MRA LPG

CODE OF PRACTICE C4:2007

LPG Driven Machinery

Gas Installations for Motive Power
on Mechanical Handling and
Maintenance Equipment

The information in this Code of Practice is given in good faith and belief in its accuracy at the time of its publication, but does not imply any legal liability or responsibility by the Malta Resources Authority.

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This guidance is not an authoritative interpretation of the Law, but if you do follow the Guidance, you will normally be doing enough to comply with the Law.

Malta Resources Authority Officials may refer to this Guidance as illustrating good practice.

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 C4

Gas Installations for Motive Power on Mechanical Handling and Maintenance Equipment

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Section 1. Introduction, objective and scope

1.1 Introduction

LPG has been used as an internal combustion engine fuel for mechanical handling and maintenance equipment for a great many years. This Code reflects current engine design and the engine management systems.

LPG engine fuel systems are now available for all generations of spark ignition management systems. These are broadly defined as follows:-

1st generation	Carburettor air-gas mixing systems.
2nd generation	Carburettor systems with micro processor control derived from engine speed, manifold pressure and lambda sensor for optimising 3-way exhaust catalyst operation.
3rd generation	Multi-point liquid or vapour (fuel) injection systems, but with non- adjustable self learning feedback controls.

- Other relevant Codes and Standards are listed in Appendix C.
- 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 is a comma (e.g. one point five is represented as 1.5).

1.2 Scope

This Code sets minimum standards for the safe installation and use of LPG as a motive fuel for mechanical handling and maintenance equipment (e.g. fork lift trucks, lawnmowers, floor polishers etc.) The Code includes the design and installation of the LPG fuel tank and the fuel feed system comprising fittings, pipework, connections and controls for the internal combustion engine.

1.3 Definitions

For the purpose of this Code the following definitions apply:-

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

1.3.2 **Component**. Any equipment through which LPG or other fuel flows and is added as part of the equipment conversion.

1.3.3 **Gas Container**. A fuel tank or cylinder which is a pressure vessel for the storage of LPG to be used as engine fuel.

Various types of fuel tanks and containers are in use:

- Fixed fuel tanks permanently attached to the equipment structure, and which require the use of tools (e.g. spanners) for their removal, which are filled by volume, without removal from the equipment, from a local refueling facility.

- Cylinders attached to the equipment structure by clamps or clips, and which do not require the use of tools for their removal, which are filled by volume, without removal from the equipment, from a local refueling facility.

- Cylinders which are attached to the equipment structure by clamps or clips, and which do not require the use of tools for their removal, which are filled by volume and which are removed from the equipment for refilling or exchange when empty.

- Cylinders which are attached to the equipment structure by clamps or clips, and which do not require the use of tools for their removal, which are filled by weight and exchanged when empty.

1.3.4 **Contents Gauge**. A gauge which gives visual indication of the liquid contents in the fuel tank.

1.3.5 **Half Coupling**. A self sealing coupling which allows the transfer of gas to the fuel line and can be manually disconnected to allow changing of the cylinder.

1.3.6 **Fixed Maximum Liquid Level Indicator.** A valve which indicates the maximum permitted liquid level in the gas container. It comprises a tube arranged with its open end located at the maximum permitted liquid level, so that gaseous discharge changes to a visible liquid discharge as the liquid surface reaches the level during filling.

1.3.7 **Hydrostatic Relief Valve**. A valve whose purpose is to relieve and prevent over pressure due to thermal expansion in any supply pipeline carrying LPG in the liquid state.

1.3.8 **Stop Fill Valve**. A double check level device, which prevents the over filling of a fuel tank beyond a pre-determined liquid level, (usually 80%).

1.3.9 **Lock-off Valve**. A term used to describe a shut-off valve in the fuel feed line which will automatically shut-off the fuel feed to the engine under specified conditions relating to equipment operation and safety.

1.3.10 **Multiple Valve**. A manifold block which requires only a single nozzle opening in the fuel tank which incorporates all or some of the following fittings: 80% stop-fill valve, level indicator, service valve with excess-flow valve, and fuel pump.

1.3.11 **Non-Return Valve**. A device to permit flow in one direction and prevent the flow in the opposite direction.

