

Australian/New Zealand Standard™

Natural gas (NG) fuel systems for vehicle engines



AS/NZS 2739:2009

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee ME-046, Gas Fuel Systems for Vehicle Engines. It was approved on behalf of the Council of Standards Australia on 4 November 2008 and on behalf of the Council of Standards New Zealand on 25 February 2009.
This Standard was published on 16 March 2009.

The following are represented on Committee ME-046:

Australian Automobile Association
Australian Industrial Truck Association
Department for Transport, Energy and Infrastructure, SA
Department of Mines and Energy, Qld
Energy Safety, WA
Engineers Australia
Federal Chamber of Automotive Industries
Gas Association of New Zealand
International Association for Natural Gas Vehicles
New Zealand Transport Agency
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This Standard was issued in draft form for comment as DR 07279.

Australian/New Zealand Standard™

Natural gas (NG) fuel systems for vehicle engines

Originated in Australia as AS 2739—1984.
Originated in New Zealand as NZS 5422.2:1980.
Previous edition AS/NZS 2739:2003.
Fifth edition 2009.

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Jointly published by Standards Australia, GPO Box 476, Sydney, NSW 2001 and Standards New Zealand, Private Bag 2439, Wellington 6020

PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee ME-046, Gas Fuel Systems for Vehicle Engines, to supersede AS/NZS 2739:2003, *Natural Gas (CNG) fuel systems for vehicle engines*.

This edition introduces requirements for the installation of equipment used in fuelling engines with Liquefied Natural Gas (LNG). The term Compressed Natural Gas (CNG) has been removed from the title of this Standard so as to allow the introduction of LNG alongside CNG.

The document has been restructured to facilitate the introduction of LNG requirements alongside the requirements of CNG and a new section dealing exclusively with LNG.

The requirement for the maximum working operating pressure of 20 MPa for CNG containers has been removed to allow for the latest designs in container specifications. The Installation Compliance Plate requirement has been modified for consistency with AS/NZS 1425, *LP Gas fuel systems for vehicle engines*.

The 2003 edition had been expanded to include engine exhaust emission testing and acceptance of components complying with ISO 15500, Parts 1 to 20 and ECE R110. This Standard further incorporates changes to the requirements of exhaust emissions, which are simplified and include requirements for both CNG and LNG fuelled engines.

The terms 'normative' and 'informative' have been used in this Standard to define the application of appendix to which they apply. A normative appendix is an integral part of a Standard, whereas an informative appendix is for information and guidance.

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STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard
Natural gas (NG) fuel systems for vehicle engines

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies requirements for natural gas (NG) fuel systems for engines mounted on motor vehicles, either for the propulsion of the vehicles or for driving some auxiliary function, e.g. a mixer or a pump. It provides requirements for the design and construction of component parts, and for their installation in vehicles, and for tests, commissioning, and periodic inspection. It applies to all vehicle types, e.g. rigid chassis, articulated chassis and semitrailers.

This Standard does not cover the areas where major structural modifications are to be carried out to the vehicle. Prior to commencement of such work guidance should be sought from the vehicle manufacturer or a professional engineer who is experienced in the automotive disciplines.

This Standard does not apply to NG usage such as the gas supply system for appliances in caravans, mobile homes, forklifts, floor sweepers, polishers, tow tractors, elevating work platforms and industrial engines (refer to AS 4983) or for the propulsion of marine craft (refer to AS 4732).

1.2 OBJECTIVE

The objective of this Standard is to provide designers, manufacturers, installers and regulatory authorities with technical requirements for natural gas fuel systems for vehicle engines so as to provide functional, safe installations.

1.3 REFERENCED DOCUMENTS

A list of the Standards referenced in this Standard is given in Appendix A.

1.4 DEFINITIONS

For the purpose of this Standard, the definitions below apply.

1.4.1 Approved, approval

Approved by or approval of the regulatory authority.

1.4.2 Authority

The authority having statutory powers to control any aspect of the design, manufacture, installation and use of equipment described in this Standard in the country, state or territory in which the vehicle is registered.

