2.7 Residues

If residues are suspected of being present, care must be taken to ensure that flammable vapours are not still being produced even after purging is apparently complete. The concentration of combustible gas should continue to be tested at 15 minute intervals until it is at, or less than, the end point for at least two consecutive readings. If difficulty is experienced in maintaining the required endpoint, consideration should be given to using a steaming technique.

2.3 Planning

Purging LPG systems requires careful planning. In drawing up the plan, the physical characteristics of the atmosphere to be purged should be considered, especially in relation to the physical characteristics of the purge medium. This is important for instance, when a ram purge is being considered. A better stratification will be achieved the greater the difference between the relative densities of the purge gas and the atmosphere to be purged and by admitting the purge gas slowly to avoid turbulence.

The plan should identify:

- the system/vessel area to be purged;
- the manner of purging (i.e. ram purge, pressure and vent or a combination of the two);
- limitations on the method to be employed (e.g. temperature or pressure);
- control and emergency measures;
- the end point of the purge;
- the isolation points;
- all equipment and spare parts required, (e.g. gaskets, bolts, etc.) which need to be available prior to isolation of the system/vessel for purging;
- the area around the system/vessel being purged which needs to be cleared of unauthorised personnel and to which access during purging should be restricted;
- the need for change of signage (see 2.2.6).

2.4 Purging Procedures

2.4.1 Gas Freeing

2.4.1.1 The system/vessel should be suitably isolated by means of spades, blind flanges as appropriate. In multi-vessel installations valves should not be relied upon to isolate a vessel to be purged.

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- 2.4.1.2 Prior to isolating, as much of the LPG should be removed from the vessel/system as possible in a safe manner. Once isolated a suitable line, armoured hose or similar, should be set up from an appropriate valve on the system/vessel to a flare-off burner at least 15m from the system/vessel and other flammable materials in an area under suitable control. The flare-off burner should only be set closer to the vessel following the written approval by a competent person.
- 2.4.1.3 The flare-off burner design should include some form of permanent pilot and a suitable terminal deflagration flame arrester.
- 2.4.1.4 A flare-off burner should not be left unattended while in use.
- 2.4.1.5 When the flame at the flare-off burner goes out following a ram purge a sample of the system/vessel contents should be taken. (See also Section 2.2.7). If the sample does not reveal a satisfactory end point the purge should then continue as per 2.4.1.6.
- 2.4.1.6 When the flame at the flare-off burner goes out following a pressure and vent purge system/vessel pressure should be raised to about 0,3 bar gauge by introducing purge gas and then venting using all available drain valves. This procedure should be repeated until analysis shows the required end point has been reached. (See also Section 2.2.7).

2.4.2 Completion of purge out of service

The end point in a gas freeing exercise is when sufficient inert gas has been added to the LPG such that it is impossible to produce a flammable mixture by the addition of air. Table 2 shows suitable end points for purging.

TABLE 2
COMBUSTIBLE GAS END POINTS FOR PURGING OUT OF SERVICE

| | Percent of Combustible below which no mixture is flammable when air is added in any amount | Purging End Points with 20% Safety |
|-----------------|---|---|
| Propane* | 6 | 5 |
| Butane* | 5 | 4 |
| Local LPG Mix** | 5,25 | 4,25 |

*Ref: American Gas Association, Purging Principles and Practice

** Values taken from the field

2.4.3 Preparation for entry

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Once the end point is reached it is safe to remove the access cover, etc., in order to ventilate the system/vessel with air. This process may be speeded up by use of air movers.

A gas-free certificate authorized by the person in charge of the safety of the operation to permit entry without breathing apparatus should not be granted unless the oxygen level in the vessel is 19% or above (by volume), and at the same time the LPG concentration is less than 5% of the lower flammable limit in air.

- Consideration should also be given to checks of total hydrocarbons and mercaptans within the vessel.

Gas free certificates authorized by the person in charge of the safety of the operation should be granted for a specified period.

If residues are known to be present this time limit may be quite short (See 2.2.7). After the specified time limit the vessel atmosphere should be retested for a new certificate to be issued.

If at any time the oxygen level in the vessel exceeds the normal (21 % by volume), it should not be allowed to rise above (23% by volume) for internal access.