1.3.12 **Check Valve (device)**. Another term for a non-return valve.

1.3.13 **Fill-Connector**. The self-sealing fitting at the fuel tank or at the terminal of the fill pipe extension designed to accept the self-sealing coupling of the refueling facility.

Section 2. LPG gas containers

2.1 Design

2.1.1 General

New gas containers should have a test pressure of not less than 30 bar gauge, and preferably be constructed of steel. Other materials are not precluded where equivalent standards of mechanical, physical, thermal and chemical integrity have been demonstrated.

Subject to proper maintenance and inspection (see 6.1) pre-existing gas containers, including those designed and produced to BS 5045-2:1989, MSA EN 13322-1:2003, EU Directive 84/527 and ECE 67-01, may continue to be fitted and used.

2.1.2 Fixed fuel tanks

New fixed fuel tanks must meet the Pressure Equipment Regulations L.N.248/2002 and carry the CE mark. They should be designed and constructed in accordance with MSA EN 1442:2006+A1:2008, MSA EN 12805:2002, ECE 67-01 or other equivalent recognized Pressure Vessel Standard and a Test Certificate issued accordingly.

Subject to proper maintenance and inspection (see 6.2.2) pre-existing fixed fuel tanks, including those designed and produced to BS 5045-2:1989 and MSA EN 13322-1:2003, may continue to be fitted and used.

2.1.3 Cylinders

New cylinders must comply with the Transportable Pressure Equipment Regulations L.N.331/2002 They should be designed and constructed in accordance with MSA EN 1442: 2006+A1:2008 or another equivalent technical code recognised by the MRA and MSA.

Subject to proper maintenance and inspection (see 6.2.3) pre-existing cylinders, including those designed and produced to BS 5045-2:1989, MSA EN 13322-1:2003 and EU Directive 84/527, continue to be fitted and used.

2.2 Marking

2.2.1 Each gas container should be conspicuously and permanently marked with its design/test pressure and other data required by the pressure vessel standard.

2.2.2 The information should include *at least* the following:-

(a) The specification or code to which the fuel tank is manufactured.
(b) The manufacturer's name and identification mark.
(c) The fuel tank serial number.
(d) The minimum designed water capacity in litres.
(e) The design/test pressure in bar gauge.
(f) The year and month of manufacture.
(g) The date of the hydraulic test, and identification mark of the testing authority and space allowed for subsequent re-tests.

2.2.3 These marks should be not less than 6 mm in height unless the design standard indicates otherwise.

2.2.4 Gas containers designed for use with internal dip pipes, contents gauges and similar fittings which rely on a correct orientation of the container for their operation should be clearly marked to indicate the correct position for installation. Where a multi-valve assembly is used the orientation of the container will be dependent upon the designed operating position of the multi-valve which must be clearly marked to this effect.

2.3 Location of the Gas Container

2.3.1 The gas container should be situated so that in the event of gas escaping due to leakage or venting, the possibility of gas entering engine compartments, battery compartments or cabs is minimized for example by:

(a) situating the gas container in a compartment used only for the storage of the container and the fittings immediately associated with it, which has ventilation to atmosphere of not less than 20 000 mm^2 at the lowest practicable level which is sealed from the remainder of the vehicle.

Note: This does not preclude the provision of an access to allow the replacement of exchangeable gas containers.

(b) situating all valves, connections, gauges and indicators in a vapour-tight security cover which is itself vented to atmosphere from the lowest point, for example by tubing. Such tubing should have a minimum internal free area of 450mm^2, be suitable for use with LPG and protected against

(c) mechanical damage or distortion. Filler connections and fixed maximum level indicators must be extended by suitable tubing to the outside of the vehicle.

(d) locating gas containers external to the vehicle in a suitably protected position maintaining adequate ground clearance and no closer than 250mm to the engine exhaust system.

2.3.2 Openings from gas container compartment and ventilation tubes should be:

(a) No closer than 250mm to the engine exhaust system.

(b) Protected by position, or other means, from blockage, both from within and without.

