National Standard

for

Commercial Vessels

PART C

DESIGN AND CONSTRUCTION

SECTION 5

ENGINEERING

SUBSECTION 5D

LPG SYSTEMS FOR ENGINES

Edition 1.1

First Published — August 2002 (on CD)

Second Publication — April 2005 (on CD)

Draft for public comment issued — 22 December 2000
Endorsed by the Australian Transport Council — July 2002

This compilation was prepared by the Australian Maritime Safety Authority on 16 June 2016 taking into account Amendment No.1, 2016 that was approved by the National Marine Safety Regulator on 7 June 2016 to commence on 10 June 2016.

FOREWORD

This Subsection of the National Standard for Commercial Vessels (NSCV), which covers the installation and operation of LPG systems as a power source for vessels, is an entirely new area for standards for commercial vessels. The use of LPG to fuel vessels has only recently been considered as an option for vessel owners. There is no standard currently available for the use of LPG as propulsion fuel in commercial vessels.

In preparing this Subsection of the NSCV, consideration was given to a number of factors, including:

a) Relevant national, land-based transport standards.

b) Relevant international standards.

c) Current operational practice.

d) Approvals currently conducted on a case-by-case basis.

e) Potential application of different standards by each marine authority.

f) Potential for unsafe installation due to misinterpretation of standards and lack of expertise in their application.

g) Fuel and administration costs for vessel owners.

h) Administration costs for marine authorities.

i) Environmental benefits.

This Part of the National Standard for Commercial Vessels is intended to be read in conjunction with Part B—General Requirements.

This Subsection of the NSCV was drafted by the NMSC Secretariat in consultation with an industry reference group and a working group comprising representatives from the various State and Territory marine authorities, and the Australian Maritime Safety Authority (AMSA).

The draft was developed over a 4-year period to ensure that the requirements were appropriate to the marine environment and safe operation of vessels. The draft Subsection was released for public comment on 22 December 2000, along with a draft Regulatory Impact Statement (RIS). Public comments were received until the end of April 2001. A reference group comprising industry and government met in May 2001 to review the public comment and provide recommendations to the NMSC. The NMSC accepted the recommendations of the reference group on 30 May 2001 and the draft Subsection and RIS were revised accordingly.

The Office of Regulation Review provided an assessment of the final RIS in February 2002. NMSC approved this version of the Subsection February 2002, with the Australian Transport Council (ATC) endorsing the document for publication in July 2002.

This standard was first published in August 2002 on CD, and again in April 2005 on CD. There were no amendments between the first and second publication.

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CHAPTER 1 PRELIMINARY

1.1 SCOPE

This Subsection of the NSCV specifies requirements for the design, manufacture, installation and operation of liquid withdrawal systems on commercial vessels for main and auxiliary internal combustion engines using liquefied petroleum gas (LPG) as the source of fuel.
It does not apply to LPG systems for appliances (vapour withdrawal) or to systems employing fuel substitution.

NOTES:

1. Part C Subsection 5A (Machinery) of the NSCV limits the use of fuel with a flashpoint less than 60°C to the following applications:
   a) Outboard engines in Class C, D and E vessels.
   b) Inboard engines in Class 2C, 2D, 2E, 3C, 3D and 3E vessels, provided such engines are not located below decks.
2. Part C Subsection 5C (LPG Systems for Appliances) of the NSCV specifies requirements for systems for appliances using LPG as the source of fuel.
3. State and Territory marine and energy supply authorities may specify additional requirements relating to the LPG systems covered by this Subsection of the NSCV.

This Subsection of the NSCV shall be read in conjunction with Part B—General Requirements of the NSCV.

1.2 OBJECTIVE

The objective of this Subsection of the NSCV is to protect against hazards arising from a liquefied petroleum gas (LPG) installation used with reasonable care and under normal conditions, having regard to the purpose for which the installation is intended.

1.3 REFERENCED DOCUMENTS

The following documents are referred to in this Subsection of the NSCV. Any documents referenced in this Subsection shall be considered to be the latest revision of the document, including amendments and supplements.

TRANSPORT AND INFRASTRUCTURE COUNCIL

National Standard for Commercial Vessels
Part B—General Requirements
Part C—Design and Construction
Section 5: Engineering
Subsection 5C—LPG Systems for Appliances

STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

AS 1210—*Pressure vessels*
AS/NZS 1425—*LP Gas fuel systems for vehicle engines*
AS 1432 *Copper tubes for plumbing, gasfitting and drainage applications*
AS 1751 *Copper brazed steel tubing*
AS /NZS 1869 *Hose and hose assemblies for liquefied petroleum gases (LP Gas), natural gas and town gas*
AS 2337.1—Gas cylinder test stations – General requirements, inspections and tests – Gas cylinder

AS 2337.2 *Gas cylinder test stations – LP gas fuel vessels for automotive use*
AS 2430.1 *Classification of hazardous areas – Explosive gas atmospheres*
AS 2473 *Valves for compressed gas cylinders (threaded outlet)*
AS 2613 *Safety devices for gas cylinders*
AS /NZS 3509 *LP gas fuel vessels for automotive use*
AS D26 *Tube fittings with Dryseal American standard taper pipe and unified threads for automotive and industrial use*

