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**Road vehicles — Liquefied natural gas  
(LNG) fuel systems —**

**Part 1:  
Safety requirements**

*Véhicules routiers — Systèmes à carburant gaz naturel liquéfié  
(GNL) —*

*Partie 1: Exigences de sécurité*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by ISO/TC 22, *Road vehicles*, Subcommittee SC 41, *Specific aspects for gaseous fuels*.

A list of all the parts in the ISO 19723 series, can be found on the ISO website.

## Introduction

For the purposes of this document, all fuel system components in contact with liquid natural gas have been considered suitable for natural gas as defined in the ISO 15403 series.

When applying this document, it is understood that a safety device to prevent overfilling the vehicle's fuel system is part of the refueling station. The pressure gauge has not been considered as a safety component.

When necessary, technical solutions regarding functional requirements are given in [Annex A](#).

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# Road vehicles — Liquefied natural gas (LNG) fuel systems —

## Part 1: Safety requirements

### 1 Scope

This document specifies the minimum safety requirements applicable to liquefied natural gas (LNG) on-board fuel system intended for use on the types of motor vehicles defined in ISO 3833.

This document is applicable to vehicles (mono-fuel, bi-fuel or dual-fuel applications) using liquefied natural gas in accordance with the ISO 15403 series. It is not applicable to original-production and converted vehicles.

All matters relating to the skills of installers and converters have been excluded from this document.

This document is only applicable on the components in the "LNG system" meaning an assembly of components (tanks, valves, flexible fuel lines, etc., see [Annex B](#)) and connecting parts (fuel lines, fittings, etc.) fitted on motor vehicles using LNG in their propulsion system and related components up to and including the vaporizer. Other parts downstream from the vaporizer are considered as CNG components covered by ISO 15501.

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 12614 (all parts), *Road vehicles — Liquefied natural gas (LNG) fuel system components*

ISO 12617, *Road vehicles — Liquefied natural gas (LNG) refuelling connector — 3,1 MPa connector*

ISO 12991, *Liquefied natural gas (LNG) — Tanks for on-board storage as a fuel for automotive vehicles*

ISO 19723-2, *Road vehicles — Liquefied natural gas (LNG) refueling connector — Test methods*

ISO 15500 (all parts), *Road vehicles — Compressed natural gas (CNG) fuel system components*

IEC 60079-1, *Explosive atmospheres — Part 1: Equipment protection by flameproof enclosures "d"*

IEC 60079-10, *Electrical apparatus for explosive gas atmospheres — Part 10: Classification of hazardous areas*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

### 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at <https://www.iso.org/obp>

— IEC Electropedia: available at <http://www.electropedia.org/>

**3.1**  
**liquefied natural gas**

**LNG**

cryogenic liquid, produced by reducing the temperature of natural gas to about  $-162\text{ }^{\circ}\text{C}$  at atmospheric pressure

**3.2**  
**pressure relief valve**

device that prevents a pre-determined upstream pressure being exceeded

**3.3**  
**working pressure**

maximum pressure that an LNG refuelling connector can be expected to withstand in actual service, equal to the setting of the primary relief valve of the vehicle on board fuel tank

Note 1 to entry: An LNG refuelling connector is understood to be a joined assembly of LNG refuelling nozzle and receptacle.

Note 2 to entry: An LNG refuelling nozzle is understood to be a device which permits quick connection and disconnection of fuel supply hose to the LNG receptacle in a safe manner.

**3.4**  
**service pressure**

intended settled pressure of the tank in use as declared by the manufacturer

**3.5**  
**check valve**

*automatic valve* (3.11) which allows gas or liquid to flow in only one direction

**3.6**  
**fuel pump**

device to establish the supply of LNG to the engine by increasing the pressure of the fluid (liquid or vapour)

**3.7**  
**category M**

<vehicle category> power-driven vehicles having at least four wheels and used for the carriage of passengers

**3.7.1**  
**M1**

<vehicle category> vehicles used for the carriage of passengers and comprising no more than eight seats in addition to the driver's seat

**3.7.2**  
**M2**

<vehicle category> vehicles used for the carriage of passengers and comprising more than eight seats in addition to the driver's seat and having a maximum authorized mass not exceeding 5 000 kg

