MRA LPG

Code of Practice C1:2008
LPG DRIVEN MACHINERY

Autogas Installations

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.

Users of this Code of Practice must give regard to any relevant legislation or authoritative recommendations, especially to those which may have evolved subsequent to the date of publication.

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.

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Foreword

This Code takes due note of progress towards European and International harmonisation, notably:

- European Standard MSA EN 589:2004; "Automotive Fuels - LPG - Requirements and Test Methods";
- European Standard MSA EN 12979:2002: "Automotive LPG systems - Installation Requirements";
- European Standard MSA EN 13856:2002: "Minimum requirements for the content of the user manual for automotive LPG systems"
- Proposal for a draft UN Economic Commission for Europe Regulation: Uniform Provisions for the Approval of specific LPG (Liquefied Petroleum Gases) retrofit systems to be installed in motor vehicles for the use of LPG in their propulsion systems;
- UN Economic Commission for Europe (ECE) Regulation 67.0: Uniform Provisions concerning:

    i) Approval of specific equipment of motor vehicles using liquefied petroleum gases in their propulsion system.

    ii) Approval of a vehicle fitted with specific equipment for the use of liquefied petroleum gases in its propulsion system with regard to the installation of such equipment.

The MRA
Code of Practice C1

Autogas Installations

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Section 1: Introduction, Definitions and References

1.1 Introduction

This code of practice includes guidance on fuel systems for heavy duty engines for goods vehicles, buses and coaches and passenger services vehicles which usually involve conversions from diesel fuel or the use of such engines specifically designed for LPG operation.

Most LPG conversions from petrol retain the petrol fuel system as an alternative.

Diesel conversions require piston or cylinder head modification, to reduce the compression ratio, and the introduction of a spark ignition system. These vehicles run only on LPG as they cannot subsequently run on diesel.

- Certain vehicles may not be suitable for operation on LPG, for example due to valve seat design, complex electronic systems etc. In cases of doubt vehicle manufacturers and conversion equipment manufacturers should be consulted to confirm suitability before work is carried out.

- Other relevant Standards are listed in Appendix B,

- This Code of Practice adopts the recommendations of MSA EN, 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 road going vehicles. 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.

Detailed design of modification of the engine and its management system, and the electronic controls for stoichiometric or lean-burn operation are all state of the art developments subject to continuous development by engine manufacturers and conversion specialists, and are not part of this Code.

The Code does not cover fuel systems for:

- Systems where two fuels are fed to the engine simultaneously (e.g. LPG addition to diesel;

Mechanical handling or maintenance equipment (MRA LPG Code of Practice C4

- Stationary engines (i.e. non-transport applications).

Guidance on garaging, repair and maintenance is given in Appendix D.

1.3 Definitions

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

1.3.1 **Competent Person:** A person who has obtained the approval of the MRA having knowledge, training and ability to carry out work safely and with the necessary proficiency to ensure the subsequent safe operation of the vehicle.

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

1.3.3 **Gas Container:** means a pressure vessel for the storage of LPG to be used as an automotive engine fuel.

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

1.3.5 **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.

1.3.6 **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%).

1.3.7 **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 vehicle operation and safety.

1.3.8 **Lambda (λ):** The ratio of air supplied to an engine to the stoichiometric air required. At stoichiometric $\lambda = 1$; lean burn $\lambda > 1$.

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

1.3.10 **Gas-Tight Housing:** A cover mounted over fuel tank fittings to protect them and to prevent gas leakage entering a vehicle, and to vent to the open air.

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 refuelling facility.

1.3.14 **Excess Flow Valve:** A suitably sized excess flow valve mounted directly to the tank. An excess flow valve in this context means a device which automatically and instantaneously reduces to a minimum the flow of gas through the valve when the flow rate exceeds a set value.

1.3.15 **Vent Tube:** A means to allow any leakage from the gas container valves to be safely led to the outside of the vehicle.

1.3.16 **Carburettor (Mixer):** A gas air mixing device in which the air and gas are metered in the correct proportions for combustion.

1.3.17 **g:** force of gravity

1.3.18 **Gauge Pressure:** Pressure referenced to one atmosphere, and is the pressure actually shown on the dial of a gauge that registers pressure relative to atmospheric pressure.

1.3.19 **Atmospheric Pressure:** The pressure exerted by the weight of the atmosphere

1.3.20 **ppm:** parts per million

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: LPG Fuel Tank or Tanks

2.1 Design

2.1.1 Fuel tanks should be designed and constructed in accordance with ECE 67.01 or be certified in accordance with an equivalent recognised Pressure Vessel Standard by the Malta Standard Authority. A Test Certificate should be supplied with any vessel not stamped in accordance with ECE 67.01.

2.1.2 Fuel tanks should be tested to a pressure of not less than 30 bar gauge.

2.1.3 Fuel tanks, fitted with their pressure relief devices, should meet the 'bonfire test' described in ECE 67.01.

2.1.4 Fuel tanks mounted outside or under vehicles should have an appropriate surface finish to protect them against corrosion and damage.

2.2 Marking

2.2.1 Each fuel tank, other than those stamped in accordance with ECE 67.01, should be conspicuously and permanently marked with its design/test pressure and other data required by the pressure vessel standard.