SOCIETY OF AUTO ENGINEERS

SAE J533 *Flares for tubing*

AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM A254
ASTM A269

1.4 DEFINITIONS

For the purposes of this Subsection of the National Standard for Commercial Vessels—

a) the definitions provided in Part B of the NSCV, in addition to those in this Clause, shall apply; and
b) where there is any duplication in the terms defined between this Clause and Part B, the definitions in this Clause shall apply.

automatic fill limiter (AFL)—

a device in the filling system for a container, which automatically terminates the filling operation when a predetermined liquid level in the container has been reached.

capacity—

the total internal volume of a container.

container—

any pressure vessel, cylinder or tank designed for the storage of LPG to be used as fuel for outboard internal combustion engines.

contents gauge—

a gauge providing a visual indication of the liquid contents of the container.

double non-return valve—

two non-return valves arranged in series for the purpose of providing dual security against backflow.

excess-flow valve—

a valve that closes automatically when flow in a specified direction exceeds a predetermined limit.

fixed liquid level gauge—

a gauge indicating the maximum permitted liquid level in the fuel container.

fuel service line—

piping or hose used for the conveyance of LPG from the filling connection to the container or from the container to the vaporiser.

gas-air mixer—

a device for mixing air and gaseous fuel.

internal (components)—

a fitting or component constructed with its significant working parts within the container perimeter (i.e. inside the sub-compartment), so that any damage to exposed portions will not prevent the safe operation of the fitting or component.

liquefied petroleum gas (LPG)—

a hydrocarbon fluid composed predominantly of any of the following hydrocarbons, or mixtures of all or any of them:

a) Propane.
b) Propylene.
c) Butane.
d) Butylene.

Unless specifically stated otherwise, any reference to propane, propylene, butane or butylene means the commercial grade of that product.

locker—

a structure enclosing the whole of the fuel container and its fittings for the purposes of

a) collecting leaked LPG; and
b) facilitating the safe discharge of the leaked LPG to the atmosphere.

maximum permitted filling level—

the level of the liquid in a container when the liquid contents are 80 percent of the total available internal volume of the container.

non-return valve—

a valve which permits fuel flow in one direction only.

pressure—

gauge pressure (as opposed to absolute pressure).

Pressure regulator—

a device that reduces fuel pressure to a level appropriate for delivery to the vaporiser.

relief valve—

a valve which, upon activation, automatically discharges fluid to atmosphere or to a reduced pressure system so as to prevent a predetermined pressure in the system being exceeded.

safety valve—

a valve which automatically discharges vapour to atmosphere so as to prevent a predetermined pressure being exceeded.

service valve—

a manually operated shut-off valve which is fitted to the container and which, when closed, isolates the LPG supply from the rest of the installation.

sub-compartment—

a structure attached to the container, which encloses the container fittings and is designed to collect any leakage of LPG from those fittings, which facilitates the discharge of the leaked LPG to the atmosphere.

NOTE: Although a sub-compartment may also protect the fittings from mechanical damage, its primary function is the collection and discharge of leaked LPG.

vaporiser—

a device that vaporises LPG liquid for delivery to the gas-air mixer.

1.5 ABBREVIATIONS

LPG—

liquefied petroleum gas

AFL—

automatic fill limiter

CHAPTER 2 SYSTEM DESIGN AND INSTALLATION

2.1 SCOPE

This Chapter sets out the requirements to ensure that the system design, installation, components and accessories for liquefied petroleum gas (LPG) systems for engines are suitable for their intended service.

2.2 OBJECTIVE

The objective of this Chapter is to ensure that the system design, installation, components and accessories for liquefied petroleum gas (LPG) systems for engines are suitable for their intended service.

REQUIRED OUTCOMES

2.3 OPERATION AND MAINTENANCE

LPG systems for engines must be designed, constructed and installed to facilitate their identification, safe use, inspection and maintenance.

2.4 RELIABILITY

LPG systems for engines must be designed, constructed and arranged to provide a level of reliability appropriate for their intended purpose.

2.5 CONTAINMENT OF FUEL

LPG containers and distribution systems must be designed, constructed and installed to prevent the leakage of gas in both normal and abnormal conditions of operation.

2.6 MINIMISING THE RISK OF IGNITION

LPG systems for engines must be designed, constructed and installed to prevent the build-up of explosive gases and to avoid potential sources of ignition.

DEEMED-TO-SATISFY SOLUTIONS

2.7 COMPLIANCE

For the purpose of this National Standard, the general design and manufacture of an LPG system for engines shall be deemed to have satisfied the required outcomes in Clauses 2.3 to 2.6 if it complies with Clauses 2.8 to 2.12.

2.8 DESIGN AND MANUFACTURE

2.8.1 General

All components in the installation shall be designed and manufactured to withstand the stress imposed by fitting and tightening the connections and to withstand the conditions encountered in a marine environment. Components shall either be manufactured from material that is resistant to

corrosion, or they shall undergo a corrosion-inhibiting process prior to installation.

NOTE: The usual system configuration is that fuel is drawn from the container in the liquid phase, passing in succession through a water-heated vaporiser and pressure regulators, thus providing gaseous fuel at atmospheric pressure to be induced by the engine through the gas-air mixer.