2.4 Gas Container Mounting

2.4.1 Means should be provided for attaching the gas container securely to the equipment. This provision may take the form of fixed lugs welded to the gas container during manufacture or the provision of cradles, straps or bonds attached to the equipment. In order to prevent distortion of the fixing area or the container breaking loose in the event of impact, reinforcement of fixings through sheet metal panels etc. should be provided by suitable means designed to equally distribute the weight of the tank and its contents. The gas container mounting should be sufficient to resist a deceleration of 5g without the gas cylinder breaking loose.

- Consideration should be given to more robust mountings when higher decelerations may be experienced when the equipment is used in accordance with its intended purpose.

2.4.2 Gas containers should be mounted in a level position and orientated in accordance with the supplier's recommendations or markings. (See 2.2.4).

Note: Vapour offtake cylinders should always be mounted with the valve uppermost. Specialist containers are often marked with an arrow indicating the correct orientation.

2.4.3 Gas containers and their fittings should be protected by position, or other means, against physical impact and tampering.

(a) The gas container shell, fittings and pipework should not overhang the main frame or structure of the vehicle.

(b) Where the requirements of 2.4.3 (a) above cannot be met collision bars or other suitable protection should be provided.

2.4.4 Where exchange containers are used they should be correctly orientated and securely clamped.

2.4.5 Where containers are mounted under the equipment and exposed to weather conditions and/or excessive moisture, consideration should be given to an additional protection for the container.

2.5 Multiple Gas Containers

If the equipment is fitted with two or more gas containers they must be connected via a multi-way valve, or other suitable means, so that LPG can be drawn only from one container at a time.

For gas containers which are filled without removal from the equipment a single refueling connection is normal. The fuel feed outlets should be manifolded to a single feed pipe to the engine. Appropriate check valves should be fitted at each fuel container connection to prevent inadvertent flow between fuel containers.

Section 3. Gas container fittings and connections

3.1 General

3. 1.1 Fittings and components subject to gas container pressure should be proven suitable for contact with vapour and liquid phase LPG and designed for a pressure not less than the gas container design pressure. They may be separately mounted on the gas container or they may be in the form of a multiple valve system incorporating some or all of the fittings in a single tank entry/exit.

3.1.2 All connections and fittings should, by position or other means, be protected against physical damage. Manually operated valves should be readily accessible.

3.2 Connections

3.2.1 All connections to gas containers greater than 3 mm diameter for liquid and 8 mm for vapour, with the exception of those for relief valves, and contents gauges, should be provided with a self closing device e.g. an excess flow valve, or non-return valve, to prevent escape of product in the event of damage to the connections.

3.2.2 All liquid and vapour connections to and from fuel tanks with the exception of those for relief valves, plugged openings, and those where blind connections through the fuel tank shell are not greater than 1,5 mm diameter should have shut off valves located as close to the fuel tank as practicable. For filling connections this requirement is met by 3.3.1(a).

3.2.3 Manually operated fuel supply valves should be clearly marked with the direction of rotation to close, if manually operated.

3.2.4 The position of any manual fuel shut off valves, if not visible from the outside of the equipment, should be indicated by a suitable notice clearly visible from outside the equipment.

3.3 Fittings

Gas containers designed to be filled on site or in situ by volume should be provided with the following fittings mounted directly on to the tank:

- Filler valve and connection;
- Service valve;

- Maximum liquid level indicator or stop-fill valve;
- Contents gauge (optional)

3.3.1 Filler Valve and Connection

(a) The filler or valve on gas containers should incorporate a double check valve to prevent reverse flow and either a fixed liquid level indicator or an automatic stop fill shut-off device fitted directly to each gas container.

(b) Where an extended filling connection is used it should terminate in a check valve.

(c) The filler connection should be located so as to be readily accessible for a filler nozzle directly, and without the use of any adapter. The preferred size of fill connection for fixed fuel tanks is 1¾ “ RH ACME thread.

3.3.2 Service Valve

Service valves should incorporate an excess flow valve as required by 3.2.1. Wherever practicable it should be mounted internally to the gas container. An excess flow valve in this context means a device which automatically and instantaneously reduced to a minimum the flow of gas through the valve when the flow rate exceeds a set value.

3.3.3 Maximum Liquid Level Indicator

(a) The fixed maximum liquid level device should be suitable for use with the LPG stored and should indicate the maximum product level in accordance with Section 3.3.1 (a).