The information should include at least the following:-

(i) the specification or code to which the fuel tank is manufactured;

(ii) the manufacturer's name or identification mark;

(iii) the fuel tank serial number;

(iv) the marking "LPG";

(v) the water capacity in litres;

(vi) the wording of the form "Maximum degree of filling 80%";

(vii) the test pressure in bar gauge;

(viii) the year and month of manufacture;

(ix) the date of the pressure test, and identification mark of the testing authority. Space should be allowed for subsequent re-tests;

(x) where appropriate, wording of the form "Pump inside".

These marks should be not less than 6 mm in height.

2.2.2 Unless tanks can only be mounted in one position they should be clearly and permanently marked to indicate the correct orientation or

appropriate instructions, and where necessary, a setting device should be available to ensure the correct operation of the safety devices, valves and contents gauge.

2.3 Location of the Fuel Tank(s)

2.3.1 *General*

2.3.1.1 Fuel tanks should be located in a place and in a manner so as to minimise the possibility of collision damage to the fuel tank and its fittings.

- Fuel tanks located toward the rear of a vehicle meet this requirement when protected by substantial bumpers or structure from rear or side impacts.

2.3.1.2 The vehicle manufacturer should, if possible, be consulted to ascertain if there is a recommended position for the fuel tank in or on the vehicle.

2.3.2 *Fuel tanks within a vehicle*

Fuel tanks within a vehicle should either:

(a) Have their valves, fittings and extensions to the outside enclosed in a gas tight housing attached to the tank. This housing should be vapour-tight to the interior of the vehicle, and vented to the outside of the vehicle, e.g. by a vent tube.

The vent system should have a free ventilation cross-sectional area of not less than 450 mm². Vent tubes should, wherever practicable, fall throughout their length.

- Care should be taken to ensure that feed pipes, wiring etc routed through vent systems do not reduce their free ventilation area below that required (e.g. typical 26 mm vent tubing has an area of 531mm², running a coated 10mm copper fuel pipe (area 95mm²) through this reduces the effective area to below that permitted.

Vent openings should be:

(i) direct to the outside air;

(ii) no closer than 100 mm from the engine exhaust system or other heat source, and not directed towards them;

(iii) protected by position or other means from blockage.

Or;

(b) Be located in a dedicated vehicle compartment which is effectively sealed from

the remainder of the vehicle and ventilated to the outside. The ventilation should be by permanent openings not less than 2 000 mm² in total area.
Openings should be:

(i) direct to the outside air from the lowest practicable position within the compartment;

(ii) no closer than 100 mm to the engine exhaust system;

(iii) protected by position or other means from blockage both from within the compartment and without.

2.3.3 *Fuel tanks beneath a vehicle*

Fuel tanks, valves and fittings may be located beneath a vehicle in a suitable protected position.

The fuel tank should be installed so that its lowest point is no lower than the original load bearing points of the vehicle which are part of the vehicle structure and so that the original approach, departure and ramp angles (typically 25°, 20° and 20°) and ground clearances are maintained.

- MSA EN 12979:2002 gives further guidance.

Fuel tank(s) mounted underneath vehicles should be situated to ensure effective ground clearance. In particular:

(i) the fuel tank, its fittings and any adjacent pipes be located so as to minimise the possibility of damage due to contact with the road or obstructions on the road;

(ii) the effective ground clearances recommended by the vehicle manufacturer should be maintained. Where these cannot be determined then (iii) below should be met. The clearance should be measured to the bottom of the fuel tank or to the lowest fitting, support or attachment of the fuel tank if this is less;

(iii) fuel tanks should be installed with as much effective road clearance as is practicable which should never be less than 200 mm unless otherwise the tank is protected to prevent contact with the road or obstructions on the road.

In assessing effective road clearance consideration reference is to be made to MSA EN 12979: 2002. should be given to.

2.3.4 *Fuel tanks mounted on rooftops*

Fuel tanks may be mounted on the rooftops of vehicles, subject to the following:

(i) the vehicle manufacturer confirms that the location will not affect the ability of the vehicle to meet statutory requirements.

(ii) crash-bars and/or roll-over protection are provided where necessary, taking into account the type of vehicle and its duty. See also 2.4.3;

(iii) tank valves, fittings and extended pipework are housed in a gas-tight housing as described in 2.3.2 (a) unless a suitable protected roof compartment as described in 2.3.2 (b) is provided;

(iv) the ventilation from the gas-tight housing or compartment takes account of the heavier than air density of LPG vapour, and ensures no discharge can enter the interior of the vehicle.

2.4 Fuel Tank Mounting

2.4.1 Means should be provided for attaching the fuel tank(s) securely to the vehicle. This provision may take the form of fixed lugs welded to the fuel tank during manufacture or the provision of cradles, metal straps, or bonds attached to the vehicle. In order to prevent distortion of the fixing area or the tank(s) breaking loose in the event of impact, reinforcement of floors, body panels etc should be provided by suitable means which are designed to equally distribute the weight of the tank and its contents.

Mountings should be designed to meet the requirements of ECE 67.01.

- For example, for cars and light goods vehicles the tank must be securely mounted to withstand acceleration of 20 g in the direction of travel and 8 g horizontally and at right angles to the direction of travel. MSA EN 12979:2002 gives further guidance.