2.8.2 Pressure rating and component suitability

The design pressure for components subjected to container pressure shall be 2.55 MPa. The suitability of such components shall be determined either by strength calculations in accordance with normal pressure vessel procedures, or by the ability to withstand a hydrostatic pressure of not less than 10.2 MPa applied for at least 1 minute. Component acceptance testing shall be in accordance with Annex A.

2.8.3 Modification of components

Modifications to any component shall not be made without the approval of the manufacturer of the component. The modified component shall be tested in accordance with Annex A prior to being put back into service.

2.8.4 Metals

The metals used in the manufacture of container valves shall be in accordance with AS 2473.
Piping and pipe fittings shall not be manufactured from aluminium alloys.
Metallic materials having a melting point lower than 500°C shall not be used in any application where failure of the component may result in the escape of gas.

2.8.5 Testing

Testing of all components and the complete installation shall be conducted in accordance with Annex A. The testing and commissioning procedures specified in Annex A shall also be carried out where second-hand equipment is being reinstalled or transferred to another vessel.

2.8.6 Modification and repairs

A modification or repair to an installation shall be inspected and tested in accordance with Annex A.

2.8.7 Inspection

Prior to testing and commissioning of the installation, an initial inspection of the LPG system and its components shall be carried out by or under the supervision of an authorised person. Subsequent inspection of the installation shall be in accordance with Annex A.

NOTE: Refer to legislation for details of licensing requirements.

2.8.8 Certification

On completion of an installation, the installer shall supply the owner of the vessel with a certificate of compliance, which shall specify the installation date and the fuel container serial number.

NOTES:

1. Refer to legislation for details of licensing requirements for certificates of compliance.
2. The certificate of compliance should be registered with the National Regulator.

2.8.9 Compliance plate

A compliance plate for each LPG installation shall be securely attached to the vessel's structure in a clearly visible location.
Where a container is changed or re-tested, it shall be fitted with a new compliance plate.

2.9 CONTAINER SUB-ASSEMBLY

2.9.1 Container

2.9.1.1 Design and construction

A fuel container shall comply with one of the following requirements:

a) AS /NZS 3509.
b) AS 1210 (for a design pressure of 2.55 MPa).

2.9.1.2 Installation

Containers shall be installed in accordance with the manufacturer's instructions and the following:

a) Containers shall be installed within a locker, or on the open deck or deckhouse top at a distance of not less than 1 m from any openings that would allow LPG into the vessel.
b) Containers shall be fixed (i.e. non-portable) and shall not be installed in the following locations:

   i) Inside a deckhouse.
   ii) Below deck.
   iii) Outside the hull contours.

c) Containers shall be installed such that the accuracy of the contents gauge, fixed liquid level gauge, safety valve and automatic fill limiter is not impaired.
d) The service valve shall be operable at all times. The valve may be located such that it can be operated manually from outside the locker, provided that the sealing on the locker is maintained by one of the following means:

   i) If a valve-actuating device passes through the locker casing, a gas-tight seal shall be fitted.

ii) If the actuating handle is located wholly within the locker, access shall be via a gas-tight captive hatch. The gas-tight captive hatch shall be capable of being operated without the need for tools.

e) The container shall be attached securely to the vessel in accordance with the following:

i) The method of attachment shall not cause undue stress in the container shell, nor shall it be a potential cause of deterioration of the container shell.

ii) Clamping bands shall be flat, round or square sections. Wire cables or material likely to localise loading shall not be used.

iii) The clamping bands shall be metallurgically compatible with the container shell.

NOTE: Galvanised bands should not contact stainless steel containers.

iv) The risk of corrosion of the container shall be minimised by avoiding entrapment of moisture in non-draining features.

v) Any welding of components and fittings to the container (e.g. fixing lugs and brackets) shall take place only during manufacture of the container.

f) The force necessary to separate the container from the vessel shall be not less than 20 times the weight of the full container. This requirement applies for any direction in which the force may be applied.

g) The container and its associated attachments shall be located (and protected if necessary) to minimise the risk of damage in the event of impact.

h) Where the thickness of the cylindrical portion of the container shell is less than 2.2 mm, the container shall be installed in a locker or in a protected zone.

i) A container should be installed in a location remote from the engine exhaust system. The distance from the container to the exhaust system shall not be less than 150 mm. Where there is a possibility of heat from the exhaust system raising the temperature of the container, a heat shield shall be fitted to protect the container, and the exhaust shall be lagged.

2.9.2 Components for containers

A container shall not be fitted with components other than those specified by the manufacturer as suitable for use with that particular container. A container shall incorporate the following components:

a) Filler connection.

b) Filler cap.

c) Filler non-return valve.

d) Automatic fill limiter.

e) Service valve.

f) Excess-flow valve.

g) Safety valve.
h) Contents gauge.
i) Automatic fuel shut-off device.

Components may be combined into multifunction units, provided that the requirements for each individual function have been satisfied.

2.9.3 Filling connection

The container filling connection shall be a 1¾-inch male Acme thread in accordance with AS 1425. A remote filling connection shall incorporate means to prevent it from rotating when the mating dispenser nozzle is connected or disconnected.

2.9.4 Filler non-return valve system

2.9.4.1 General

The filler non-return valve system shall incorporate a fill line with a nominal internal diameter not less than 8 mm, and shall be in accordance with Clauses 2.9.4.2 to Clause 2.9.4.6. The number of elbows in the fill line shall be minimised.