1.4.3 Authorized person

In Australia—a person who has completed an authorized training course and is licensed/registered by the relevant statutory authority to install or service natural gas equipment in automotive vehicles.

In New Zealand—a person, normally an automotive tradesman, registered by the New Zealand Transport Agency as holding an Automotive Trade Extension Certificate in Motor Vehicle Conversion—Petrol to Gas (LP Gas/NG), or a person approved by separate statutory authority.

1.4.4 Automatic fuel shut-off device

A provision for shutting off the fuel supply unless certain essential conditions exist.

1.4.5 Breakaway coupling

A device designed to disconnect in the event of the towing vehicle moving off while coupled to the towed trailer.

1.4.6 Capacity (of a container)

The total internal volume of the container, expressed in litres.

NOTE: This was previously known as 'water capacity'.

1.4.7 Certified kit

A kit comprising the fuel control and engine management system components and detailed installation instructions, as specified in Section 6, which has been successfully tested in accordance with the relevant requirements of Appendix E.

1.4.8 CNG (compressed natural gas)

A compressed gaseous fuel composed of natural gas as defined in AS 4564.

1.4.9 Container

An NG container for the storage of CNG or LNG to be used as a fuel for an engine.

1.4.10 Container compartment

A structure of rigid or pliable material that encloses the whole of the container and its fittings, whose purpose is to collect any gas leakage which might occur, so that it can be discharged to open air.

1.4.11 Container manufacturing certificate

A manufacturer's certificate containing information including the container design information/drawing, the container standard, the container model number, the rated working pressure, serial numbers, an Australian container design registration number, the expiry date (if applicable) and periodic inspection interval.

1.4.12 Container sub-compartment

A structure of rigid or pliable material attached to the container, which encloses the container fittings, and whose purpose is to collect any gas leakage which might occur, so that it can be discharged to open air.

1.4.13 Cryogenically conditioned system pressure (LNG)

The pressure of LNG when stored at a nominal -132°C .

NOTE: LNG is stored at an ideal pressure of 500 kPa at -132°C . The pressure will rise as the temperature increases resulting in a release of vapour from the pressure relief valve (PRV) once the first PRV setting has been exceeded.

1.4.14 Design pressure

The maximum pressure to which a container or component is designed to be subjected, and the basis for determining the strength of the component under consideration.

1.4.15 Fuel

1.4.15.1 *Bi-fuel vehicle*

A vehicle that can operate on either natural gas or an optional fuel (e.g. petrol).

1.4.15.2 *Dual fuel vehicle*

A vehicle that can operate on part natural gas and part optional fuel (e.g. diesel) or the alternative fuel (diesel) only.

1.4.15.3 *Mono fuel vehicle*

A vehicle that can operate on NG only.

1.4.16 Fuel flow regulation device

A liquid flow excess control valve that will actuate at a predetermined drop in downstream pressure allowing upstream pressure to seat the valve and stop flow.

1.4.17 Fuel metering system

A component or series of components which control the flow of gas into the engine.

NOTE: A fuel metering component could be a gas air mixer, fuel injection device, etc.

1.4.18 Fuel service line

The fuel line supplying the engine and running from the container(s) to the engine.

1.4.19 Gas air mixer

A device for introducing gaseous fuel to the induction air of the engine.

1.4.20 Ignition source

A source of energy sufficient to ignite a flammable atmosphere and includes naked flames, exposed incandescent material, electric welding arcs, and electrical or mechanical equipment or components not approved for use in hazardous areas.

NOTE: A vehicle will not be regarded as being an ignition source while it is entering or leaving the hazardous zone surrounding a fuel dispenser, for refuelling.

1.4.21 LNG (liquefied natural gas)

A cryogenic liquid, produced by reducing the temperature of natural gas to a nominal -162°C at atmospheric pressure.

1.4.22 May

Indicates the existence of an option.

1.4.23 NGV

Natural gas fuelled vehicle.

1.4.24 Non-return valve

A valve that permits fuel flow in only one direction.

1.4.25 Pressure

Gauge pressure (as opposed to absolute pressure).

1.4.26 Pressure relief device (PRD)

A device that prevents a predetermined upstream pressure being exceeded.