Straps, bolts and spreader plates should be designed bearing in mind the material, profile and thickness of the mounting panel to ensure an adequate contact area.

Straps should be of corrosion protected steel having a minimum tensile strength of grade E 235-B to ISO 630. Bolts and spreader plates should be of appropriate corrosion resistant materials or subsequently protected against corrosion.

➢ MSA EN 12979:2002 gives further guidance.

2.4.2 Fuel tank(s) should be mounted in a level position in accordance with the orientation marks or suppliers instructions.

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

The fuel tank shell, fittings and pipework should not be outside the plan area of the vehicle viewed from above. Where this cannot be met collision bars or other suitable protection should be provided.

2.5 Multi-tank Installations

A means to prevent the flow of liquid from one tank to any other, e.g. a non return valve, must be fitted into both the filling and fuel supply lines.

Section 3: Fuel Tank Fittings and Connections

3.1 General

3.1.1 Fittings and components subject to tank pressure should be suitable for contact with vapour and liquid phase LPG and designed for a pressure not less than 30 bar.

3.1.2 Fittings should be those recommended by the fuel tank supplier/manufacturer.

3.1.3 Connections and fittings should, by position or other means, be protected against physical damage, weather and tampering where possible. Any manually operated valves should be readily accessible.

3.1.4 Particular care should be observed when selecting equipment for use outside or under vehicles.

3.2 Connections

3.2.1 Connections to fuel tanks 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, to prevent escape of product in the event of damage to the connections.

3.2.2 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 3.3.2.

3.3 Fittings

3.3.1 *General*

Fittings may be separately mounted on the fuel tank 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.

Fittings should meet the requirements of ECE Regulation 67.01 or be certified in accordance with an equivalent standard by the Malta Standards Authority.

3.3.2 *Tank Fill Valves and Fill Connector*

The fill valve on the tank(s) should incorporate:

- a double check valve to prevent reverse flow;
    - An automatic stop fill shut-off device designed to limit the maximum quantity of LPG to 80% of each tank capacity.

Where tanks are located inside a vehicle an extended fill line to the outside of the vehicle should be provided terminating with a further check-valve and refilling connection. This should be protected to prevent ingress of road dirt.

The fill connector should be located so as to be readily accessible for the user.

- Petrol fillers are often positioned approximately 800 mm above the ground. Fillers mounted at a height of less than 500 mm above the ground are likely to prove awkward to use.

It should not be necessary to keep any passenger door, bonnet or load compartment door open during the filling process.

No gas should enter the vehicle during filling or on connection or disconnection of the filling gun. A gas tight sealing "boot" should be fitted to the part of the filler assembly inside the vehicle unless other effective means of ensuring a seal during service are provided.

The fill connector should not be fitted within 250 mm of any exhaust outlet.

The fill connector should be mounted securely and be able to withstand the forces applied during filling and in the event of unintended drive-away with the filling hose still connected (~500 N).

Pending the adoption of the common European filling system, the "Bayonet" fitting (see fig. 1) should be used for cars and light commercial vehicles. This should be fitted with the axis of the fitting horizontal and with the bayonet pins horizontal. (3 o'clock and 9 o'clock).

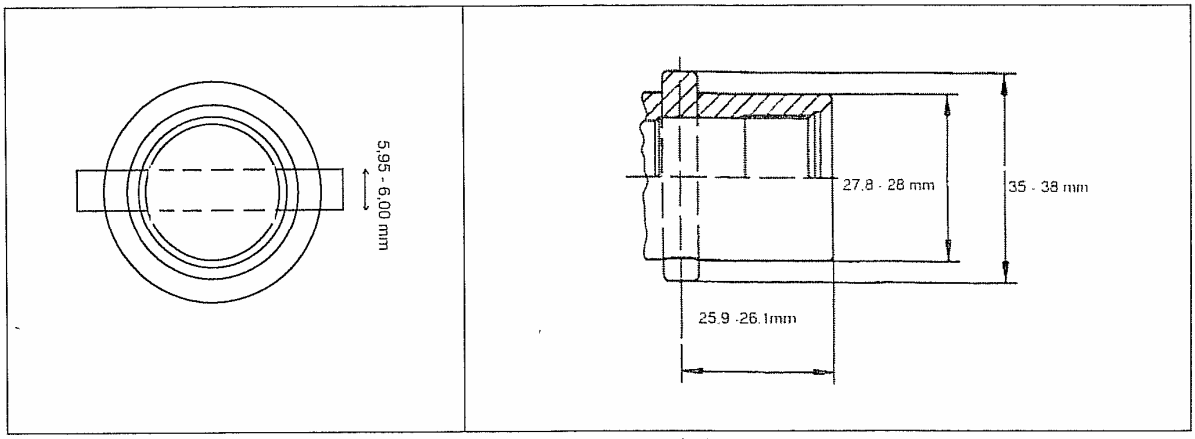

Figure 1 : "Bayonet" Fitting

Vehicle filling connections that require the use of adaptors, for filling with "Bayonet" filling guns, should not be fitted.