**3.7.3**  
**M3**

<vehicle category> vehicles used for the carriage of passengers and comprising more than eight seats in addition to the driver's seat and having a maximum authorized mass exceeding 5 000 kg

**3.8**  
**category N**

<vehicle category> power-driven vehicles having at least four wheels and used for the carriage of goods

**3.8.1****N1**

<vehicle category> vehicles used for the carriage of goods and having a maximum authorized mass not exceeding 3 500 kg

**3.8.2****N2**

<vehicle category> vehicles used for the carriage of goods and having a maximum authorized mass exceeding 3 500 kg but not exceeding 12 000 kg

**3.8.3****N3**

<vehicle category> vehicles used for the carriage of goods and having a maximum authorized mass exceeding 12 000 kg

**3.9****protected position**

area where components are installed to be protected against impact or collision

**3.10****excess flow limiting device**

device that automatically shuts off, or limits, the gas or liquid flow when the flow exceeds a certain defined criteria

**3.11****automatic valve**

valve or combination of valves that is/are not operated manually

Note 1 to entry: A manual valve is a valve which is operated manually.

**3.12****gas-tight housing**

device which vents gas leakage to outside the vehicle including the gas ventilation hose, the clear opening of which is at least 450 mm<sup>2</sup>

**4 Requirements****4.1 Design****4.1.1 General**

The LNG on-board fuel system components shall comply with ISO 12614 (all parts) and ISO 12617, as applicable.

The pressure system, specified in ISO 12614-1, shall be designed on the basis of the service pressure.

For bi-fuel vehicles, provision shall be made to avoid accelerated deterioration of the non-LNG fuel system as a result of sustained operation on natural gas. Such measures shall be as recommended by the original vehicle manufacturer (e.g. fuel hoses).

All fuel system components shall fulfill the following conditions.

- a) They shall withstand the environmental temperatures and other environmental conditions safely during their operational life.
- b) They shall be located with full regard for anticipated damage while the vehicle is being used safely. Such damage can be caused by the vehicle itself, by extraneous factors such as heat, road debris, automotive chemical splash (brake liquid, oil, petrol, cooling liquid, etc.), or by rust, etc.

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- c) They shall not exceed the outermost, highest or lowest parts of the vehicles without further protection.
- d) They shall be fitted so as not to affect ground clearance, approach angle, ramp (break-over) angle or departure angles as defined by the vehicle manufacturer.
- e) They shall be located so that they will not suffer corrosion damage by accumulation of water or cargo chemicals.
- f) They shall assure the proper electrical conductivity throughout the fuel system in order to avoid electrostatic charges. This provision does not apply to gas-tight housing and ventilation hoses.
- g) All connections shall be made in locations where access is possible for inspection.

The system shall be so designed that galvanic corrosion is minimized.

The system shall be so designed that using a grounding point protects it against electrical discharge.

The following tank components, when used, shall be placed in a safe place or suitably protected against damage, such as that arising from moving vehicle components, collision and grit or that due to loading or unloading of the vehicle or the shifting of those loads:

- manual valve(s);
- pressure relief valve(s) (PRV);
- automatic shut-off valve;
- excess flow limiting device;
- fill check valve.

The manual valves shall be easily accessible.

The LNG on-board fuel system shall include:

- LNG tank(s) or vessel(s);
- LNG heat exchanger/vaporizer;
- LNG pressure relief valve(s);
- LNG venting system;
- LNG receptacle;
- LNG excess flow limiting device;
- LNG manual valve or means to isolate the tank;
- LNG/CNG automatic valve or means to isolate the tank;
- LNG fuel line;
- LNG couplings;
- LNG check valve or non-return valve;
- LNG pressure indicator or fuel indicator;
- Electronic Control Unit (no separate ECU necessarily – can be integrated);
- natural gas detector or gas-tight housing for category M vehicles.

The LNG on-board fuel system may include:

- LNG pressure control regulator;
- LNG pressure and/or temperature sensor;
- LNG fuel pump;
- LNG level gauge;
- a device inside the gas tank or a functionally equivalent system to control gas leakage in the event of a rupture in the fuel supply system (see [Annex A](#));
- gas-tight housing.