The conditions for entry into a vessel should be controlled by using a Permit to Work signed by the responsible person in charge by the work at hand, following receipt of the gas free certificate. This should include:

- the use of life-lines and harnesses;
- personal protective equipment;
- when breathing apparatus is required;
- the permanent attendance of at least one person outside the vessel in communication with the person inside the vessel;
- provision of rescue equipment;
- any other conditions to ensure the safety of personnel.

Note: The Work Place (Minimum Requirements for Work) (Confined Spaces and Spaces Having Explosive Atmospheres) Regulations (LN 41 of 2004) contain legal requirements for the entry of tanks etc., with and without breathing apparatus.

- Advice on work in confined spaces is given in LN41/2004 - Workplace (Minimum Requirements for work) (Confined Spaces and Spaces having Explosive Atmospheres) Regulations.
- Residues may be found occasionally in vessels (See 2.2.7). The disposal of residues may be subject to the Environment Protection Act and in particular to the Waste Management (Landfill) Regulations (LN 168 of 2002). This

may also apply to the disposal of contaminated water following a purge with water or steam.

Workplace Exposure Limits may be found in L.N. 120/2003 – Regulations establishing a first list of indicative occupational exposure limit values on the protection of the health and safety of workers from the risks related to chemical agents at work, 2003.

2.4.4 *Purging into Service*

2.4.4.1 Purging into service normally follows a pressure test. Where this test has been carried out using compressed air or water methanol may have been added. Methanol is flammable and toxic and should only be added in accordance with a written approval by a competent person and after purge gas has been added in accordance with 2.4.2.2.

2.4.4.2 Nitrogen gas should be added until the oxygen content in the mixture is less than that given in Table 1.

TABLE 1
OXYGEN END POINTS FOR PURGING INTO SERVICE

| | Percent of Oxygen below which no mixture is flammable | Purging End Points with 20% Safety Factor |
|-----------------|---|---|
| Propane* | 11,4 | 9,1 |
| Butane* | 12.1 | 9,7 |
| Local LPG Mix** | 11,92 | 9,55 |

* Ref: American Gas Association, Purging Principles and Practice

** Ref: Values taken from the field

Safety Note: Most gas analysers/detectors measure gas in air and will not indicate gas in nitrogen. Care must be exercised in the selection and use of analysers/detectors when oxygen is not present, i.e. during the purging out of service operation. Analysers should be appropriate for the service and be calibrated for the gas and medium for which they are used. They should be checked for sensor function in the L.F.L. (Lower Flammable Limit) range before use.

2.4.5 *Filling with LPG*

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- 2.4.5.1 To avoid rapid (flash) vaporisation of LPG, vapour only should be admitted into the vessel until the vessel pressure is approaching that of the delivery vessel. This may also be achieved by pressurising the vessel with the purge gas to about 3 bar gauge for propane or 1 bar gauge for butane.
- 2.4.5.2 A flare-off burner should be set up as indicated in 2.4.1 and connected to a suitable vapour connection.

Filling should be commenced and vessel pressure observed (a vapour return connection should not be used until all purge gas has been expelled). When the pressure in the vessel rises to $P_n + P_v + 1,5$ bar gauge filling should be ceased.

Where: P_n = Initial pressure in vessel.

and P_v = LPG vapour pressure for observed temperature.

Vapour should be released through the flare burner with pilot alight until pressure in the vessel approaches the LPG vapour pressure P_v . If the flare has not ignited the flare and pilot should be shut off and filling recommence until pressure has reached $P_v + 1$ bar gauge, then filling should be ceased, the vehicle engine stopped and vapour released through the flare as before. This procedure should be continued until a stable flare has been established; the flare and pilot burner should then be shut off. Thereafter filling may be continued in the normal way with, where applicable the vapour return connected up.

This system, with appropriate modifications, can be adapted to purge back into service most LPG systems. Selection of the points at which purge gas is introduced into and vented from the system must be chosen with care to avoid trapping pockets of air or purge gas. If this method is not possible a form of the pressure and vent technique may be used to adequately complete the purge.

Section 3: Purging with Water

3.1 General

Before purging with water is carried out, the MRA Water Directorate should be consulted on water supply and disposal.

Water may be used as a medium for purging out of service. It should be admitted into the vessel/system via a bottom connection once the vessel/system is free of liquid LPG. LPG vapour will then be expelled from a suitable vapour connection which can then be piped to a safe place or a flare burner as per 2.4.1.