3.3.3 *Fuel Feed Valves*

The fuel feed outlet from each tank should be fitted with:-

(a) A suitably sized excess flow valve mounted directly to the tank;

(b) An electrically controlled solenoid valve which closes on de-energising and closes automatically when the ignition control is in the off position and also whenever the engine is not running. If it is not practical for the valve to be fitted directly to the tank, it should be fitted as close as practical to the tank and a manually operated shut-off valve should be fitted directly to the fuel tank;

(c) A device to relieve thermal over pressure in the fuel feed pipework due to lock-up when the solenoid valve is closed. For single tank installations the solenoid valve may be designed to permit reverse flow back to the fuel tank. If the valve does not permit this, or if a manual valve is fitted at the tank outlet and where the volume of gas which is locked up exceeds 200 ml, a hydrostatic relief valve should be incorporated, which may relieve back to the tank. See 4.6.

For inter-connected multi-tanks, solenoid valves which permit reverse flow are not suitable unless other means are provided to ensure that overfilling of any tank from the others is prevented. See 3.4.

3.3.4 *Safety Relief Valve*

(a) Each fuel tank should be fitted with a spring loaded safety relief valve mounted directly in the vapour space of the tank.

(b) Safety relief valves should be designed to start discharge and attain full flow at pressures in accordance with the design code of the fuel tank to which they are fitted with full allowance for the effect of extended discharge pipework.

- Reference should be made to ECE 67.01.

(c) The discharge from safety relief valves must be vented to the outside of the vehicle and as far as practicable from possible sources of ignition and should, in any case, be no closer than 100 mm from the exhaust system. The outlet should be positioned in such a manner as to prevent impingement of escaping gas on any fuel tanks.

In the case of externally mounted tanks the captive raincap or other captive protector should be used to keep water and dirt from collecting in the relief valve or vent pipe. This should not prevent free discharge when venting.

(d) Piping or ductwork used to convey the escaping gas from the safety relief valve should be of a material suitable for use with LPG, and should not reduce its maximum flow to less than that required by 3.3.4 (b).

Elbows and bends can have a severe effect on flow.

Discharge lines should be able to withstand the pressure resulting from the discharge of vapour when the safety relief valve is in the fully open position.

They should be of sufficient mechanical strength and adequately protected against physical damage or leaks.

Piping or duct work for relief valve discharge should be mechanically secured by metallic devices, e.g. worm drive clips, and should not rely on adhesives etc. for retention to enclosures or spigots.

3.3.5 *Contents Gauge*

A contents gauge should be fitted.

- Direct reading magnetic type float gauges are generally employed.

Contents gauges should clearly indicate "FULL" at 80% of the water capacity of the tank. The sensing device of any indicator operated by an electrical system that may be exposed to LPG vapour should be of an approved construction for use in flammable atmospheres.

All contents gauges materials should be suitable for the application. Those mounted under vehicles should not be manufactured from aluminium or other materials susceptible to salt spray.

All wiring connections within the tank valve box should be adequately fixed and protected.

A remote reading fuel gauge should be provided where it may be readily seen by the driver.

3.4 Multiple Tanks

A single refuelling connection may be employed for multiple tanks. Where the fuel feed outlets are manifolded to a single feed pipe to the engine, appropriate check valves should be fitted at each tank connection to prevent inadvertent flow between tanks.

➢ MSA EN 12979:2002 gives further guidance.

Section 4: Pipework

4.1 LPG Pipelines

4.1.1 *General*

Pipelines or pipework for automotive applications are classified as "high pressure pipelines" if either are carrying LPG in the liquid phase, or carrying vapour in excess of 4,5 bar gauge. In either case, the pipelines and their assemblies should be resistant to liquid phase LPG. Pipelines carrying vapour up to 4,5 bar gauge are classified as "low pressure pipelines".

4.1.2 *High pressure pipelines*

High pressure pipelines should be of:

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

(b) Rubber or plastic sheathed Copper or copper alloy to DIN 1787 or DIN 17671 or equivalent, having a wall thickness of at least 0,8 mm or;

(c) Flexible tubing, fabric or metallic reinforced synthetic rubber or polymer hose designed for a service pressure of not less than 30 bar gauge with a burst pressure not less than 125 bar gauge and to meet the criteria of ECE 67.01.

Flexible fabric or metallic reinforced synthetic rubber hose should only be used to connect the fuel tank to the fill connector.

Engine compartment hoses should be suitable for an ambient temperature of 120℃ and need to be specifically specified as required by ISO 8789. A lower temperature may be acceptable if approved by the vehicle manufacturer.

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

4.1.3 *Low pressure pipelines*

Low pressure pipelines 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 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 pipelines (hoses) should be suitable for an ambient temperature of 120℃. A lower temperature may be acceptable if approved by the vehicle manufacturer.

4.2 Joints and Connections

4.2.1 Every joint or connecting 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 non-metallic seals within the fitting, complying with MSA EN 549:1995. Jointing compound for screw threads should be suitable for use with LPG and comply with MSA EN 751:1997.

4.2.2 The number of joints and connections should be no more than necessary 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 4.1.2 and 4.1.3 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 Pipelines

4.3.1 The internal diameter of LPG liquid pipelines linking the fuel tanks and the engine should be as small as possible to avoid undue rigidity and sufficiently large to provide for maximum engine fuel demand. The outside diameter should never exceed 12 mm.