1.4.27 Professional engineer

A person who is—

- (a) a professional engineer in the relevant discipline who has appropriate experience and competence in the relevant field; or
- (b) a Corporate Member of the Institution of Engineers Australia or the Institution of Professional Engineers New Zealand; or
- (c) eligible to become a Corporate Member of the Institution of Engineers Australia or the Institution of Professional Engineers New Zealand, and has appropriate experience and competence in the relevant field.

1.4.28 Rated working pressure (CNG)

The maximum pressure to which it is permitted to fill a cylinder with CNG, measured when the cylinder and its contents are at an equilibrium temperature of 15°C.

1.4.29 Refuelling connection

Joint assembly of refuelling nozzle and receptacle.

1.4.30 Refuelling interlock device

A system that prevents the engine starting when the dust plug/cap is removed.

1.4.31 Refuelling nozzle

Device attached to the refuelling hose that permits quick connection and disconnection of fuel supply hose to the receptacle in a safe manner.

1.4.32 Refuelling receptacle

Device connected to a vehicle or storage system that receives the NG refuelling nozzle and permits safe transfer of fuel.

1.4.33 Regulator

A device used to control the delivery pressure of gaseous fuel to the engine.

1.4.34 Removable container

A container that is removed from the vehicle when refuelling is necessary, usually in exchange for a full cylinder.

1.4.35 Shall

Indicates that a statement is mandatory.

1.4.36 Should

Indicates a recommendation.

1.5 NEW DESIGNS AND INNOVATIONS

Any alternative materials, equipment, designs, method of assembly or procedures, which do not comply with the specific requirements of this Standard, or are not mentioned in it, but which, given equivalent results to those specified, may be acceptable. Under such conditions the regulatory authority can give advice on the procedure for approval.

1.6 VEHICLE MODIFICATIONS

Any alterations or modifications to any vehicle resulting from the installation of NG equipment shall be carried out in accordance with sound engineering practices. Areas of alteration or modification include the following:

(a) *Suspension*

Including mounting locations, geometry, ground clearance adjustment, axles and stub axles, or steering mechanism.

(b) *Original fuel storage*

Including the fuel tank assembly, fuel tank mounting, venting or filler assemblies.

(c) *Vehicle structure*

Including any additional holes, welded joints, direct load bearing points and structural alteration near seat belt anchorages.

Holes greater than 13 mm shall not be located within 40 mm of the edge of a panel, welded joint or direct load bearing point or any structural alterations within 200 mm of any seat belt anchorage. The only holes permitted, which are greater than 13 mm diameter, are for the installation of the filling valve or for venting purposes.

(d) *Braking system*

Including the hand brake and components.

(e) *Spare wheel location*

Including the spare wheel mounting and its anchorage.

The spare wheel mounting and its anchorage shall be designed using the design factors given in Table 3.2.

(f) *Anchorage*

Including seat anchorages, seat belt anchorages and child restraint anchorages.

Modifications carried out to areas listed in Items (a) to (f) shall comply with—

- (i) *in Australia*—Australian Design Rules (ADRs), or relevant Codes and Standards accepted by Ministerial Councils comprising Federal, State and Territory Ministers, or relevant Acts and Regulations; or
- (ii) *in New Zealand*—relevant Codes and Standards accepted by the New Zealand Transport Agency.

1.7 IMPACT ON VEHICLE LOADING

The weight of the container(s) will affect the tare weight of the vehicle. The vehicle manufacturer's and the legal rating on the tyre and axle loadings should be considered. In no circumstances shall the vehicle's critical load distribution, which affects safety, be compromised.

1.8 ENGINE MANAGEMENT SYSTEM ALTERATIONS

1.8.1 General

Any alteration(s) made to a vehicle's original equipment or the engine's fuel management system shall not adversely affect the original manufacturer's design, safety level and performance when operating on the fuel for which it was designed, including On-Board Diagnostics (OBD).

1.8.2 Additional requirements for Australia only

The following requirements of this Clause do not apply in New Zealand.

Where a vehicle was originally designed to operate with a closed loop engine management system, NG closed loop management system shall be installed that results in exhaust emission levels for NG operation that meet the requirements of the Australian Design Rules (ADR) applicable to the vehicle.