(b) If the device relies on a bleed to atmosphere it should be so designed that the bleed hole does not exceed 1,5 mm diameter.

(c) The device should be designed so that the moveable parts of the device cannot be withdrawn completely in normal gauging operations.

(d) The bleed from the device should be extended to the outside of the equipment except where the fuel tank is fitted in a ventilated compartment permanently sealed from the interior of the equipment or located in a non enclosed position.

(e) Where a cylinder is filled away from the equipment the device should operate correctly with the cylinder upright or when correctly aligned in the horizontal position.

3.3.4 Automatic Stop Fill Device

Automatic stop fill shut-off devices should be designed to limit the maximum quantity of LPG to 80% of each fuel container capacity, and should meet the requirements of ECE Regulation 67 or equivalent.

3.3.5 Contents Gauge (Optional Fitting)

(a) Direct reading magnetic type float gauges are suitable.

(b) All contents gauges should clearly indicate whether they read in percentage water capacity, percentage rated LPG capacity or actual contents in litres, etc.

(c) The sensing device of any indicator operated by an electrical system exposed to LPG vapour, should be of an approved construction for use in flammable atmospheres.

Section 4. Pipework

4.1 LPG Pipework

Pipework for these applications is classified as “high pressure pipework” if they are carrying LPG in the liquid phase, or carrying vapour at a pressure in excess of 200 mbar gauge. In either case, the pipelines and their assemblies should be resistant to liquid phase LPG. Pipework carrying vapour up to 200 mbar gauge are classified as “low pressure pipework”.

Where flexible hoses are used these should be as short as possible.

4.1.1 High pressure pipework should be:

(a) Seamless stainless steel to BS 6362:1990 ISO 7598:1988 or equivalent or,

(b) Copper or copper alloy to DIN 1787 or DIN 17671 or equivalent or,

(c) Flexible fabric or metallic reinforced synthetic rubber or polymer hose designed for a service pressure of not less than 25 bar gauge with a burst pressure not less than 125 bar gauge and to meet the criteria of BS ISO 8789:1994

Engine compartment hoses should be suitable for an ambient temperature of 120 ℃ and need to be specifically warranted for this temperature as stated in BS ISO 8789:1994. A lower temperature may be acceptable if approved by the equipment manufacturer.

Hoses should be permanently marked as required by their specification standard and in relation to their test certificate.

4.1.2 Low pressure pipework may be rigid or flexible. In either case they should be impervious and resistant to LPG in both liquid or vapour phase at the predicted operating temperatures. They should be capable of sustaining at least 3,5 bar gauge without leaking or excessive distortion. If the operating conditions will involve an internal vacuum, they should be capable of withstanding safely the maximum operating vacuum, or preferably a full vacuum, without collapse or undue distortion. Engine compartment flexible pipework (hoses) should be suitable for an ambient temperature of 120 ℃. A lower temperature may be acceptable if approved by the equipment manufacturers.

4.2 Joints and Connections

4.2.1 Every joint or connective fitting should be of metal and of a type suitable for service with LPG at the operating pressure. This does not preclude the use of suitable nonmetallic seals within the fitting, complying with MSA EN 549:1995. Jointing compound for screw threads where appropriate should be suitable for use with LPG and comply with MSA EN 751-1:1997 or MSA EN 751-2:1997.

4.2.2 The number of joints and connections should be the minimum for the inclusion of essential components.

4.2.3 Flared joints or compression union fittings with brass olives are preferred. Soldered or welded joints and ‘bite’ type compression unions should not be used.

4.2.4 Fuel feed connections to engine mounted components need adequate flexibility to accommodate engine vibration. Flexible high pressure or low pressure pipelines as described in 4.1.1 and 4.1.2 may be used depending on the maximum operating pressure.

4.2.5 Joint fittings and connections should be compatible with one another and their mating materials should not create electrolytic corrosion.

4.3 Sizing of Pipework

4.3.1 The LPG liquid pipework bore should be as small as possible to avoid undue rigidity and sufficiently large to provide for maximum engine fuel demand.