4.3.2 To avoid undue pressure losses during filling the internal diameter of LPG filler pipelines and connections should be as large as practicable, but not exceed 20 mm.

4.4 Pipeline Location

4.4.1 Every pipeline feeding from or into the fuel tank should follow the safest route and be protected from impact. It should not be routed through any passenger compartment. It should be below the body shell where it may be shielded by structural members of the vehicle wherever possible.

4.4.2 Pipelines should be no closer than 100 mm remote from the vehicle exhaust system. Where this is not practicable, the pipeline must be shielded from the vehicle exhaust system by a suitable heat shield so as to ensure that the pipeline is not subjected to a temperature above 120℃.

4.4.3 Pipelines should be effectively secured to the chassis frame or body shell using purpose designed pipe clips at intervals of not exceeding

600 mm and in such a manner to be protected against excessive strain and vibration.

Plastic strapping, tie wrap etc is not suitable

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

4.4.5 The positioning of pipelines should be such that they are not affected by chassis, panel, suspension or propshaft movement. Pipelines should not be located at jacking points.

4.5 Flexibility

To avoid chaffing and damage pipelines should be installed so as to take up safely the relative movement between the chassis/body and the fuel system components and secured in such a manner so as to prevent wear taking place. Particular care should be taken when using non-metallic pipelines.

4.6 Pipeline Over Pressure Protection

4.6.1 Every section of LPG liquid pipeline between positive shut-off or lock-off valves should be protected against resultant damage from over pressure due to liquid thermal expansion (see also 3.3.3(c)).

4.6.2 Any hydrostatic relief valves should be vented to open air, away from the vehicle exhaust or people.

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 electronic or fuel system is installed neither should impair the safety or efficiency of the other.

"VRT" exhaust emissions checks should be carried out at "idle" or "fast idle" (~2 500 RPM) before work commences on a vehicle to ensure that it is fit to convert. After conversion similar emissions checks should be carried out to ensure that, within the limits of the measuring method (typically ± 10 ppm for HC) emissions on the original fuel have not deteriorated and that emissions on LPG are less than those on the original fuel

Attention is drawn to the requirements for electromagnetic compatibility of electrical components fitted to vehicles – see the Motor Vehicles (EC Type Approval) Regulations.

5.2 Components for all Engines

5.2.1 *General*

All components should comply with ECE 67.01 or equivalent

5.2.2 *Installation*

The LPG control equipment should be:-

- installed in positions that are easily accessible for routine inspection, maintenance and adjustment;
- securely mounted and reasonably protected by location from accidental damage;
- located in a position where it is not vulnerable to accidental damage;
- as remote as possible from the engine exhaust system or protected from it by a heat shield;
- no closer to any electrical equipment capable of sparking than is avoidable.

5.2.3 *Filter*

Filters should be fitted to systems or devices in which components are susceptible to malfunction or damage from solid particulate matter.

5.2.4 Lock-off (shut off) valve

In addition to the fuel feed valve(s) (see 3.3.3) a lock-off valve should be installed immediately upstream of any pressure reducing regulators and or, for liquid injection systems, any fuel rail distributing fuel to the injectors and after any filter.

- The lock off valve may be incorporated in the pressure reducing regulator or fuel rail assembly.

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

The lock-off valve should be capable of automatically opening to relieve excess hydrostatic pressure generated on the engine side of the valve.

5.2.5 *Automatic Safety Controls*

Safety control systems should be initiated by at least two means, either of which should cut off the LPG supply to the engine, and at least one of which should operate if the engine stops for any reason.

Various methods may be adopted to meet these requirements. For example:

- a pressure regulator designed to give total closure on zero engine manifold depression;
- a manifold pressure sensitive switch, normally open at zero depression, connected in series with the electric supply to the lock-off valve;
- an oil pressure sensitive switch open for zero oil pressure, connected in series with the electric supply to the lock-off valve;
- an ignition coil triggered switch in the electric supply to the lock-off valve which is open when the coil is de-energised.

Electrical switches controlling the lock-off valve should be connected in series with the electrical supply to the solenoid shut-off valves at the fuel tank(s) required by 3.3.2(b) to provide simultaneous shut-off.

Any electrical switch or mechanical means used to bypass such a device to facilitate engine starting or tuning should require continuous manual pressure to operate and should automatically return to the off position.

Additional safety controls in the fuel system may be incorporated, e.g. inertia cut-off, tilt switches. See Section 6.

5.3 Components for Non-fuel Injection Engines

Vaporisers and pressure regulators may be incorporated into single units.

5.3.1 *Vaporisers*

Vaporisers normally utilise heat from the engine coolant system to turn the liquid LPG into vapour.

Where water circulation is employed a continuous flow of water should be ensured which is not subject to interruption by operation of the vehicle heater controls.

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.

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 may have several 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 upstream regulator should reduce the pressure to a value appropriate to the downstream regulator inlet pressure.

(c) The final 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 Mixers*

The carburettor or mixer 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.

5.4 Components for Vapour Phase Fuel Injection

5.4.1 *Vaporisers*

Vaporisers normally utilise heat from the engine coolant system to turn the liquid LPG into vapour.