Where NG equipment is fitted to a vehicle which was originally certified to ADR79/00, the installer shall use a certified kit tested and installed in accordance with one of the requirements of Paragraph E2 of Appendix E.

Where NG equipment is fitted to a vehicle which was originally certified to ADR79/01, the installer shall use a certified kit tested and installed in accordance with the requirements of Paragraph E3 of Appendix E.

Where NG equipment is fitted to a vehicle which was originally certified to ADR70/00, the installer shall undertake the conversion in accordance with one of the methods specified in Paragraph E4 of Appendix E.

Where NG equipment is fitted to a vehicle which was originally certified to ADR80/00 or ADR80/01, the installer shall use a certified kit tested and installed in accordance with the requirements of Paragraph E5 of Appendix E.

Where NG equipment is fitted to a vehicle which was originally certified to ADR 79/02, the installer shall use a certified kit tested and installed in accordance with the requirements of Paragraph E6 of Appendix E.

1.9 APPROVED EQUIPMENT

Only equipment acceptable to the relevant agency shall be used.

NOTE: Appendix B lists the agencies in the Australian States and Territories and New Zealand responsible for activities relating to NG vehicles.

1.10 PREVIOUSLY USED EQUIPMENT

1.10.1 Provisions

Previously used equipment may be transferred to another vehicle provided that the following criteria apply:

- (a) The equipment shall be in good condition and continue to comply with this Standard.
- (b) The container(s) recertification interval shall not have expired.
- (c) Double ferrule fittings shall only be reused if the ferrules are replaced subject to the manufacturer's published catalogue instructions.

1.10.2 Prohibitions

The following components and materials shall not be reused:

- (a) Any piping or hose that has been subject to NG.
- (b) Any fittings used for the connection of pipes or hoses that have been removed from components, except as specified in Clause 1.10.1(c).
- (c) Any grommets or fittings used to seal piping through bulkheads.

1.11 WORKING AREA AND SAFE PRACTICES

The working area specialist equipment and the practices applied during installation, inspection, testing and commissioning shall comply with AS 2746 or New Zealand Transport Agency, Vehicle Inspection Requirements Manual Alternative Fuel System Certification, Section 5, Inspection premises and equipment.

SECTION 2 COMPONENTS

2.1 GENERAL SUITABILITY

2.1.1 General

Components including piping shall be approved and suitable for the conditions of use, e.g. temperature, pressure, corrosion, compatibility and vibration. Components may be combined into multifunction units, provided that such units comply with the requirements for each function.

2.1.2 Suitability for pressure

All components subject to CNG container pressure, excluding the container, shall have a burst pressure of not less than four times the fuel container rated working pressure.

All other components subject to gas fuel system pressure shall have a burst pressure of not less than four times their maximum operating pressure.

2.1.3 Suitability for installation

Components shall be robust enough to withstand the stresses imposed by fitting and tightening the connections.

2.2 COMPONENT PARTS

Components shall be approved in accordance with AG 805 or ISO 15500 Parts 1 to 20 or ECE R110 subject to the requirement of Clause 2.1.2.

2.3 MODIFICATION

Modifications to an approved component shall not be made without specific approval.

SECTION 3 CNG CONTAINER AND FUEL SYSTEM COMPONENTS

3.1 APPLICATION

3.1.1 General

This Section addresses the components, location, mounting, protection, venting and installation requirements for the equipment utilizing CNG operating under container pressure.

3.1.2 Fuel supply system components

The fuel supply system shall be provided with the following components:

- (a) One or more fuel containers.
- (b) Container valve or valves.
- (c) A refuelling connection.
- (d) A refuelling non-return valve.
- (e) Service isolation valve.
- (f) Fuel filter.
- (g) Fuel shut-off device (lock-off).
- (h) Fuel flow regulation devices.
- (i) Refuelling interlock device (New Zealand only).

3.1.3 Use of multiple components

The components specified in Clause 3.1.2 may be combined into multifunction units (see Clause 2.1.1).

3.2 CONTAINER

3.2.1 General

The container shall be a gas cylinder approved for automotive CNG use, for a rated working pressure of at least 20 MPa.