4.3.2 It should be recognised that an excess flow valve incorporated into an LPG service valve will not protect the pipe in every eventuality, and it is therefore emphasised that the liquid pipework should be as small a bore as is practicable whilst meeting the maximum fuel requirement of the engine.

4.4 Pipework Location

4.4.1 Pipework feeding from or into the fuel tank should follow the safest route and be protected from impact, preferably below the body shell where it may be shielded by structural members of the equipment.

4.4.2 Pipework should be no closer than 250 mm to the equipment exhaust system.

4.4.3 Where the requirement of 4.4.2 above is not practicable, the pipework should be shielded from the equipment exhaust system by a suitable heat shield.

4.4.4 Pipework should be effectively secured to the chassis frame or body shell at intervals of not exceeding 600 mm and in such a manner to be protected against excessive strain and vibration.

4.4.5 Pipework should not be installed where any part is permanently hidden from view and cannot be inspected regularly.

4.4.6 Pipework positioning should be such that it will not be affected by suspension or propshaft (driveshaft) movement. It should not be located at vehicle jacking points.

4.5 Flexibility

Pipework should be installed so as to take up safely the relative movement between chassis/body and the fuel system components and secured in such a manner so as to prevent wear taking place. All runs of rigid pipework between components should be installed with gentle curves, U-bends or loops to provide flexibility.

4.6 Pipework Over Pressure Protection

4.6.1 Every section of LPG liquid pipework between positive shut-off or lock-off valves should be protected against resultant damage from over pressure due to liquid thermal expansion.

4.6.2 Hydrostatic relief valves, where fitted, should be vented away from the equipment exhaust or people, to open air.

Section 5. LPG control equipment

5.1 Purpose

The control equipment comprises components which are necessary to supply the LPG in a state, either vapour or liquid, and at the pressure required by the engine design and the fuel management system and to ensure safe and efficient operation under all foreseeable modes of vehicle operation and use. Where an alternative fuel system is installed (bi-fuel), neither should impair the safety or efficiency of the other.

5.2 Components for all Engines

5.2.1 Installation

The LPG control equipment should be:

(a) Installed in positions that are easily accessible for routine inspection, maintenance and adjustment.

(b) Securely mounted and reasonably protected by location from accidental damage.

(c) As remote as possible from the engine exhaust system or protected therefrom by a heat shield.

(d) No closer to any electrical equipment capable of sparking than is avoidable.

5.2.2 Filter

Systems in which components are susceptible to mal-function or damage from solid particulate matter may need a filter of suitable mesh in the fuel supply or such other device which will protect these components. Some components have integral filters or devices.

5.2.3 Lock-off valve

(a) An efficient lock off valve should be installed immediately after any filter and upstream of any pressure reducing regulators.

(b) The lock-off valve should be designed for automatic closure whenever there is no fuel demand from the engine.

(c) The lock-off valve should be capable of automatically opening to relieve excess hydrostatic pressure generated on the engine side of the valve back into the fuel system.

5.2.4 Automatic Safety Controls

(a) Safety control systems should operate if the engine stops for any reason.

Various methods can be adopted to meet these requirements. The following are examples:

(i) A device designed to give total closure on zero engine manifold depression.

(ii) A manifold pressure sensitive switch, normally open at zero depression, connected in series with the electric supply to the lock-off valve.

(iii) An oil pressure sensitive switch open for zero oil pressure, connected in series with the electric supply to the lock-off valve.

(iv) An ignition coil triggered switch in the electric supply to the lock-off valve which is open when the coil is de-energised.

(b) Any electrical switches controlling the lock-off valve, should be connected in series with the electrical supply to any solenoid shut-off valves at the fuel tank(s), to provide simultaneous shut-off.

(c) Any electrical switch or mechanical means used to bypass a device as defined in (a) above to facilitate engine starting or tuning should require continuous manual pressure to operate and should automatically return to the off position.

(d) Additional safety controls in the fuel system may be incorporated e.g. inertia cut-off tilt switches.

5.3 Components for Non-fuel Injection Engines

5.3.1 Vaporisers

Vaporisers normally utilise heat from the engine coolant system.

(a) Where water circulation is employed.

(i) A continuous flow of water should be ensured which is not subject to interruption by operation of the vehicle heater controls.