Water may be used to purge a vessel into service but is rarely used because of the residual moisture which may be difficult to eliminate and may cause difficulties in subsequent service.

3.2 Specific Precautions

- 3.2.1 Before water is used the design and construction of the vessel and its foundations on which it is sitting should be checked to ensure they can take the extra load. Water is approximately twice as dense as LPG.
- 3.2.2 The vessel must be adequately vented to avoid creating a vacuum when the water is released.
- 3.2.3 The design of the system should be assessed with a view to any dead legs or blind holes where a gas pocket could be trapped and not eliminated by filling the vessel/system with water. Care should be taken to see that flammable vapours are not still being produced even after the purge has been apparently completed. (See Section 2.2.7).
- 3.2.4 To minimise corrosion the wet inner surface of the vessel/system should be exposed to the air for as short a time as possible.
- 3.2.5 When the purge is complete the vessel/system should be dried out thoroughly before refilling with LPG. Where this involves the use of methanol see 2.4.2.1.

Section 4: Purging by Evacuation

4.1 General

To avoid implosion of the vessel/system it needs to be designed for full vacuum conditions.

If the vacuum rating is not known this may be calculated by reference to the correct section in the appropriate design code provided that the necessary design details are available.

4.2 Specific Precautions

- 4.2.1 When purging out of service by vacuum should only be used to remove LPG vapour after the vessel/system is free of the liquid phase LPG. Discharge from the compressor must be broken by an inert gas. If air is used it is possible to create a flammable mixture.
- 4.2.2 Purging by evacuation requires a vacuum pump/compressor, these are not always available nor are they easy to run at remote sites.
- 4.2.3 When purging into service the vacuum should be broken by an inert gas. If air is used it is possible to create a flammable mixture.

Section 5: Purging by Steam

5.1 General

Steam may be used as a medium to purge vessels and systems out of service and expel the LPG vapour via a piped connection to a suitable safe place or to a flare burner as described in 2.4.1. It is often used immediately after a vacuum purge to break the vacuum. It has the advantage of providing heat to assist in expelling volatile residues.

When purging with an inert permanent gas it is sufficient to purge until the percentage of LPG is such that any addition of air cannot form a combustible mixture. However, with steam which can condense it is necessary to purge further such that a combustible mix cannot be formed with air even if all the steam is condensed, i.e. to below the Lower Flammable Limit for the LPG (2,0% for propane and 1,8% for butane).

5.2 Specific Precautions

5.2.1 A close watch should be kept on a pressure gauge during the purge in order to avoid over-pressurising the vessel/system.

5.2.2 Care should be taken to avoid rapid condensation of the steam giving rise to vacuum conditions which could cause implosion of the vessel/system.

5.2.3 When residues are present care must be taken when sampling that flammable vapours are not still being produced even when purging is apparently complete. To ensure this at least two readings indicating a satisfactory combustibles level is required with at least 15 minutes between each reading.

5.2.4 The vessel should be electrically earthed to avoid the danger of static build-up.

5.2.5 The higher temperatures involved with the use of steam will often vaporise many sulphurous and residues that a cooler technique would leave behind. This may make it more difficult to reach a purge end point and will increase the amount of heavy ends, etc. collected from the vessel/system.

Where significant quantities of residues have accumulated advice should be sought from the Malta Environment and Protection Authority in respect of disposal.

5.2.6 When the purge is complete the vessel/system should always be dried out thoroughly before refilling with LPG. Where this involves the use of methanol see 2.4.2.1.

5.2.7 The comparatively high temperatures involved in steam purging will result in expansion of the vessel/system being purged. Care should be taken to ensure

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that undue or excessive strain is not imposed on pipework and fittings connected to the vessel/system.

- 5.2.8 Whilst purging it is necessary to keep a positive pressure in the vessel/system to prevent ingress of air.
- 5.2.9 Measurement of flammables in a steam atmosphere can be difficult. An alternative method is to measure the temperature of the purge gas (LPG/steam mixture) at the vent pipe. Experiments have shown that a temperature of 86°C (187°F) is sufficient to prevent a flammable mix being formed on the admission of air.

(Ref: American Gas Association, Purging Principles and Practice.)

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Appendix A: Safe Handling and Properties of LPG

A.1 Safe Handling of LPG

The liquid petroleum gas which is generally available in Malta consists of a mixture of Butane and Propane (70-80% and 30-20% respectively) according to MSA EN 589 depending on the season. These component gases of the present LPG mixture may be made available for sale and use as separate products in accordance with BS 4250:1997 or equivalent.