The container shall comply with the requirements of—

- (a) ISO 11439; or
- (b) ANSI NGV 2; or
- (c) CSA B51 Part 2; or
- (d) ECE R110; or
- (e) an approved equivalent Standard.

3.2.2 Container identity and type

The installer shall confirm that—

- (a) the serial numbers stamped or labelled on the containers are identical with those on their associated manufacturing certificates; and
- (b) the container construction type is as specified by the design information/drawing given in the container manufacturing certificate.

3.2.3 Use of removable containers

Containers that are removed for refuelling shall be used only with specific approval for each installation, and then only for vehicles that are unable to refuel at a refuelling station by reason of their slow travelling capability or the inability to place a refuelling station within their reach.

3.2.4 Container painting

Steel containers shall be protected from external corrosion by the application of a protective anti-corrosive coating.

3.3 COMPONENTS FOR REMOVABLE CONTAINERS

A container that is removed from the vehicle for filling shall be provided with at least the following components:

- (a) Refuelling receptacle.
- (b) Dust cap.
- (c) Container valve.

3.4 CONTAINER VALVE

A container valve shall comply with AS 2473, ISO 15500-5 or ANSI/AGA NGV3.1 unless specifically approved otherwise, and shall be mounted directly to the container neck. Container valves shall—

- (a) be equipped with an operating handle which is removable only with the aid of tools; and
- (b) be fitted with one or more pressure relief device(s) which shall be either a combination bursting disc/fusible plug (Type BD/FP2) or a combination pressure relief valve/fusible plug (Type PRV/FP2) or a fusible plug (Type FP2) in accordance with either AS 2613, ANSI/PRD 1, ISO 15500-13 or ECE R110.

NOTE: For containers manufactured to AS 4838 (ISO 11439), ANSI NGV2 or CSA B51, Part 2, the container, the container valve and the pressure relief devices must be approved as a system.

3.5 REFUELLING CONNECTION

3.5.1 Design of connection

In Australia—the refuelling connection shall meet the requirements of ISO 14469 or ANSI/CSA NGV1. The rated working pressure of the refuelling connection shall be suitable for the rated working pressure of the fuel container(s) used. Alternative designs may be used for special applications with specific approval. The receptacle shall be attached to the vehicle.

In New Zealand—the refuelling connection shall be of an approved type, designed to receive a probe type refuelling connection with basic dimensions as given in Appendix C.

3.5.2 Dust cap

In Australia—the refuelling receptacle shall be provided with a captive dust cap (protective cap) which complies with the requirements of ISO 14469 or ANSI/CSA NGV1.

In New Zealand—each refuelling connection shall be provided with a captive dust cap or plug designed to prevent the ingress of foreign material.

3.5.3 Refuelling interlock device (New Zealand only)

In New Zealand—refuelling connections on motor vehicles shall be fitted with a system that prevents the engine starting when the dust plug is removed. This system shall isolate the starting device of the vehicle.

3.6 REFUELLING NON-RETURN VALVE

A non-return valve shall be fitted on the refuelling line to prevent the return flow of gas from the container to the refuelling connection. The non-return valve shall be located as close to the refuelling connection as practicable.

3.7 LOCATION OF REFUELLING RECEPTACLE

The refuelling receptacle shall be located so that the following conditions are satisfied:

- (a) The engagement of the dispenser nozzle to the refuelling receptacle is made and refuelling is supervised from outside the vehicle. The refuelling connection may be directly mounted on the container only if the method of access to it from outside does not result in the opening of a vapour path to the interior of the vehicle, thereby negating the effectiveness of a container compartment or sub-compartment.
- (b) The refuelling receptacle is protected by being located in a recess below the surface of a body panel, or by being located so that equivalent protection is provided by the construction of the vehicle.
- (c) The refuelling operation can be carried out without requiring the operator to kneel or to crawl or lie under the vehicle or be otherwise subject to inconvenience, discomfort or hazard.
- (d) The refuelling receptacle is located and mounted so that any loading resulting from normal refuelling operations, and applied to the refuelling receptacle by the operator or by the refuelling hose in the course of normal refuelling procedures, is minimized.