2.9.4.2 Direct filling system

Where the filling connection is on the container, it shall incorporate a double non-return valve to ensure a gas-tight condition.

2.9.4.3 Remote filling system

Where the filling connection is remote from the container, the backflow prevention system shall be one of the following:

a) A single gas-tight non-return valve at the filler connection and a double non-return valve at the container, of which at least one element shall be gas-tight.
b) A gas-tight non-return valve at the container, plus a double non-return valve at the filler connection, of which at least one element shall be gas-tight.
c) A double non-return valve at both the container and the filling connection, of which at least one element of each valve shall be gas-tight.
d) A single gas-tight non-return valve at the filler connection, plus a manual shut-off valve together with a gas-tight non-return valve at the container.

2.9.4.4 Internal non-return valve

At least one of the non-return valves in the backflow prevention system shall be installed such that the valve shall be operable in the event of damage to the assembly external to the container.

2.9.4.5 Filler cap

The filler cap shall be captive, and shall either be capable of withstanding the design pressure (2.55 MPa) or shall be designed to prevent the accumulation of pressure.

2.9.4.6 Location of filling connection

The filling connection shall not be installed on any impact surfaces on the sponson, and shall be located such that—

a) it can be supervised from the open deck of the vessel; and
b) it is protected by its location.

2.9.5 Automatic fill limiter (AFL)

2.9.5.1 Design

The design of an AFL shall be such that—

a) the operation of the shut-off action shall not depend on a bleed of LPG to the atmosphere;

b) it shall not be possible to alter the setting of the AFL from outside the container after installation;

c) an AFL that depends on correct radial orientation for its accuracy (e.g. a screw-in type) shall incorporate a means to correct its setting or position; and

d) where the installation has more than one container, an AFL shall be incorporated in each container.

2.9.5.2 Performance

Subsequent to the testing specified in Annex A, the performance of an AFL shall be as follows:

a) Filling shall be shut off before the maximum permitted filling level has been exceeded.
b) The filling shut-off function shall be operable at any pressure differential between 70 kPa and 1000 kPa across it.

   NOTE: For this requirement, any adjacent or in-built non-return valve is not considered to be part of the AFL.

c) The rate of leakage into the container after shut-off shall be such that the liquid volume does not increase by more than 5 per cent of the total container volume within 8 minutes.

2.9.5.3 Fixed liquid level gauge

A fixed liquid level gauge shall comply with the following:

a) The design of the gauge shall be such that either—

   i) it incorporates a tube arranged with its open end located at the liquid level, so that gaseous discharge changes to liquid discharge as the liquid surface reaches the level; or
   ii) it incorporates a sight glass of the circular window type, marked at the level.

b) It shall indicate when the liquid level is at the maximum permitted filling level.
c) It shall be accessible to facilitate periodic checking of the AFL.
d) The arrangement shall be such that any discharge occurring during checking can be directed away from both the deckhouse and below the deck of the vessel.

NOTE: Temporary extension tubing may be used to facilitate this discharge requirement.

e) Any opening communicating between the gauge and the interior of the container shall be restricted by an orifice with an internal diameter not greater than 1.4 mm.

2.9.6 Contents gauge

An electrically operated contents gauge shall be designed for use in a Zone 2 area, as defined in AS 2430.1.

2.9.7 Excess-flow valve

An excess-flow valve shall be located upstream of the service valve, and shall comply with the following:

a) The valve shall be internal.
b) The nominal closing flow rate shall not exceed 215 mL/s of LPG.
c) When the valve is shut, the bypass flow rate shall not exceed 3.3 mL/s of LPG at 350 kPa differential pressure.
d) The valve shall reopen automatically when the excess flow condition has ceased.

NOTE: The excess-flow valve is usually attached directly to the service valve.

2.9.8 Service valve

A service valve shall be manufactured in accordance with AS 2473.

2.9.9 Automatic fuel shut-off valve (container)

Provided the valve is located in a protected position, the automatic fuel shut-off valve at the container shall be fitted between the filter and the inlet of the first stage of the regulator, and shall act automatically to prevent the flow of LPG to the fuel service line at all times other than when both the ignition is on and the engine is running.

The following requirements also apply for the automatic fuel shut-off valve:

a) The valve may open for a period of up to 3 seconds when the ignition is first turned on to allow priming of the fuel system. In the event of the engine stalling (as opposed to the engine being switched off), the valve may similarly remain open for a period not exceeding 3 seconds.
b) The valve shall have a reflux (backflow opening) pressure not greater than 0.275 MPa, and a filter shall be installed upstream of the valve.

NOTE: Care should be taken when fitting the valve to ensure correct direction of flow.

c) Where the valve is fitted within a locker or sub-compartment of a container, it shall be of the electrically encapsulated type, with electrical terminals located outside of the locker or sub-compartment.

d) Wiring circuits, electronics and terminals provided for activation of the valve shall be protected so as to minimise the possibility of the safety shutdown feature being overridden. This protection shall be achieved by routing the wiring clear of any potential voltage sources, or by the incorporation of back-feed protection in the circuitry.

NOTE: This requirement does not preclude the use of combination modules comprising dual fuel selector/safety switch/fuel gauge units.

e) The valve shall not be activated by switching to earth.

