
**Road vehicles — Compressed natural
gas (CNG) fuel systems —**

Part 1:
Safety requirements

*Véhicules routiers — Systèmes d'alimentation en gaz naturel
comprimé (GNC) —*

Partie 1: Exigences de sécurité

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Published in Switzerland

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 15501-1 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 25, *Vehicles using gaseous fuels*.

This second edition cancels and replaces the first edition (ISO 15501-1:2001), which has been technically revised.

ISO 15501 consists of the following parts, under the general title *Road vehicles — Compressed natural gas (CNG) fuel systems*:

- *Part 1: Safety requirements*
- *Part 2: Test methods*

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Introduction

For the purposes of this part of ISO 15501, all fuel system components in contact with natural gas have been considered suitable for natural gas as defined in ISO 15403.

When applying this part of ISO 15501, it is to be understood that a safety device that prevents overfilling of the vehicle's fuel system is part of the refuelling station. The pressure gauge is not considered a safety component.

Where necessary, technical solutions to functional requirements are given in Annex A.

This part of ISO 15501 makes reference to a service pressure of 20 MPa¹⁾ [200 bar²⁾] for natural gas used as fuel, settled at 15 °C. It is possible to accommodate other service pressures by adjusting the pressure using the appropriate factor (ratio). For example, a 25 MPa (250 bar) service pressure system will require pressures to be multiplied by 1,25.

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1) 1 MPa = 1 N/mm².

2) 1 bar = 0,1 MPa = 10⁵ Pa.

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Road vehicles — Compressed natural gas (CNG) fuel systems —

Part 1: Safety requirements

1 Scope

This part of ISO 15501 specifies the minimum safety requirements applicable to compressed natural gas (CNG) on-board fuel systems intended for use on the types of motor vehicles defined in ISO 3833. This part of ISO 15501 is applicable to vehicles using compressed natural gas as defined in ISO 15403, including bi-fuel, original-production and converted vehicles.

Matters relating to the skills of installers and converters are outside the scope of this part of ISO 15501.

2 Normative references

The following referenced documents are indispensable for the application 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 1176, *Road vehicles — Masses — Vocabulary and codes*

ISO 11439, *Gas cylinders — High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles*

ISO 14469-1, *Road vehicles — Compressed natural gas (CNG) refuelling connector — Part 1: 20 MPa (200 bar) connector*

ISO 14469-2, *Road vehicles — Compressed natural gas (CNG) refuelling connector — Part 2: 20 MPa (200 bar) connector, size 2*

ISO 14469-3, *Road vehicles — Compressed natural gas (CNG) refuelling connector — Part 3: 25 MPa (250 bar) connector*

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

ISO 15501-2, *Road vehicles — Compressed natural gas (CNG) fuel systems — Part 2: Test methods*

IEC 60079-10-1, *Explosive atmospheres — Part 10-1: Classification of areas — Explosive gas atmospheres*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 15500-1, ISO 1176, and the following apply.

3.1

service pressure

settled pressure of vehicle fuel system at a uniform natural gas temperature of 15 °C

3.2

CNG on-board fuel system

compressed natural gas fuel system comprising a cylinder, or cylinders, mounting hardware, a refuelling receptacle or more than one of each of these, in accordance with ISO 14469, and the components described in ISO 15500-3 to ISO 15500-20

3.3

main shut-off valve

automatic valve designed to isolate a high-pressure source

3.4. Vehicle mass

3.4.1

kerb mass

complete shipping mass of a vehicle fitted with all equipment necessary for normal operation plus the mass of the following elements for categories M1, N1 and M2 whose maximum authorized mass does not exceed 3 500 kg:

- lubricants, coolant (if needed), washer fluid;
- fuel (tank filled to at least 90 % of the capacity specified by the manufacturer);
- other equipment if included as basic parts for the vehicle, such as spare wheel(s), wheel chocks, fire extinguisher(s), spare parts and tool kit

NOTE The definition of kerb mass can vary from country to country, but in this part of ISO 15501, it refers to the definition given in ISO 1176.

3.4.2

maximum authorized mass

kerb mass plus the maximum allowable payload

3.5 Vehicle categories

3.5.1

category M

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

3.5.1.1

category M1

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

3.5.1.2

category M2

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

3.5.1.3

category M3

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

3.5.2

category N

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

3.5.2.1

category N1

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

3.5.2.2

category N2

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

3.5.2.3

category N3

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

4 Requirements

4.1 Design

4.1.1 General

4.1.1.1 The CNG on-board fuel system components shall comply with ISO 11439, ISO 14469 and ISO 15500, as applicable.

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

4.1.1.3 All fuel system components shall fulfil 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 liable to occur while the vehicle is being used safely.

NOTE 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.

- c) They shall be fitted so that they are not the outermost, highest or lowest parts of the vehicle; otherwise they shall be protected.
- d) They shall be fitted so as not to affect the ground clearance, approach angle, ramp (break-over) angle or departure angles defined by the vehicle manufacturer.
- e) They shall be located so as not to suffer corrosion damage through accumulation of water or cargo chemicals.
- f) They shall ensure 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.