## 4.1.2 Components

### 4.1.2.1 Receptacle

The receptacle shall comply with the applicable part of ISO 12617. The receptacle shall be provided with a cap to minimize the entry of dust, fluid or other foreign matter, which shall be attached to the vehicle or to the fuel system.

The following data should be displayed near the receptacle (marking shall be made either by labels attached, by adhesive or plates attached by welds):

- type of fuel (i.e. “LNG” for liquefied natural gas);
- service pressure for the vehicle.

### 4.1.2.2 LNG pressure relief valves (primary and secondary)

The primary pressure relief valve outlet shall be connected to an open ended pipe-away system to move vented gas away to a high level. Consideration shall be given to preventing any blockage or freezing of the pipe away.

The secondary relief valve may relieve gas immediately from its outlet. Protection from water ingress and damage shall be considered. The secondary relief valve outlet shall not be connected to the same pipe away as the primary relief valve.

### 4.1.2.3 LNG excess flow limiting device

The LNG excess flow limiting device can be fitted inside or directly on the LNG tank (in a protected position).

The LNG excess flow limiting device function may be fulfilled by an LNG/CNG valve (automatic) in a protected position.

### 4.1.2.4 LNG/CNG valve (automatic)

The LNG/CNG valve (automatic) shall only be open when:

- LNG operation has been selected, either manually or automatically; and
- the engine is cranking or running, irrespective of the position of the ignition switch.

An auxiliary system may be permitted if the propulsion system and related components are adequately protected and the required operation of the LNG system is not affected.

Only automatic valves that are normally closed when deactivated shall be used in the LNG on-board fuel system for each LNG tank mounted.

In vehicles equipped with start-stop system, the LNG/CNG automatic valve can stay open or closed provided they are of the correct type.

- The automatic valve shall be installed in the fuel supply line, directly on every LNG tank (in a protected position).
- The automatic valve shall be operated such that the fuel supply is cut off when the engine is switched off, irrespective of the position of the ignition switch, and shall remain closed while the engine is not running. The heating system shall be permitted if the heating system is adequately protected and the required operation of the normal CNG and/or LNG system is not affected.

#### 4.1.2.5 LNG check valve or non-return valve

No bypass is allowed.

Manual override for vent return is allowed.

It shall be mounted inside the protected area of the LNG tank as close as possible to the tank itself.

#### 4.1.2.6 LNG pressure indicator or fuel indicator

The pressure indicator shall have visibility during fuelling.

#### 4.1.2.7 Vent line or connector

The vent line or connector may be mounted inside or on the LNG tank (in a protected position). It should be readily accessible. The vent connector shall be suitable for the purpose at temperatures indicated in ISO 12614-2 and for the working pressure of the tank. A Vent (manual) valve is allowed and shall be located in protected position.

#### 4.1.2.8 Venting management system

The primary pressure relief valve shall be piped to a vent stack which extends to a high level. The primary and secondary relief valve outlets shall be protected from fouling by dirt, debris, snow, ice and/or water. The vent stack shall be sized to prevent flow restriction due to pressure drop. Gas exiting the vent stack or secondary relieve valve shall not impinge on enclosed areas, other vehicles, exterior-mounted systems with air intake (i.e. air-conditioning systems), engine intakes, or engine exhaust. In the case of multiple tanks, the primary relief valve outlets piping for each tank may be manifold to a common stack.

#### 4.1.2.9 Natural gas detector

The LNG system in category M vehicles shall be equipped with a natural gas detector and/or gas-tight housing. The LNG system in category N vehicles may be equipped with a natural gas detector if the fuel storage tank and associated piping is mounted on the exterior of the vehicle without the possibility of gas accumulation. If the fuel storage tank is located inside the cargo area of a category N vehicle, then a natural gas detector and/or gas-tight housing shall be present.

NOTE LNG powered vehicles use un-odourized LNG. Therefore, using natural gas detector is the proper way to detect any LNG leakage.