NOTE: The valve may be connected to the service valve by means of a fitting.

2.9.10 Fuel filter

A fuel filter capable of removing all matter from the fuel that could cause malfunction of the system shall be fitted on the high-pressure side.

2.9.11 Safety valve

2.9.11.1 General

The safety valve shall be internal. The safety valve and its installation shall be in accordance with Clauses 2.9.11.2 to 2.9.11.5.

2.9.11.2 Design and manufacture

The safety valve shall comply with the requirements appropriate to the type of container to which it is fitted as follows:

a) AS 2613 for a gas cylinder or an automotive fuel container.
b) AS 1210 for a pressure vessel.

2.9.11.3 Start-to-discharge setting

The start-to-discharge setting of the safety valve shall be 2.55 MPa.

2.9.11.4 Discharge from safety valve

The discharge from the safety valve shall be such that there is no possibility of gaseous LPG discharging—

a) on the container;
b) towards any person in the vicinity;
c) on adjacent vessels; or
d) towards or directly into the deckhouse or below deck.

2.9.11.5 Discharge arrangements

The following arrangements shall be considered as fulfilling the discharge requirements specified in Clause 2.9.11.4:

a) The discharge is directed into a sub-compartment or locker.
b) The discharge line to the point of discharge is rigid piping complying with all of the following:

i) The size of piping and fittings and the general arrangement of the piping shall be such that the overall discharge capacity of the safety valve and the piping is not less than that specified by the manufacturer of the container.
ii) The maximum length of the discharge line shall be 3 m, which shall be reduced by 0.5 m for each right-angle fitting, and 0.3 m for each short-radius bend or sweep bend of radius less than three times the outside diameter of the pipe.
iii) The piping shall have a pressure rating appropriate for the pressure of discharging gas.
iv) Any connecting fitting attached to the safety valve outlet shall not interfere with the operation of the valve.
v) The type of piping and the general design of the system shall be such that it cannot cause the safety valve to be damaged under normal conditions of vessel operation or in an accident.
vi) The piping system shall be arranged, and protected if necessary, to minimise the possibility of mechanical damage.
vii) The point of discharge shall be fitted with a device to prevent the ingress of water and dirt.
viii) The direction of discharge shall be upwards, at an angle of not greater than 45^{o} from the vertical.

c) Provided that the manufacturer has confirmed that the flow rate remains adequate for the installation, an externally mounted container having no sub-compartment or locker may be fitted with a short discharge pipe, directional guide or baffle having an equivalent effect, to reduce the velocity of the discharge or direct it safely.
NOTE: Fittings, piping attachments or deflectors that are attached to the outlet of the safety valve can interfere with the action of the valve or with gas flow so as to reduce the discharge flow rate.

2.9.12 Lockers

The design, construction and installation of a locker shall be in accordance with the following:

a) A locker shall be vapour-tight to the interior of the vessel, and shall be located above the waterline. It shall not be installed inside a deckhouse or below deck.
b) A locker shall provide adequate protection for the container under accident and impact conditions.
c) A locker shall be accessible from the top only and shall be fitted with a vapour-tight cover. The vapour-tight cover shall be of such design as to enable it to be readily opened to facilitate operation of container valves and testing of the system for leakage.
d) A locker shall be vented at the bottom by a pipe of at least 25 mm inside diameter, which shall be routed directly overboard through the

hull to a point lower than the container but not closer than 230 mm to the designed waterline in the loaded condition.

e) A locker shall not have electrical connections or wiring within it unless any electrical equipment or components inside the locker are suitable for use within a Zone 2 area, as defined in AS 2430.1.
f) A locker shall not be used for any purpose other than housing containers and associated equipment.
g) For sailing vessels, the drain outlet of a locker shall be located 230 mm above the anticipated sustained heeled waterline.

2.10 FUEL SERVICE LINES

2.10.1 General

LPG fuel service lines that are subjected to container pressure shall be manufactured from one of the following:

a) Copper-brazed steel tubing complying with AS 1751 or ASTM A254, terne-coated.
b) Seamless stainless steel tubing complying with ASTM A269.
c) Hose or a hose assembly complying with AS /NZS 1869.

LPG fuel service lines and their fittings shall comply with Clause 2.10.2 to Clause 2.10.8.

2.10.2 Copper and copper alloy tubing

2.10.2.1 Size of tubing

The tubing shall have a nominal wall thickness not less than 0.91 mm if under 10 mm diameter, or not less than 1.02 mm if 10 mm or larger, and shall be no larger than that required to satisfy the maximum requirements of the engine. In no case shall the tubing be less than 6 mm outside diameter.

2.10.2.2 Configuration

Tubing joints and connections shall comply with Clause 2.10.4. The number of joints and connections in a fuel service line shall be minimised. Tubing joints and connections manufactured by the installer shall be restricted to the connection of essential components.
Tubing shall not be used between parts that can move in relation to each other (e.g. between the vessel and the engine).

2.10.3 Hose and hose assembly

Where a fuel service line is manufactured from hose, the hose and hose assembly shall be of a class suitable for the pressure and temperature of the application, in accordance with relevant national and/or international standards.