(ii) The design of the water jacket of the vaporiser should take into account the possibility of internal expansion resulting from water freezing and should be resistant to antifreeze.

(b) The use of exhaust gas/LPG heat exchangers is not recommended.

(c) Every vaporiser should be constructed of materials suitable for use with LPG and be capable of withstanding the maximum pressure likely to be encountered in service.

5.3.2 Pressure Regulators

(a) LPG systems have one or two stages of pressure reduction. The pressure regulators and the vaporiser may be separate units but frequently are combined into a single unit referred to as a converter.

(b) The first stage regulator should reduce the pressure to a value appropriate to the second stage regulator inlet pressure.

(c) The second stage regulator should be designed to give the pressure required at the carburettor, gas-air mixer or injectors.

(d) Every pressure regulator should be constructed of materials suitable for use with LPG and capable of withstanding the maximum pressure likely to be encountered in service.

5.3.3 Carburettors and Adapters

The carburettor or adapter is a gas/air mixing device in which the gas and air are metered in the correct proportions for combustion. The choice of carburation depends on the engine layout and application:

(a) Single fuel - applies where complete conversion to LPG is effected, and a purpose designed LPG carburettor may be employed.

(b) Bi-fuel - applies on an engine which may be supplied with an alternative fuel, normally petrol; the engine operating wholly on one or other fuel according to choice.

5.4 Components for Vapour Phase Fuel Injection

5.4.1 Vaporiser

The fuel is changed to a vapour by the use of water heat and then is transferred under pressure to a distribution valve that feeds the vapour to the injectors. The essential requirements are the same as for a non-fuel injection system. See 5.3.1.

5.4.2 LPG Distribution Valve

The LPG distribution valve should be designed to provide the fuel to the injectors at the right time and quantity and linked into the electronic control system via the Lambda sensor.

The unit should be designed to fail safe in any condition and is triggered electronically.

5.5 Components for Liquid Phase Fuel Injection

5.5.1 Fuel Feed System

The essential difference between the fuel feed system for a liquid fuel injection system and a non-fuel injection engine (carburettor) or a vapour injection engine is the absence of a vaporiser.

5.5.2 Fuel Feed Pump

A pump is required to raise the fuel pressure, which will otherwise be at the vapour pressure of the liquid in the fuel tank, to a sufficiently high pressure to ensure it remains liquid throughout the fuel system allowing for heat gain in the vicinity of the engine when running and to avoid hot restart problems due to heat soak after shut down, or at switch-over, if it is a bi-fuel system.

(a) **Pump external to the fuel tank.** Feed from the bottom of the tank or from the top via a dip tube. In either case the suction line should be generous in diameter and as short as possible to avoid pump damage from cavitation.

(b) **Submerged Pump in the fuel tank.** This avoids the likelihood of cavitation.

5.5.3 Pressure Control

To provide a constant feed pressure to the injectors, a pressure controller is normally provided. This may form part of the engine management system or the conversion equipment.

Section 6. Commissioning, maintenance and inspection

6.1 Installation and Commissioning

6.1.1 General

Installation and commissioning of the fuel supply system should only be carried out and supervised by competent persons adequately trained in LPG automotive installation work and conversant with the properties of LPG.

6.1.2 Leak Test

(a) Except as described in (b) the complete system, including the gas container(s) and all joints, should be leak tested with air or inert gas at a pressure not less than 6 bar gauge, but not more than 90% of the fuel tank design pressure. Soap solution or a proprietary leak detection fluid, or other method of at least equal sensitivity, should be used.

(b) If the gas container(s) and fittings are tested independently of the remainder of the system, and charged with LPG, the remainder of the system should be tested separately as (a) before connection to the container(s) and the final connection(s) then leak tested at the available tank pressure.

6.1.3 Charging the Gas Container and System with LPG.

(*Fuel tanks which are filled without removal from the equipment*)

(a) Subject to the elimination of all leaks as in section 6.1.2, the gas container(s) may be charged with LPG. It is good practice to reduce the oxygen content of the tank(s) to 10% or less by volume before introducing LPG. This can be achieved by introducing an inert gas like nitrogen to dilute the air in the gas container(s) until the required end point is reached. When charging the gas container(s) with LPG, the inert gas/air/LPG vapour, should be vented or discharged in a safe place into the open air, and away from any sources of ignition. This should continue until the inert gas/air has been eliminated.