## 4.2 Refuelling

### 4.2.1 General

The piping, receptacle and all valves and fittings installed on board the LNG vehicle should be selected to minimize the pressure drop along the lines, and hence minimize the filling time of the LNG on-board fuel system.

#### 4.2.2 Receptacle location

The receptacle should be installed in a suitable on-board location that is easy to reach, allowing safe operation. The preferred location is on the side of the vehicle.

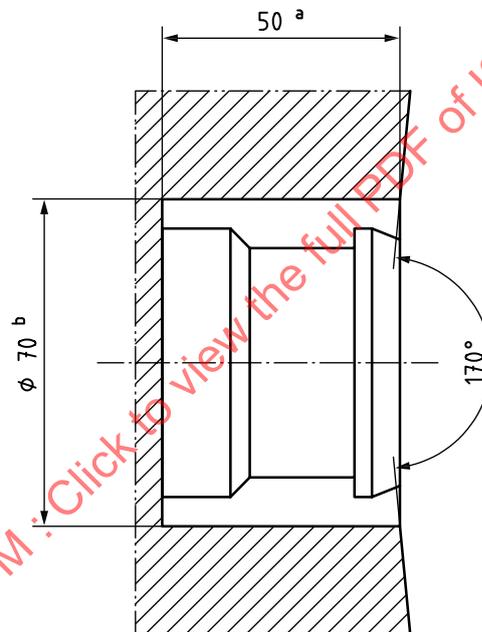
Receptacles shall not be installed in the engine compartment. They shall not be fixed near the battery or the ignition high-tension circuit.

#### 4.2.3 Receptacle mounting

The vehicle's LNG on-board fuel system shall be able to withstand a minimum loading on the receptacle in any direction without its gas-tightness being affected (in the case of a refueling hose breakaway) as described in ISO 12617:2015, 10.6.1.

#### 4.2.4 Minimum receptacle clearance

The minimum receptacle clearance is shown in [Figure 1](#).



#### Key

- a Minimum length of the receptacle clear of provision for attachment of receptacle or protective cap.
- b For minimum coupling clearance only. System designers should ensure that the dust- or pressure-tight cap operates freely in the provided space.

**Figure 1 — LNG Receptacle/nozzle interface envelope**

NOTE Depending on the vehicle design, the overall depth of the refueling cavity does not need to be as large as indicated in [Figure 1](#).

### 4.3 Leakage control

**4.3.1** Pressurized gas systems shall be designed so that they withstand the stresses that can be expected during operation without leakage.

After assembly, the vehicle's LNG on-board fuel system shall be tested for leakage.

**4.3.2** The tank or parts of the gas system, or both, shall be mounted in a position which ensures that any leaking or venting gas from the fuel systems does not directly enter the driver or passenger

compartment, boot or other spaces not sufficiently ventilated. Alternatively, it shall be ensured that any leaked gas is directed safely to the atmosphere (see [Annex A](#)).

**4.3.3** Where a tank or vessel is located within the driver or passenger compartment or other insufficiently ventilated space, the valves, connections and pipework shall be enclosed in a gas-tight housing such that any gas leakage is vented and directed to the outside of the vehicle.

**4.3.4** Any ventilation opening shall be positioned away from any openings into any vehicle compartment, away from any ignition source, and in a location where it is not susceptible to blockage.

#### **4.4 Mounting of the tank(s)**

**4.4.1** The tank(s) shall be securely attached to the vehicle to prevent slipping, rotating and dislodging. The installation shall be according to the tank manufacturer's instructions and ISO 12991.

**4.4.2** LNG tank and attachments for mounting on the vehicle shall be designed and constructed to minimize wear, corrosion (field welding on tanks is not permitted) and fatigue during the service life of the vehicle.

**4.4.3** Testing of tank(s) or vessel (s) shall be conducted in accordance with ISO 19723-2. The tank(s) or vessels(s) shall be mounted and fixed so that the following accelerations can be absorbed (without damage occurring) when the tanks are full.