In addition, the refuelling receptacle shall be attached to the motor vehicle in such a manner as to resist, without permanent deformation of the mounting attachment, the following minimum proof load applied in the forward and reverse directions of travel of the vehicle:

In Australia 670 N

In New Zealand 500 N

The proof load shall be applied by full engagement of the refuelling receptacle and shall be representative of attempted movement of the vehicle while refuelling.

3.8 REFUELLING INFORMATION PLATE

The following information shall appear on a plate that shall be installed near the refuelling receptacle and be clearly visible to the refueller:

- (a) 'CNG'.
- (b) The rated working pressure, in megapascals at a stated temperature.
- (c) Except for removable container systems, the container identification numbers and the stamped date of the next recertification of the container(s) and the capacity of the total installation. When a container is changed or recertified, this information shall be updated.

NOTE: Figure 3.1 illustrates a typical refuelling information plate.

CNG
RATED WORKING PRESS ____ MPa AT 15°C
TOTAL CAPACITY ____ LITRES
FUEL CONTAINER SERIAL NO. ____
NEXT RECERTIFICATION DATE ____

FIGURE 3.1 TYPICAL REFUELLING INFORMATION PLATE

3.9 SERVICE ISOLATION VALVE

A quick acting quarter turn isolation valve shall be installed so that it is—

- (a) readily accessible; and
- (b) arranged to isolate the refuelling receptacle and the engine from the fuel service line.

In Australia, for a vehicle having only one container, this valve is not required.

3.10 FUEL FILTER

A fuel filter shall be installed immediately upstream of the fuel shut-off device and shall be capable of removing from the fuel all particulate matter that could cause malfunction of the valve.

3.11 AUTOMATIC FUEL SHUT-OFF DEVICE

A fuel shut-off device shall be installed immediately upstream of the first stage regulator and shall prevent a flow of gas to the engine unless both the following conditions exist:

- (a) The ignition is on.
- (b) The engine is rotating.

The fuel shut-off device may be permitted to open for a period of up to 3 s when the ignition is first turned on, so as to allow priming of the fuel system.

3.12 FUEL FLOW REGULATION DEVICE

The regulator equipment shall be installed so that—

- (a) it is easily accessible for routine maintenance, adjustment, and inspection;
- (b) it is mounted as close to the point of introduction of natural gas to the engine as practical but shall not be mounted on the engine unless specifically approved by the manufacturer;
- (c) it is reasonably protected from impact in a collision;
- (d) it is closely adjacent to or connects directly with the automatic fuel shut-off device, to which any pipe connection shall be kept as short as possible; and in no case shall the line length be more than 500 mm;
- (e) it allows sufficient free movement of gas and water hoses;
- (f) it is securely mounted;
- (g) the water-circulating system is connected in accordance with the manufacturer's instructions, and so that no flow control valve in the system can shut off hot water flow, e.g. thermostat, heater control valve; and

- (h) the regulator shall, where necessary, be provided with the heat shielding requirements of Clause 3.18.

NOTE: The regulator should, where possible, be no higher than the level of the top of the radiator tank as incomplete water-flooding may cause freezing immediately after starting.

3.13 CONTENTS INDICATOR

The fuel-contents indicating device, where fitted, shall be of a type that does not require gas pressure piping to be located within a driver's or passenger's enclosure.

3.14 CONTAINER COMPARTMENTS AND SUB-COMPARTMENTS

3.14.1 Internal containers

Where a container is located within the body shell of a vehicle—

- (a) the whole of the container together with its attached components and fittings shall be enclosed in a compartment (see Note); or
- (b) the valves, fittings, and pipe connections associated with or attached to the container shall be enclosed in a localized sub-compartment attached to the container.

NOTE: The luggage boot of a car is not considered to be acceptable as a container compartment under Item (a) because of difficulties concerning effectiveness of sealing, the maintenance of ventilation openings, and the presence of electrical equipment in most boots.

3.14.2 Pressure relief device discharge

Any discharge from the container safety device shall be ducted to open air outside any enclosed space for passengers, luggage or goods.