2.10.4 Joints and connections

Olive- or ferrule-type fittings shall not be used in any joint or connection subjected to container pressure. Joints used for connecting or mounting tubing, hose assemblies or components subjected to container pressure shall be one of the following:

a) For tubing, the joint shall be a 90^{o} double-flared connection in accordance with AS D26 or SAE J533.

NOTE: Care should be taken to use the correct flaring tool. Using a flaring tool of an incorrect size can result in a reduction of tubing wall thickness.

b) A flanged joint.
c) A welded or brazed joint, provided that such joints are limited to components assembled during manufacture.
d) A screwed joint provided that when the thread is used as a seal, only taper-to-taper threads are used.
e) A ground-face union.

2.10.5 Installation

Fuel service lines shall be installed in accordance with the following:

a) They shall be routed such that they are protected against mechanical damage by the vessel's structure in the event of impact or collision. They should follow the shortest practicable route.
b) Any tubing likely to be subjected to corrosion shall be adequately protected.

NOTE: Clear plastic tubing is not suitable for providing protection from corrosion as the marine environment causes it to change colour, thus impairing visibility for inspection.

c) They shall be secured to the vessel's structure by metallic clips. Such clips shall be spaced at intervals not exceeding 600 mm. In order to prevent the possibility of fretting, corrosion or erosion of the fuel service lines, cushioning shall be provided to protect them from the vessel's structure and the clips themselves. Grommets shall be fitted where the fuel service line passes through the vessel's structure.
d) Where a fuel service line (including any of its joints or connections) or any connected component or fitting is subjected to container pressure, and is located within 150 mm of an object at a temperature above the normal water jacket temperature of the engine, a heat shield shall be fitted.

NOTE: Such heat sources include parts of the exhaust system, turbochargers and compressors.

2.10.6 Multiple container installations

Where there is more than one container in an installation, and the liquid spaces in the containers are connected to a common fuel service line—

a) a spring-loaded non-return valve shall be installed between each container and the common fuel service line; and
b) a relief valve complying with Clause 2.10.7 shall be fitted to the common fuel service line.

Manifolds used in multi-container installations shall be installed in a protected location.

2.10.7 Relief valve

A relief valve shall be set to operate at 3.1 MPa, and shall be installed in accordance with the following:

a) The discharge shall be directed away from enclosed spaces and sources of ignition.
b) The valve shall be protected from mechanical damage and shall be accessible for inspection and service.

2.10.8 Fuel service lines for applications under 100 kPa

Fuel service lines for applications under 100 kPa shall comply with the following:

a) Hose shall comply with the Class B requirement of AS/NZS 1869, and shall be of sufficient length and flexibility to accommodate engine movement.
b) Joints and connections shall be capable of sustaining a pressure 5 times the maximum pressure likely to be encountered in service. They shall comply with Clauses 2.10.2.2 and 2.10.4. Pipework for safety valve discharges in applications less than 100 kPa shall comply with Clause 2.9.11.5 b).

2.11 FUEL CONTROL EQUIPMENT

2.11.1 General

Fuel control equipment shall comply with the requirements specified in Clauses 2.11.2 to 2.11.6. Any alterations made to the original equipment shall not adversely affect the performance of the equipment, the safety of the installation or the exhaust emission levels.

2.11.2 Components comprising LPG fuel control equipment

The LPG fuel control equipment shall incorporate all equipment necessary to convert LPG at high pressure at the fuel service line to the gas-air mixture supplied to the engine, and shall comprise the following components:

a) An internal fuel filter, arranged to protect the automatic fuel shut-off device.
b) An automatic fuel shut-off device (lock off).
c) A vaporiser.
d) A pressure regulator.
e) A fuel selector, where a dual-fuel system is employed.

f) A gas-air mixer.

2.11.3 Vaporiser and pressure regulator

2.11.3.1 Performance

A vaporiser and pressure regulator assembly shall incorporate a safety device that prevents the passage of vapour after the engine has stopped running, irrespective of whether the ignition is on or off.

2.11.3.2 Installation

The vaporiser and pressure regulator assembly shall be securely mounted and installed in accordance with the following:

a) It is accessible for routine maintenance, adjustment, and inspection.
b) It is mounted adjacent to or near the engine inlet.
c) It is protected from impact in the event of a collision.
d) It is either connected directly to, or adjacent to, the automatic fuel shut-off device.
e) The length of any vapour pipe between the converter and the engine shall be minimised, and in no case shall be more than 500 mm.
f) It allows sufficient free movement of fuel and water hoses.

2.11.3.3 Marking

Each vaporiser shall be legibly and permanently marked with the following information:

a) The manufacturer’s name and trademark.
b) A definitive model, make, or series identification.
c) The serial number, month and year of manufacture.

2.11.4 Water circulation system

The water circulation system shall be connected such that no flow-control valve in the system (e.g. thermostat or heater control) is capable of shutting off the flow of hot water.

2.11.5 Gas-air mixer

The gas-air mixer shall be mounted securely and, when fitted remotely, shall be capable of supporting its own weight and any forces applied under normal conditions of operation.
Air filter elements shall not be fitted downstream of the gas-air mixer.

2.11.6 Electrical wiring

2.11.6.1 General

The cross-sectional area (determined by current flow) and the insulation (determined by temperature) of wiring cable shall comply with appropriate national and international standards. The conductors in the wiring cable shall be tinned.