- a) Vehicles of categories M1 and N1:
  - 20 g in the direction of travel (forward/backward);
  - 8 g horizontally perpendicular to the direction of travel;
  - if the cylinders are mounted under the vehicle, 5 g in the vertical downward direction.
- b) Vehicles of categories M2 and N2:
  - 10 g in the direction of travel (forward/backward);
  - 5 g horizontally perpendicular to the direction of travel;
  - if the cylinders are mounted under the vehicle, 5 g in the vertical downward direction.
- c) Vehicles of categories M3 and N3:
  - 6,6 g in the direction of travel (forward/backward);
  - 5 g horizontally perpendicular to the direction of travel;
  - if the cylinders are mounted under the vehicle, 5 g in the vertical downward direction.

LNG fuel tank(s) shall be located or given protection such that its piping, fittings, and valve are protected from damage due to contact with objects encountered during operation of the vehicle.

#### **4.5 Heat protection**

To prevent heat damage, proper shielding against heat of adjacent components shall be considered. Components shall be installed at least 100 mm from the exhaust system. Otherwise, heat shields shall be installed.

## 4.6 Minimizing risk of gas ignition

To prevent fire in a vehicle, the ignition sources shall be minimized.

Electric and electronic components in gas-tight housings shall be suitable for hazardous areas as defined in IEC 60079-1 and IEC 60079-10.

The location of electrical cables and mountings of LNG on-board fuel system components shall be designed to protect against the potential ignition of leaked gas.

In case of fracture of the component, in order to prevent electric sparks on the surface of fracture, electrical operated devices containing LNG shall:

- be insulated so that no current is lead through LNG containing parts;
- have the electrical system of the device isolated from the body of the vehicle and from the LNG fuel tank for the fuel pump.

The isolation resistance of all electrical operated devices shall be according to the mentioned values of ISO 15500 (all parts).

The electrical connections inside the boot and passengers compartment shall comply with protection degree class IP 40 according to IEC 60529.

All other electrical connections shall comply with protection degree class IP 54 according to IEC 60529.

## 4.7 Venting system

**4.7.1** There is no general best direction to release the gas through the PRV; it should be evaluated on a case by case design.

The gas shall be released in a dispersed manner. The dispersion method shall not restrict the venting capacity of any PRV.

Vent systems shall prevent the accumulation of water or debris in the tubes or in the PRV, as this can cause the PRV to fail or prevent proper venting after actuation. Ice, in particular, can damage PRVs or vent lines. Care shall be taken that any vent line closures are durable and not damaged by use, including power washers and brushes, impact with overhead branches, or other handling.

In addition, the PRV vent ports on each LNG tank shall be arranged such that no gas jet can impinge directly on other LNG tanks in the on-board fuel storage systems.

Leakage and venting of natural gas (or other flammable substances) from the PRVs shall be dealt with properly to avoid the dangers due to releasing flammable substances in enclosed spaces.

### 4.7.2 Ventilation lines for PRVs.

If a ventilation line is installed on a pressure relief valve, it shall be of sufficient diameter for the purpose. In addition, this ventilation line and system shall:

- a) have a minimum internal diameter not less than the pressure relief valve discharge opening(s), and the diameter shall be of sufficient size to not be obstructed by any material discharged by the PRV;
- b) be secured at intervals in a manner that minimizes the possibility of damage, corrosion, or breakage due to expansion, contraction, vibration, strains, or wear and that precludes any loosening while in operation;
- c) have a minimum burst pressure at least 1,5 times the working pressure of the LNG tank. Where vent lines are discharged into an increased diameter manifold or line, the pressure requirement of that manifold or line shall be fit for purpose;

- d) not direct the discharge into or toward the passenger or luggage compartment, into or toward wheel housings, toward LNG storage systems, or toward the front of the vehicle;
- e) minimize the possibility of external hazards (e.g. projectiles) resulting from activation of the device;
- f) be constructed of materials that mitigate the risk of corrosion, and shall not cause galvanic corrosion at the interface connection to the pressure relief valve.

## **5 Instruction for use**

An instruction manual shall be provided which includes specific instructions regarding LNG fuel system operation and that alerts the owner to the tank inspection or expiration date.

## **6 Marking**

If other than vehicle original equipment manufacturer (OEM), a label or plate identifying the installer of the LNG system with reference to this document shall be permanently attached to the vehicle in an accessible area.

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