3.14.3 Construction

A container compartment or sub-compartment shall comply with the following requirements:

- (a) Construction shall be such that any gas which might leak from any fitting, component, or piping cannot pass to any other enclosed compartment, passenger space, luggage space or goods space of the vehicle.
- (b) Where pliable material is used as the means of enclosure, the material shall comply with the following requirements:
- (i) Sufficiently strong to resist mechanical damage, preserve venting integrity, and not support combustion.
 - (ii) Minimum tensile strength to ISO 527-3.

Parent material	14 MPa
Material incorporating a transverse seam.....	10 MPa

 All seams shall be lapped and Radio Frequency (RF) welded.
 - (iii) Minimum elongation at break to ISO 527-3.....65%
 - (iv) Minimum tear force to BS 2782: Part 3, Method 360B..... 35 N/mm
 - (v) Resistance to cold cracking. The material shall withstand a bend of 180° applied within 0.5 seconds around a 6 mm diameter former at a temperature of -35°C without cracking.
 - (vi) Flammability. The material shall conform to SAE J369 class SE/NBR.
 - (vii) Resistance to ultraviolet degradation shall be incorporated in the material at manufacture.
- (c) Mechanical protection shall be provided by a separate shield.

- (d) The arrangement shall not create a thermal shield around the container's pressure relief device.
- (e) Where the pressure relief device of the cylinder valve is piped directly away, the container is deemed to not have a sub-compartment and the requirements of Clause 3.14.5 shall be met.

3.14.4 Ventilation

The interior of a compartment or sub-compartment shall be vented to open air by one or more vents that comply with the following requirements:

- (a) The aggregate area, taking into account any piping passing through the vent, shall be not less than 500 mm².
- (b) The vent exit shall be at least 75 mm from an exhaust pipe or similar heat source.
- (c) The location and arrangement of the vent and any associated conduit shall be such that the accumulation of gas is minimized.

The ventilation area shall be the net area. Vent hole data is provided in Table 3.1.

TABLE 3.1
VENT HOLE DATA

Dia. mm	Area mm ²	Dia. mm	Area mm ²
6	30	30	700
8	50	35	960
10	80	40	1250
12	115	45	1590
15	180	50	1960
20	315	55	2370
25	490	60	2830

3.14.5 Conduits

Any conduit required by Clause 3.14.4 shall be installed and comply with the following requirements:

- (a) The thickness of the material at its thinnest point shall be not less than the following:
 - (i) For a material that is a composite of a fabric with an elastomer or plastics 0.7 mm.
 - (ii) For a material that is of plastics or an elastomer without reinforcement as described in Item (i) 1.5 mm.
 - (iii) For material that is a composite of a helical reinforcement and an elastomer plastic 1.0 mm.
- (b) A sample of the conduit, when placed on a flat surface and loaded with 20 kg on an applicator plate 100 mm × 100 mm, placed flat across the conduit, in an ambient temperature between 15°C and 30°C, shall not crush to less than 80 percent of its diameter, and shall return to at least 90 percent of its original diameter when the load is released.
- (c) A sample of the conduit, arranged with both ends connected in a representative manner and plugged, and pressurized to 30 kPa, shall not lose more than 2 kPa in 30 min.

NOTE: Certain conduit materials that feature pronounced internal spiral grooves can prove difficult to seal to spigots and should be avoided where possible, as even with considerable care in applying sealant difficulties in passing the pressure test may be experienced.

- (d) End attachments shall resist a pull-off force of 100 N.
- (e) The material shall conform to SAE J369 class SE/NBR
- (f) The material shall have a resistance to ultraviolet degradation.
- (g) The conduit shall be sealed gastight from the enclosed area, and shall be ventilated to outside atmosphere.

NOTE: Certain conduit materials that feature pronounced internal spirals require considerable care in the application of sealants to ensure that they are gastight.

- (h) The conduit shall be as short as practicable, commensurate with safety.
- (i) The end connections shall be mechanically clamped and shall not depend on adhesives or sealing compounds to retain them in place.
- (j) The holes for the conduit shall be positioned not less than 40 mm from the edge of a panel or a welded joint or direct load bearing point (see Clause 1.6(c)).