2.11.6.2 Securing of wiring cable

All wiring shall be taped, clipped or contained in a loom along its length.

2.11.6.3 Connectors and terminals

Connectors and terminals shall have soldered joints and shall be insulated to prevent accidental earthing during operation or routine servicing.

2.12 MARKINGS AND INSTRUCTIONS

Any gas-tight hatch providing access to a sub-compartment or locker shall be legibly and permanently marked with the following warning:

WARNING: KEEP CLOSED AND GAS-TIGHT EXCEPT WHEN THE SERVICE VALVE MUST BE OPERATED

2.12.1 Operating instructions

The installer shall provide a set of operating instructions for the vessel, which shall include (but need not be limited to) the following information:

a) Refuelling procedures.
b) Operation of the fuel system.
c) Procedures to follow in the event of various faults or emergency situations.

ANNEX A TESTING, COMMISSIONING AND INSPECTION

A1 SCOPE

This Annex A provides requirements for the testing, commission and inspection of LPG systems for engines. It forms a normative (mandatory) part of this document.
This Annex is referenced in Clauses 2.8.2, 2.8.3, 2.8.5, 2.8.6, 2.8.7, and 2.9.5.2 of this Subsection.

A2 PRE-INSTALLATION COMPONENT ACCEPTANCE TESTING

A2.1 General

The components in an LPG installation shall undergo the following acceptance tests:

a) *Non-metallic materials*

Non-metallic, synthetic materials used in seals or diaphragms in contact with LPG shall not—

i) show visible evidence of deterioration after exposure to oxygen at 2 MPa and 20°C for 96 hours; and
ii) change volume or mass in excess of that shown in Table A.1 after immersion in hexane or pentane at a temperature of 20°C for 70 hours.

Table A.1 — Immersion test limits

Nature of Change	Maximum permissible change (%)	
	Diaphragms	Other parts
Volumetric swelling	25	25
Volumetric shrinking	10	1
Loss of mass	15	10

b) *Cyclic pressure test*

Each component shall not suffer damage sufficient to cause leakage or malfunction after being subjected to a cyclic pressure test comprising 10,000 applications of a hydrostatic pressure of 5 MPa. Connections to the components under test, methods of mounting and means of blanking openings shall be representative of actual installation fittings, and shall not provide additional stiffening or support for the component under test.

c) *Moving parts test*

Components having moving parts shall not leak or suffer loss of performance when subjected to repeated cycles or operation specified in Table A.2.

Table A.2 — Moving parts cycle test

Components	Cycles
Non-return valve	6 000
Bleed valve (of a fixed liquid level gauge)	6 000
Service valve	6 000
Excess-flow valve	6 000
Automatic fill limiter (valve function only)	6 000
Liquid level sensor, whether a part of a filling shut-off valve or of	100 000
Safety valve and relief valve	6 000
Automatic fuel shut-off device	100 000
Pressure regulator	100 000
Filling connection	6 000

A3 LEAK DETECTION TESTS

A3.1 Container leak test

Every container sub-assembly shall be subjected to a leak test by the manufacturer with air or an inert gas. A container that has previously contained LPG shall be purged thoroughly prior to using pressurised air for the leak test. The leak test shall be in accordance with the following procedure:

a) Close the service valve and the fixed liquid level gauge valve (if fitted).
b) Pressurise the container to an internal pressure of 2.3 ± 0.05 MPa.
c) Remove the pressurising attachment.
d) Check all joints between the container and the components for leaks.
e) Check the filler valve, fixed liquid level gauge valve (if fitted) and the service valve for leakage through the valve seal.
f) With the service valve outlet plugged or capped and the valve opened, check for leaks at the valve stem seal of any valve that is normally open in service.

WARNING: OXYGEN SHALL NOT BE USED FOR PRESSURISING THE CONTAINER

A3.1.1 Acceptance criteria

All leaks found shall be rectified and the area re-tested, or the item under test shall be discarded and replaced. Any leakage test shall be invalidated if the joint tested is subsequently dismantled, and a repeat test shall be carried out on the reassembled joint.

A3.2 Installation tests

A3.2.1 General

The installer shall carry out the following installation tests. All air shall be purged from the container with inert gas prior to commencing the LPG installation testing.

NOTE: For convenience, it is recommended that this purging be carried out before the container is installed.

A3.2.2 Leak testing of gas system

After all connections have been made, the LPG system shall be tested for leaks in accordance with the following procedure:

a) Ensure the container and all liquid lines are full of liquid propane.

WARNING: IT IS IMPORTANT THAT PROPANE (AS OPPOSED TO BUTANE) IS USED FOR THIS TEST BECAUSE IT HAS A RELATIVELY HIGH VAPOUR PRESSURE AT LOWER TEMPERATURES. IF THE PRESSURE GAUGE ON THE CONTAINER INDICATES A PRESSURE BELOW 450 KPA, THEN TESTING SHOULD BE POSTPONED. UNDER NO CIRCUMSTANCES SHOULD THE CONTAINER BE HEATED TO RAISE THE PRESSURE.

b) Test all pipe and component connections, including those on remote filling and remote ullage gauge lines, and test the filler non-return valve.
c) Where a leak is indicated, rectify the fault by remaking the joint, and retest the area.