6.1.4 Testing the Fuel System.

(a) A final leak test should be carried out on any joints not previously tested under LPG pressure, once LPG has been introduced.

Testing of controls under static conditions may be undertaken at this stage.

6.1.5 Test

Following engine tuning, the vehicle should be given a thorough test for satisfactory performance.

6.1.6 Inspection Report

(a) The operations detailed in 6.1.1, 6.1.2 and 6.1.3 above should be carried out under the supervision of a competent person. For the purposes of Inspection Reports the competent person should be a qualified motor technician who has received training on LPG carburation systems and installation requirements and on the characteristics and properties of LPG.

(b) The person nominated in (a) above should also inspect the L.P.G. installation on the equipment to ensure that it conforms to the requirements of this Code and the appropriate Statutory Regulations.

6.2 Maintenance and Inspection

6.2.1 General

6.2.1.1 The Service Manual for LPG fuelled equipment should specify any regular service requirements for the LPG fuel system.

6.2.1.2 Every service should include a check of the condition of all valves and connections for corrosion, damage or leakage, and corrected or replaced as necessary.

6.2.1.3 At five year intervals flexible pipework and half couplings should be replaced.

6.2.2 Fixed Fuel Tank(s)

A suitable inspection scheme should be established before tanks are put into service. As a minimum this should specify that:

(a) Examinations and tests should be carried out by a competent person.

(b) Every five years an external visual examination should be made of the tank(s) and its fittings, for signs of deterioration, corrosion or leakage.

(c) Every 15 years the tank(s) should be subjected to a hydraulic pressure test and marked with the date and the testing authority symbol.

(d) The accuracy of the stop fill valves, should be verified whenever the fuel tank is emptied by using a re-fuelling meter or by cross checking with the contents gauge.

6.2.3 Cylinders

- Cylinders often remain the property of the gas supply company which retains ownership and which is responsible for their maintenance and inspection.

A suitable inspection at time of fill inspection and periodic examination procedure should be established before cylinders are put into service in order to demonstrate how the requirements are met.

- MSA EN 1439: 2008 and MSA EN 1440: 2008 give guidance.

6.3 Garaging, Repair and Maintenance

Equipment fuelled with LPG may be parked, serviced and repaired inside garages provided that the following conditions are observed:

(a) Only trained and competent personnel on the use of LPG as a fuel should be allowed to work on the engine or fuel system.

(b) There should be no leaks in the fuel system and the gas containers should not be filled beyond the 80% maximum level or fixed liquid level gauge.

(c) Such equipment should not be parked within 3m of sources of heat, open flames or other sources of ignition e.g. welding apparatus.

(d) LPG fuelled equipment being repaired in garages, unless the fuel is required for engine operation, should have the gas container(s) shut-off valve closed and the LPG fuel in the service line exhausted by running the engine or, if this is not possible, by disconnecting, in the open air, where the LPG cannot accumulate.

(e) Equipment undergoing repairs involving welding or the application of heat, to any part within 1m of the fuel tank, should have the fuel lines emptied as (d) and the tank removed or shielded from the source of heat. See 6.5.

(f) If the equipment is to be repaired over an open pit, the pit should be adequately ventilated. It is recommended that lighting needs to be safe to use in a zone 2 area and that gas detectors are permanently fitted at the bottom of the pit. These should be checked daily.

(g) Equipment should not be put through a low bake repainting oven or similar heating process unless the entire LPG system is safely removed or rendered gas-free.

6.4 Transfer and Refit of the LPG Fuel System

6.4.1 Whenever this takes place, the completed system should be tested and inspected prior to re-installation and rectification work, as necessary, carried out.

6.4.2 Demounted fuel tanks containing LPG should be handled with care, and stored in accordance with MRA LPG Code of Practice B1.

6.4.3 All non-flexible pipework should be replaced.

6.4.4 All flexible liquid phase hoses over five years old should be changed or retested in accordance with production proof tests in BS 4089:1999 or equivalent.