3.15 MOUNTING OF FUEL CONTAINER

3.15.1 Access to valves

It shall be possible to operate the service isolation valve and the container valve in the installed position.

The container valve may be arranged so that it can be operated from an internal area of the vehicle provided that the sealing of the compartment or sub-compartment is maintained. The valve-actuating device may either pass through the compartment or sub-compartment wall or be completely enclosed within the compartment. The following requirements shall apply:

- (a) If a valve-actuating device passes through the wall of a compartment or sub-compartment, a gastight seal shall be provided.
- (b) When the compartment or sub-compartment is of rigid construction and the actuating handle is wholly within the wall of the compartment or sub-compartment, access shall be by a gastight captive hatch which can be opened without tools. Marking shall be provided giving instructions that the hatch must be kept closed except when access to the valve is necessary for maintenance or in an emergency.
- (c) Where a rigid construction sub-compartment is used, the sub-compartment shall not form a thermal barrier to the PRD. If the PRD is relocated outside the sub-compartment, it shall be piped to the PRD port of the cylinder valve and the arrangement shall be approved by the cylinder manufacturer.
- (d) When a compartment or sub-compartment is constructed of a pliable material, the valve actuating devices shall be clearly identified by a bright red circle. Adequate surplus material shall be provided to allow rapid closing of the valve without damage to the integrity of compartment sealing.

3.15.2 Attachment to vehicle

The container shall be securely attached to the vehicle to prevent slipping, rotating, and jarring loose, in accordance with the following requirements:

- (a) The method of attachment shall not cause undue stresses in the container wall. Any attaching lugs, brackets or bolts shall be designed so that they will not rupture the container in the event of an accident.
- (b) Supports shall not be welded or bolted to gas containers.

- (c) The mounting method shall not significantly weaken the vehicle structure.
- (d) The area of the vehicle to which the container is attached shall be reinforced if necessary to ensure compliance with Item (e).
- (e) The force necessary to separate the container(s) from the vehicle in any direction shall be not less than the mass of the full container(s) times the design factor shown in Table 3.2.

Where the vehicle is of the original manufactured construction, the design factor shall be as determined by the vehicle manufacturer and the above prescribed design factors may not be applicable.

In all cases, fatigue factors shall be taken into account in the design of the container mounting system.

Where practicable, the strength of the anchorages may be established by—

- (i) dynamic test (where deceleration is at least the applicable value given in Table 3.2 for a duration of 20 ms;
- (ii) static test (forces directed through the centre of mass of the cylinder); or
- (iii) by calculation.

If this is impracticable refer to Clause 3.15.3.

TABLE 3.2
ATTACHMENT DESIGN FACTOR

Acceleration direction	Gross vehicle mass ≤ 3.5 t	Gross vehicle mass > 3.5 t
Longitudinal	20.0g	10.0g
Lateral	8.0g	5.0g
Vertical	4.5g	4.5g

NOTE: g is the gravitational acceleration.

- (f) Screwed fasteners or clamping devices shall either be inherently resistant to loosening or be locked or pinned after tightening.
- (g) Where the container(s) are mounted on the vehicle roof, the container(s) and valves shall be mounted within the perimeter of the vehicle body as determined by the vehicle manufacturer.

3.15.3 Alternate anchoring

If dynamic testing or calculations referred to in Clause 3.15.2(e) are impracticable, the following requirements shall apply:

- (a) For each container, there shall be at least four points of attachment to the vehicle structure, the distance between which shall be sufficient to ensure the stability of the container.
- (b) Where the container is anchored to sheet metal, the sheet metal shall be reinforced at each attachment point with metal plates of areas not less than 3600 mm² and thickness not less than 2.5 mm. Any such reinforcement plates shall be contoured to the shape of the sheet metal or chassis rail. It is preferred that a round washer be used but where a square plate is fitted the corners shall be radiused to 5 mm and the bolt hole shall be positioned in the centre of the plate/washer. Where the bolt hole is not central in the plate, the nearest edge shall be bent to form an L-section for stiffening.

NOTE: Flat areas, even if ribbed, can be unsuitable for mountings without substantial reinforcement, because of flexing and fatigue. Anchoring should be to structural members wherever possible.