Where water circulation is employed a continuous flow of water should be ensured which is not subject to interruption by operation of the vehicle heater controls.

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.

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.

5.4.2 *Distributor*

The distributor should be designed to provide the fuel to the injectors at the right time and quantity under the control of an electronic system via the Lambda sensor.

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 needs to be fitted 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 to any alternative fuel.

5.5.3 *Pressure Control*

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

5.6 Wiring

Terminations should be soldered and insulated.

Earth terminations should not be made within any gas tight housing, or adjacent to vent outlets.

All wiring should be appropriately loomed, clipped or tied back neatly, and protected from chaffing.

Wiring beneath the vehicle should be protected from impact damage.

- MSA EN 12979:2002 gives further guidance.

Section 6: Requirements for M2 and M3 vehicles

6.1 Regulations

6.1.1 Vehicles for transport of passengers, M2 and M3, are required to undergo a vehicle roadworthiness test (Motor vehicle Roadworthiness Test Regulations ; {LN 126 of 1999} as subsequently amended) before entry into service or following any modifications.

6.2 Fuel Tanks

The LPG fuel tanks, pipework arrangements, associated fittings and valves should be located to comply with 2.3 and the following special requirements.

6.2.1 Fuel tanks should not be situated within 600 mm of the entrance/exit on a vehicle having between 10 to 18 passenger seats.

6.2.2 Fuel tanks may be externally mounted or may be within the passenger compartment only if suitably enclosed and protected as 2.3.2(b)

6.2.3 Fuel tanks mounted beneath a vehicle should:

a) preferably be at least 500 mm inboard of the sides of the vehicle or on the inside of the chassis longitudinal frame members where applicable. If this location is not technically possible, it is permissible to locate LPG fuel tanks outboard of this, but within the width of the vehicle, in which case, suitable caging or structural fixtures should be provided to protect them and their associated fittings from severe side impacts.

b) have adequate ground clearance in line with the vehicle manufacturer's recommendations for laden and unladen use. See 2.3.3.

6.2.4 Fuel tanks for vehicles over 5 tonnes Gross Vehicle Weight should be situated between the front and rear axles.

6.2.5 Fuel tanks should be situated as far as practicable from the exhaust system; if the clearance is less than 250 mm, adequate shielding against heat radiation should be provided.

6.2.6 Roof-mounted fuel tanks should comply with 2.3.4. Vehicles need to be assessed for stability following conversion and conversion needs to endorsed by vehicle manufacturer or his representatives.

6.3 Tilt/Inertia Cut-off Switches

6.3.1 A vehicle tilt switch and an inertia switch are required both of which should cause the electric solenoid valves at the outlet of each tank to close (see 3.3.2).

6.3.2 The tilt-switch should cause the fuel tank valves to close when the vehicle body angle of tilt to the vertical is greater than 35° for single deck vehicles, or 28° for double deck vehicles.

6.3.3 The inertia switch should cause the fuel tank valves to close in the event of deceleration of the vehicle exceeding 5 g. The valves should remain closed after actuation until the inertia switch is manually reset.

6.4 Fuel Tank Fill Connection

6.4.1 The filling point should be accessible only from the outside of the vehicle

6.4.2 For vehicles with less than 12 passenger seats, the filling point should not be at the rear of the vehicle

6.4.3 The fuel tank fill connection should not be within 300 mm of any door or other aperture into the vehicle interior

6.4.4 The fuel tank fill connection should not be located within 500 mm of the exhaust outlet.

6.5 Pressure (Safety) Relief Valve (PRV) Discharge

The discharge should be directed downwards so as not to impinge on any part of the vehicle and should be arranged as far as practicable so as to be clear at all times of the vehicle flooring, tyres, wheel arches, fuel tanks, manifolds and exhaust systems.

6.6 LPG Fuel System Relative to Vehicle Interior Apertures

6.6.1 The design, location and installation of the LPG fuel system should be arranged so that no leakage from the LPG fuel system should enter the vehicle interior.

6.6.2 The PRV discharge should be directed as far away as is necessary from all openings and apertures into the vehicle to avoid leakage into the vehicle interior and so as not to interfere with people exiting from the vehicle in an emergency when the PRV may be venting and so that no fuel overflowing or leaking can accumulate on any woodwork or other part of the body such that it might be readily ignited

6.7 Fuel Feed Pipe

The LPG feed pipework should comply with 4.1 and should not pass through the passenger or driver compartments.

6.8 Manual External Fuel Cut-off [Applies to buses having 10 to 18 passenger seats]

6.8.1 A device should be provided, by means of which the supply of fuel to the engine can be readily cut off. The means of cut off should at all times be readily accessible from outside the vehicle and should be operated by hand. The location of the means of cut off should be

clearly marked on the outside of the vehicle, and indication of the function and means of operation of the cut off should be provided nearby. The "off" position should be clearly indicated

6.8.2 The fuel cut-off may be provided by any combination of the following:

(a) A manual device, accessible from outside the vehicle, which directly or indirectly closes a valve in the LPG supply and simultaneously for vehicles that can operate on petrol or LPG, cuts off the petrol feed.

(b) Closing of the externally operated isolation switch which in turn, results in the closure of the valves in (a) above;

(c) Closing of an LPG fuel pipe manual valve located near to and upstream of the vaporiser.