6.4.5 Consideration should be given to exchanging the relief valve on the fuel tank, whenever it might be refitted to a different vehicle or if vehicle ownership changes, whether or not this coincides with a five or 15 year inspection.

6.5 Hot work

No hot work, e.g. welding, cutting or bending etc. should be carried out on vehicles unless the risk of affecting the LPG tank or system has been eliminated. This may require the removal of the tank or system.

Appendix A. Properties and handling of LPG

A.1 Safe Handling of LPG

The two liquefied petroleum gases which are generally available in Malta are Commercial Butane and Commercial Propane as defined in BS 4250:1997.

Butane is normally supplied in cylinders up to 15 kg capacity and has a much lower vapour (or cylinder) pressure than propane.

The combustion of LPG produces carbon dioxide (CO_2) and water vapour, but sufficient air must be available. Inadequate appliance flueing and / or ventilation, or poor air-gas mixing (for example due to lack of servicing) can result in the production of poisonous carbon monoxide (CO).

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 and will also burn at the interface 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 odorised before distribution by the addition of an odorant, 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 odorant may be detrimental to a process (for example in aerosol applications) the LPG is not odorized.

(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.

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. 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.

Appendix B. Example of a typical inspection certificate

Installer's Letter Heading

Certificate No:____________

1. Equipment Details:

Make and Model____

Year____

Registration/Serial No:____

Owner ____

2. Installed LPG Fuel Tank Details: (if applicable)

Manufacturer____

Serial No:____

Water Capacity____

Test/Retest Date____

3. Valve Details: (installed fuel tanks)

Type No:______________________________

Exchange Date______________________________

This is to certify the LPG system of the above equipment has been installed, examined and tested in accordance with the MRA LPG COP C4 and found to be satisfactory.

Signed______________________________

Name______________________________

Date______________________________

Appendix C: References

STANDARDS

BRITISH STANDARDS

BS 4089:1999	Specification for metallic hose assemblies for liquid petroleum gases and liquefied natural gases
BS 4250:1997	Specification for commercial butane and commercial propane
BS 5045-2: 1989	Transportable gas containers. Specification for steel containers of 0.5 L up to 450 L water capacity with welded seams
BS 6362:1990, ISO 7598:1988:	Specification for stainless steel tubes suitable for screwing in accordance with BS 21 ('Pipe threads for tubes and fittings where pressure-tight joints are made on the threads')
BS ISO 8789:1994	Rubber hoses and hose assemblies for liquefied petroleum gas in motor vehicles. Specification.

MSA EN STANDARDS

MSA EN 549:1995	Specification for rubber materials for seals and diaphragms for gas appliances and gas equipment
MSA EN 751-1:1997	Sealing materials for metallic threaded joints in contact with 1st, 2nd and 3rd family gases and hot water. Anaerobic jointing compounds
MSA EN 751-2:1997	Sealing materials for metallic threaded joints in contact with 1st, 2nd and 3rd family gases and hot water. Non-hardening jointing compounds
MSA EN 1439: 2008	LPG equipment and accessories. Transportable refillable welded and brazed steel Liquefied Petroleum Gas (LPG) cylinders. Periodic Inspection

MSA EN 1440: 2008	LPG equipment and accessories. Periodic inspection of transportable refillable LPG cylinders
MSA EN 1442:2006 +A1: 2008	LPG equipment and accessories. Transportable refillable welded steel cylinders for LPG. Design and construction
MSA EN 12805:2002	Automotive LPG components. Containers
MSA EN 13322-1:2003	Transportable gas cylinders. Refillable welded steel gas cylinders. Design and construction. Carbon steel

DIN STANDARDS

DIN 1787	Copper - Half Finished Products
DIN 17671	Wrought Copper and Copper Alloy Tube Properties

MRA LPG CODES OF PRACTICE

Number	DESCRIPTION
	GROUP A - BULK VESSELS
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
	GROUP B - SMALL CYLINDERS STORAGE AND FILLING
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
	GROUP C - LPG DRIVEN MACHINERY
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
	GROUP D - ANCILLARY EQUIPMENT
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
	GROUP E - LPG CYLINDER USAGE AT DIFFERENT PREMISES
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