A3.2.3 Testing of automatic fill limiter (AFL)

The accuracy of the shut-off function of the AFL shall be checked in accordance with the following procedure with the vessel on even trim and without any list:

a) Ensure all LPG is emptied from the container.
b) Fill the container via a pump-meter unit. The meter reading at which the AFL cuts off shall be within ± 2 per cent of the maximum permitted filling volume.

NOTE: The accuracy of the contents gauge may be checked at the same time. A fixed liquid level gauge may also be used for checking, but is less accurate.

c) The cyclic pressure test specified in Clause A2.1 b) shall be carried out using either air or water at a pressure of 700 kPa. The liquid level sensor may be operated either by a mechanical device or by changing the liquid level.
d) The liquid level sensor shall move through its full available travel, with acceleration and deceleration of the vessel not exceeding 1 g.
e) The complete unit shall be subjected to vertical vibrations at 17 Hz and 6 mm amplitude for 200 hours. The unit shall be mounted in its working attitude with the liquid level sensor unrestrained for this test.

f) The liquid level sensor shall be subjected to an external LPG liquid pressure of not less than 1.1 times the design pressure (i.e. 2.8 MPa for 30 minutes). It shall then be subjected to LPG vapour pressure at ambient temperature for a further 30 minutes.

A3.2.4 Test of fuel control device

A test shall be carried out to ensure that the automatic shut-off device functions correctly.

A3.2.5 Water system test

The water circulation system supplying hot water to the vaporiser shall be tested for leaks.

A3.2.6 Excess flow valve test

The excess flow valve shall be tested to ensure that it closes and reopens, by opening then closing the service valve while the container remains under pressure.
Where an automatic fuel shut-off device is integral with the excess flow valve and service valve, downstream of this assembly may be removed for the excess flow valve test.
Where multiple containers are installed, each excess flow valve shall be tested separately.

A3.2.7 Non-return valve

The function of each non-return valve shall be tested by pressurising the valve and testing for leaks.

A3.3 Inspection

The following checks and tests shall be carried out annually:

a) Container life—the date stamp on the container shall be checked. Renewal of certification is generally required after a period of 10 years, and is conditional on re-examination for deterioration. The fuel tank may need to be removed to facilitate proper examination. The examination shall be made in accordance with AS 2337.2 by an authorised test station, licensed under the terms of that Standard.
b) Leakage test.
c) Container damage.
d) Container corrosion.
e) Container attachments.
f) Automatic fill limiter.
g) Fuel containment system [i.e. the automatic fuel shut-off device (container) and the excess flow valve].
h) All manual valves.
i) Relief valves and safety valves.
j) Filler connection.
k) Filters.
l) Container locker (if fitted).

ANNEX B METHODS OF LEAK DETECTION

B1 SCOPE

This Annex B describes a variety of leak detection methods for LPG, and indicates the advantages or disadvantages of each method.
It forms an informative part of this document, unless designated as mandatory by the National Regulator.

B2 COMBUSTIBLE-GAS DETECTOR

Combustible-gas detectors are suitable for testing for leaks after fuel gas has been introduced to the system, and are particularly useful for checking assembly joints after installation. Care in interpretation is necessary, as the detectors can respond to the presence of any of several vapours that are combustible, some of which may not be LPG (e.g. oil smears, jointing compound, etc.). They may also detect residual LPG vapour that is present for reasons other than leakage, and which must be cleared before a valid test for leakage can be made. If a leak is present, a detector will signal its existence, but not its size, and will indicate a general location, but may not be able to locate it exactly, so a follow-up or proving check with foam is recommended.
The combustion-gas detector is capable of detecting 25 parts per million (ppm) of LPG in air. Exhaust gas analysers are not suitable for leak detectors.
It is important to keep the sensing element in contact with the surface of the part being tested, and that the test be carried out under still air conditions.

B3 TRACE-GAS DETECTORS

Trace-gas detectors are suitable for checking the gas-tightness of the construction joints in a locker, conduit connections and similar, particularly where it is impracticable to apply internal pressure.
The basic method is to plug or blank off openings such as vents, and inject a trace gas under pressure. The gas used may be any convenient gas for which a suitable gas detector is obtainable (e.g. halogenated hydrocarbons, carbon dioxide or similar). The gas detector should be capable of detecting 25 ppm in air and should be of the continuous sample-aspiration type.

B4 FOAMING AGENTS

Foaming agents are more effective for detection of small leaks, as large leaks tend to blow the solution away from the leak without forming a bubble. Care in applying the solution slowly with a brush will provide easier detection of large leaks.
The foaming agent should be a proprietary leak test solution, formulated specifically for the purpose. It is essential that fresh solution be used, that the whole of the surface to be tested is coated and that time be allowed for bubbles to foam. All areas under test should be able to be observed during the test.

B5 TOTAL IMMERSION

Total immersion may not always indicate very small leaks, or leaks which may be inhibited by the head of water. Good illumination and an ability to

manipulate the item submerged are important. A wetting agent is desirable, provided that foaming does not result.

B6 VISUAL INSPECTION

Leaking LPG will often cause a frost to form on the surrounding surface, even when the rate of leakage is too small to be readily detectable by immersion or foam method. Visual checks for signs of frost patches are particularly appropriate for the welded seams of containers.