6.9 Fuel Gauges

A remote fuel gauge should be provided where it may be readily seen by the driver. For multiple tanks one gauge for each tank is recommended. Gauge(s) should read "FULL" at 80% of the water capacity of the tank.

Section 7: Commissioning, Final Certificate and Documentation

7.1 Commissioning

7.1.1 *Initial Leak Test*

LPG has a low viscosity. This means great care must be taken in making joints to avoid leaks.

After initial assembly and the introduction of LPG vapour or a minimum quantity of liquid, the complete system, including the tank(s) and all joints, should be leak tested with LPG at a pressure not less than 6 bar gauge. A proprietary leak detection fluid, or other method of at least equal sensitivity, should be used.

7.1.2 *Final Leak Test*

Final leak test should be carried out on all joints following the road test.

7.1.3 *Road Test*

Following engine tuning, the vehicle should be given a thorough road test for satisfactory performance. Vehicles which can run on more than one fuel should be subjected to fuel change over tests to ensure smooth transition.

7.2 Final Certificate and Documentation

(a) A competent person responsible for ensuring compliance with the Code of Practice and relevant Statutory Regulations should, upon satisfactory completion of all tuning and tests, issue a signed Certificate of Conformity for the purchaser with a recommendation that this is carried in the vehicle at all times, for examination by authorised enforcement agencies. The Certificate of Conformity should:

- identify the company carrying out the work;
- identify the vehicle on which the work has been done;
- include the statement "This is to certify the LPG system of the above vehicle has been installed, examined and tested in accordance with the MRA LPG Code of Practice C1 and found to be satisfactory".

The Certificate of Conformity may be incorporated in the Drivers Operating Manual (7 .2(b))

(b) The vehicle owner should be provided with a Drivers Operation Manual which may include the Certificate of Conformity with a recommendation that this is carried in the vehicle at all times, for examination by authorised enforcement agencies. Appendix C describes the information which should be provided.

(c) The vehicle owner should be informed that:

- No person may, without the prior written approval of the ADT, make any mechanical alteration to the chassis or

engine of any motor vehicle, as per regulation 91 (1) (a) of the Motor Vehicles Regulations.

- The vehicle's insurers should be advised.

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 ($C0_2$) 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 odorised before distribution by the additional 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 odorised.

(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 bums 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 ℃	0,57 to 0,58	0,50 to 0,51
Imperial gallons/ton at 15 ℃	385 to 393	439 to 448
Litre/tonne at 15 ℃	1 723 to 1 760	1 965 to 2 019
Relative density of gas compared with air at 15 ℃ 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 ℃ and 1 013,25 mbar g	406 to 431	537 to 543
Volume of gas (ft^3) per lb of liquid at 60 ℉ and 30 in Hg	6,5 to 6,9	8,5 to 8,7
Boiling point at atmospheric pressure ℃ approx.	-2	-45
Vapour pressure for products at their maximum specified vapour pressure (gauge)		
Temp. ℃	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℃	372,2	358,2
Latent heat of vaporisation (Btu/lb) at 60 ℉	160	154
Specific heat of liquid at 15℃ (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:		
Gross		
(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
Nett	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 524 mbar g.

Appendix B: References and Bibliography

British Standards

BS 4250:1997	Specification for commercial butane and commercial propane
BS 5430-6:1994	Periodic inspection, testing and maintenance of transportable gas containers (excluding dissolved acetylene containers). Specification for seamless steel and aluminium alloy containers having a water capacity of less than 0.5 litre
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.
MSA EN 549:1995	Specification for Rubber Materials for Seals and Diaphragms for Gas Appliances and Gas Equipment.
MSA EN 589:2004	Automotive Fuels – LPG – Requirements and Test Methods.
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 751-3 1997	Sealing materials for metallic threaded joints in contact with 1st, 2nd and 3rd family gases and hot water. Unsintered PTFE tapes
MSA EN 12979:2002	Automotive LPG Systems - Installation Requirements
MSA EN 589	Automotive fuels – LPG – Requirements and test methods
MSA EN 13856:2002	Minimum Requirements for the content of the user manual for automotive LPG systems
DIN 1787	Copper - Half Finished Products.
DIN 17671	Wrought Copper and Copper Alloy Tube Properties.

ISO 8789	Rubber Hoses and Hose Assemblies for Liquefied Petroleum Gas in Motor Vehicles. Specification.
ISO 630	Structura1 steels - Plates, wide flats, bars, sections and profiles.

Statutory Instruments

Motor Vehicles Regulations (LN128 of 1994 as subsequently amended)

Motor Vehicle Roadworthiness Test Regulations (LN 126 of 1999 as subsequently amended)

Scheduled and Unscheduled Public Transport Services Regulations (LN242 of 1997 as subsequently amended)

ECE Regulation 67.01

ECE Regulation 10

EU Directive 72/245

Appendix C: Drivers Operation Manual

C.1 Technical Specifications

The manual should contain at least the following information:

a) description of the system ;

b) a list of components and their alternatives of the LPG system containing their identification number, their manufacturer code and a type approval number, if applicable

c) Installation instructions for vehicles of the same type

d) Detailed drawings or photographs indicating the exact position of each component of the LPG system;

e) Detailed drawings or photograph of the installation of the container in the vehicle;

f) Assembly instructions for the components

g) Detailed wiring diagram of the electrical system indicating the connections to components;

h) limits imposed by ambient influences, e.g. fuel mix;

i) instructions for the start-up operations which shall be performed by the installer;

j) a detailed description of the diagnostic system, if fitted, including the corrective actions to be taken in case of malfunctioning.