The mixture is normally supplied in cylinders up to 25 kg capacity and has a much lower vapour (or cylinder) pressure than propane.

The combustion of LPG produces carbon-dioxide (CO₂) and water vapour, but sufficient air should be available. Inadequate appliance flueing and/or ventilation, or poor air-gas mixing e.g. due to lack of servicing, can result in the production of toxic carbon monoxide.

Everyone concerned with the storage and handling of LPG should be familiar with the following characteristics and potential hazards: -

- (a) LPG is stored as a liquid under pressure. It is almost colourless and its weight is approximately half that of an equivalent volume of water.
- (b) LPG vapour is denser than air, butane is about twice as heavy as air and propane about one and a half times as heavy as air. Consequently, the vapour may flow along the ground and into drains, sinking to the lowest level of the surroundings and be ignited at a considerable distance from the source of leakage. In still air vapour will disperse slowly.
- (c) LPG can form a flammable mixture when mixed with air. The flammable range at ambient temperature and pressure extends between approximately 2 % of the vapour in air at its lower limit and approximately 10 % of the vapour in air at its upper limit. Within this range there is a risk of ignition. Outside this range any mixture is either too weak or too rich to propagate flame. However, over-rich mixtures can become hazardous when diluted with air.

At pressures greater than atmospheric, the upper limit of flammability is increased but this increase with pressure is not linear.

- (d) Escape of even small quantities of the liquefied gas can give rise to large volumes of vapour/air mixture and thus cause considerable hazard. A suitably calibrated explosimeter may be used for testing the concentration of LPG in air.

A NAKED FLAME SHOULD NEVER BE USED TO SEARCH FOR A LEAK.

- (e) At very high concentrations in air, LPG vapour is anaesthetic and subsequently an asphyxiant by diluting or decreasing the available oxygen.
- (f) Commercial LPG is normally odourised before distribution by the additional of an odourant such as ethyl mercaptan or dimethyl sulphide, to enable detection by smell of the gas at concentrations down to one-fifth of the lower limit of flammability (i.e. approximately 0,4 % of the gas in air). However in certain cases where the odourant may be detrimental to a process (for example in aerosol applications) the LPG is not odourised.
- (g) Escape of LPG may be noticeable other than by smell. When the liquid evaporates, the cooling effect on the surrounding air causes condensation and even freezing of water vapour in the air. This effect may show itself as frost at the point of escape and thus make it easier to detect an escape of LPG. Because the refractive index of LPG differs from air, leaks can sometimes be seen as a shimmering.
- (h) Owing to its rapid vaporisation and consequent lowering of temperature, LPG, particularly liquid, can cause severe frost burns if brought into contact with the skin. Personal protective equipment (e.g. hand and eye protection) should be worn if this hazard is likely to occur.
- (i) A container, which has held LPG and is empty may still contain LPG in vapour form and is thus potentially dangerous. In this state the internal pressure is approximately atmospheric and if a valve is leaking or is left open, air can diffuse into the container forming a flammable mixture and creating a risk of explosion; alternatively, LPG can diffuse to the atmosphere.

Note: These properties are general characteristics of LPG and items such as (h) should not occur in normal cylinder usage.