C.2 Safety Instructions

The manual should give:

a) instructions for safe use of the system;

b) a warning of possible dangers due to misuse or when the manual or procedures are not observed;

c) actions to be taken when the user detects a gas smell or gas leakage;

d) any adverse effects due to temperature or humidity (e.g. if there is a risk of starting problems due to vaporisation in liquid feed pipes when the vehicle is parked during very hot weather);

e) any statutory restrictions on the use of the vehicle (e.g. parking, maintenance, re-qualification);

f) detailed procedure and actions taken by the installer to check that the system has been properly assembled and installed.

C.3 LPG System Description

C.3.1 *Filling of the LPG system*

The manual should indicate the sequence of operations needed to fill the LPG tank.

Particular attention should be paid to the maximum filling level of 80% of the total volume of the tank installed in the vehicle.

The manual should indicate that in case of a malfunction of the automatic 80% filling system the user should stop filling manually at the 80% value that can be indicated by the LPG system installer when the total tank volume is known.

C.3.2 *Switchover Procedure*

The manual should clearly describe the method of switching over from one fuel to the other by giving the sequence of operations.

C..3.3 Opening/Closing of manual valves

The manual should indicate the proper procedure to operate any manual valves. This is particularly important when maintenance of the LPG system has to take place.

C.3.4 Level Indicator

The manual should state the location of the level indicator, for example at the dashboard or at the tank. The read-out should be explained, giving particular attention to the 80% filling level.

C.4 Maintenance

If maintenance, for example draining of vaporisers, is required, the manual should state the frequency and type of maintenance to be carried out. The manual should indicate who is recommended to carry out such work.

Any recommended inspection, re-qualification or replacement dates for LPG tanks, hoses or components should be stated.

Guidance should be given that vehicles should not be put through a low bake repainting oven or similar heating process unless the temperature is controlled to less than 40 ℃.

C.5 Defects and Repair

The manual should indicate what to do in the case of a defect and of repair of faulty components in the LPG system.

When the LPG system is equipped with a diagnosis system the manual should describe this system and indicate what actions need to be taken.

C.6 Scrapping

The manual should indicate that:

- LPG fuel tanks should be removed from a vehicle before the vehicle is sent to be scrapped;

- Tanks should be handled with care and stored in accordance with MRA LPG Code of Practice B1 "Storage of Full and Empty LPG Cylinders and Cartridges";

- Tanks to be scrapped should be destroyed in accordance with BS 5430-6:1994 or equivalent by, or under the supervision of, a competent person and in a manner rendering them unserviceable for holding gas.

Appendix D: Garaging, Repair and Maintenance

Vehicles 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 road vehicle fuel should be allowed to work on the vehicle engine or fuel system;

b) There should be no leaks in the fuel system and the fuel tanks should not be filled beyond the 80% maximum level;

c) Such vehicles should not be parked within 3m of sources of heat, open flames or other sources of ignition;

d) LPG fuelled vehicles being repaired in garages, unless the fuel is required for engine operation, should have the fuel tank(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) Vehicles 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;

f) If the vehicle is to be repaired over an open pit, the pit should be adequately ventilated. Lighting needs to be safe for use in a zone 2 area. Gas detectors should be permanently fitted at the bottom of the pit. These should be checked daily;

g) Vehicles should not be put through a low bake repainting oven or similar heating process unless the temperature is controlled to less than 40 ℃.

LPG fuel tanks should be removed from a vehicle before the vehicle is sent to be scrapped. Tanks should be handled with care and stored in accordance with MRA LPG Code of Practice B1 - "Storage of Full and Empty LPG Cylinders and Cartridges". Tanks to be scrapped should be destroyed in accordance with BS 5430-6:1994 or equivalent by, or under the supervision of, a competent person and in a manner rendering them unserviceable for holding gas.

Appendix E: International classification of vehicle categories

Category M:	Motor vehicles with at least four wheels used for the carriage of passengers;
Category M1:	Vehicles used for the carriage of passengers and comprising no more than eight seats in addition to the driver's seat;
Category M2:	Vehicles used for the carriage of persons, comprising more than eight seats in addition to the driver's seat and having a maximum mass exceeding 5 tonnes;
Category M3:	Vehicles used for the carriage of passengers, comprising more than eight seats in addition to the driver's seat and having a maximum mass exceeding 5 tons;
Category N:	Motor vehicles with at least four wheels used for the carriage of goods;
Category N1:	Vehicles used for the carriage of goods and having a maximum mass not exceeding 3.5 tonnes;
Category N2:	Vehicles used for the carriage of goods and having a maximum mass exceeding 3.5 tonnes but not exceeding 12 tons;
Category N3:	Vehicles used for the carriage of goods and having a maximum mass exceeding 12tons

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