A.2 Typical properties of commercial LPG

| | Commercial Butane | Commercial Propane |
|---|----------------------------|-----------------------------|
| Relative density of liquid at 15 °C | 0,57 to 0,58 | 0,50 to 0,51 |
| Imperial gallons/ton at 15 °C | 385 to 393 | 439 to 448 |
| Litre/tonne at 15 °C | 1 723 to 1 760 | 1 965 to 2 019 |
| Relative density of gas compared with air at 15 °C and 1 013,25 mbar g | 1,90 to 2,10 | 1,40 to 1,55 |
| Volume of gas (litres) per kg of liquid at 15 °C and 1 013,25 mbar g | 406 to 431 | 537 to 543 |
| Volume of gas (ft ³) per lb of liquid at 60 °F and 30 in Hg | 6,5 to 6,9 | 8,5 to 8,7 |
| Boiling point at atmospheric pressure °C approx. | -2 | -45 |
| Vapour pressure for products at their maximum specified vapour pressure (gauge) Temp. °C | bar g | bar g |
| -40 | - | 0,5 |
| -18 | * | 2,3 |
| 0 | 0,9 | 4,5 |
| 15 | 1,93 | 6,9 |
| 38 | 4,83 | 14,5 |
| 45 | 5,86 | 17,6 |
| Latent heat of vaporisation (kJ/kg) at 15°C | 372,2 | 358,2 |
| Latent heat of vaporisation (Btu/lb) at 60 °F | 160 | 154 |
| Specific heat of liquid at 15°C (kJ/kg deg C) | 2,386 | 2,512 |
| Sulphur content per cent weight | Negligible to 0,02 | Negligible to 0,02 |
| Limits of flammability (percentage by volume of gas in a gas-air mixture to form a combustible mixture) | Upper 9,0 Lower 1,8 | Upper 10,0 Lower 2,2 |
| Calorific Values: | | |
| <i>Gross</i> | | |
| (MJ/m ³) dry | 121,8 | 93,1 |
| (Btu/ft ³) dry | 3 270 | 2 500 |
| (MJ/kg) | 49,3 | 50,0 |
| (Btu/lb) | 21 200 | 21 500 |
| <i>Nett</i> | 112,9 | 86,1 |
| (MJ/m ³) dry | 3 030 | 2 310 |
| (Btu/ft ³) dry | 45,8 | 46,3 |
| (MJ/kg) | 19 700 | 19 900 |
| (Btu/lb) | | |
| Air required for combustion (m ³ to burn 1m ³ of gas) | 30 | 24 |

*Minimum Commercial Butane vapour pressure at -18°C is minus 524mbar g

Appendix B: References

British Standards

BS 4250:1997 Specification for Commercial Butane and Commercial Propane

MSA EN 589 Automotive fuels – LPG – Requirements and test methods

Legal

Occupational Health and Safety Act, Chapter 424 Laws of Malta

Work Equipment Regulations L.N. 282/2004.

General Provisions for Health and Safety at Work Places L.N. 36/2003

Work Place (Minimum Requirements for Work) (Confined Spaces and Spaces Having Explosive Atmospheres) Regulations (L.N. 41 Of 2004)

Protection of the Health and Safety of Workers from the Risks related to Chemical Agents at Work Regulations L.N. 227/2003

Waste Management (Landfill) Regulations (LN 168 of 2002).

Bulk LPG (Installation and Use) Regulations 2007

| MRA LPG CODES OF PRACTICE | |
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| <u>Number</u> | <u>DESCRIPTION</u> |
| <u>GROUP A - BULK VESSELS</u> | |
| A1 | Design and Installation |
| A2 | Examination and Inspection |
| A3 | Buried/Mounded LPG Storage Vessels |
| A4 | Purging LPG Vessels and Systems |
| A5 | LPG Central Storage and Distribution Systems for Multiple Consumers |
| <u>GROUP B - SMALL CYLINDERS STORAGE AND FILLING</u> | |
| B1 | Storage of Full and Empty Vessels |
| B2 | Recommendations for the Safe Filling of LPG Cylinders at Depots |
| B3 | Hazard Information and Packaging for Commercial LPG Cylinders |
| <u>GROUP C - LPG DRIVEN MACHINERY</u> | |
| C1 | Autogas Installations |
| C2 | The Safe Use of LPG as a Propulsion fuel for boats, yachts and other craft |
| C3 | Automotive LPG Refuelling Facilities |
| C4 | Gas Installations for Motive Power on Mechanical Handling and Maintenance Equipment |
| <u>GROUP D - ANCILLARY EQUIPMENT</u> | |
| D1 | Hoses for the Transfer of LPG in Bulk: Installation, Inspection, Testing & Maintenance |
| D2 | Safety Valves |
| D3 | Valves for Transportable LPG Containers |
| D4 | Flow rates up to 80 litres/min in Installations dispensing Road Vehicle Fuel |
| D5 | Flow rates above 80 litres/min between Mobile Equipment and Fixed LPG Storage |
| D6 | LPG Piping Systems: Design & Installation |
| <u>GROUP E - LPG CYLINDER USAGE AT DIFFERENT PREMISES</u> | |
| E1 | The Use & Storage of LPG in Cylinders at Residential Premises |
| E2 | The Storage and Use of LPG on Construction Sites |
| E3 | Use of Propane in Cylinders at Commercial and Industrial Premises |