4.1.1.4 The CNG system [including the gas cylinder valve(s), pressure-relief device(s) (PRDs) and one or more automatic valves designed to close when the engine is not running on CNG and to be opened or closed manually in the event of automated failure (see Annex B)] shall be installed in such a way that it is 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.

4.1.1.5 The CNG on-board fuel system shall include

- a) a main shut-off valve that remains closed when the engine is not running on CNG,
- b) a manual or automatic override valve located on each gas cylinder,
- c) a PRD installed on each cylinder, which is functionally independent from any other component, and
- d) a device located inside the cylinder, or a functionally equivalent system, to control gas leakage in the event of an abnormal flow (see Annex A).

4.1.1.6 The main shut-off valve shall only be open when

- a) CNG operation has been selected, either manually or automatically, and
- b) the engine is cranking or running.

4.1.1.7 Only automatic valves that are normally closed when deactivated shall be used in the CNG on-board fuel system.

4.1.2 Components

4.1.2.1 Receptacle

The receptacle shall comply with the applicable part of ISO 14469.

The receptacle shall be provided with a dust cap, which shall be attached to the vehicle, to prevent entry of dust, fluid or other foreign matter.

The following data should be displayed near the receptacle (with permanent marking):

- a) type of fuel (i.e. "CNG" for compressed natural gas);
- b) expiry date for gas cylinders;
- c) service pressure for the vehicle.

4.1.2.2 Gas cylinder

Gas cylinders shall be provided with cylinder valves and pressure-relief devices and shall be mounted in accordance with 4.4.

To prevent heat damage, gas cylinders and appurtenances shall either use a heat shield or be located in relation to the exhaust system such that their skin temperature does not exceed the value specified by the vehicle or cylinder manufacturer.

All fiber-reinforced gas cylinders (types 2, 3, and 4 in accordance with ISO 11439) shall be protected from ultraviolet radiation.

4.1.2.3 Pressure regulator

Components located downstream of the pressure regulator shall be protected from overpressurization due to regulator failure.

4.1.2.4 PRD and PRV

The PRD and the pressure-relief valve (PRV) shall be protected from dirt and water ingress and shall be located as far away as possible from sources of ignition and heat in the vehicle.

The PRD shall comply with ISO 15500-13, venting gas to prevent the cylinder from rupturing.

The PRV shall be used to prevent overpressurization of the system downstream of the first stage of the pressure regulator(s). If multiple regulators are used, it may be necessary to provide additional PRVs.

4.1.2.5 Pipework

Pipework shall be laid, if possible on the chassis, in such a way that no damage from intrinsic vibrations occurs (e.g. resonance with engine vibration) and so that there are no friction points. The interval between two attachment points shall not exceed 0,60 m, and pipework installation and bending shall be in accordance with the pipe and fitting manufacturer's specification. Adequate provision shall be made to allow adequate essential flexibility.

4.2 Refuelling connection

4.2.1 General

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

4.2.2 Receptacle location

The receptacle should be installed in a suitable on-board location that is easily accessible, thereby ensuring safe operation. The preferred location is on the side of the vehicle.

Receptacles installed inside the engine compartment shall be attached to the vehicle chassis or body.

They shall not be fixed near the battery or the ignition high-tension circuit.

4.2.3 Receptacle mounting

The vehicle's CNG on-board fuel system shall be able to withstand a minimum 670 N loading and 200 N·m bending moment on the receptacle in any direction without its gas tightness being affected (in the case of a refueling hose breakaway).

4.2.4 Minimum receptacle clearance

Minimum receptacle clearances shall be as stated in the appropriate part of ISO 14469.

4.3 Leakage control

4.3.1 Pressurized gas systems shall be designed to withstand without leakage the stresses that can be expected during operation. After assembly, the vehicle's CNG on-board fuel system shall be tested for leakage.

4.3.2 The cylinder 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/trunk or any other insufficiently ventilated space. Alternatively, it shall be ensured that any leaked gas will be directed safely to the atmosphere (see Annex A).

4.3.3 Where a cylinder is located within the driver or passenger compartment or another 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 outside of the vehicle. If the valves are self-venting, the gas-tight housing shall enclose the connections, pipework and venting orifices. There is no need to enclose the body of the valve if all the possible leakage sources (included the cylinder–valve interface) are sealed and vented into the valve's interior venting passages. In the event of fire, the requirement of venting gas to the outside of the vehicle does not apply.

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.

4.3.5 Any enclosure containing the thermal-reactive elements of a PRD shall be permeable to heat in order to allow the temperature of the PRD to rise to the temperature of the cylinder surroundings.

4.4 Mounting of the cylinder(s)

4.4.1 The cylinder(s) shall be securely attached to the vehicle so as to prevent slipping, rotating and dislodging. The installation shall be in accordance with the cylinder manufacturer's instructions and ISO 11439.

4.4.2 The gas cylinder and attachments for mounting it on the vehicle shall be constructed so that the mountings are not subject to failure due to wear, corrosion or fatigue during the service life of the vehicle. Welding on cylinders is not permitted.

4.4.3 The fuel container(s) or cylinder(s) shall be mounted and fixed so that the accelerations listed below can be absorbed (without damage occurring) when the containers are full and operating at the service pressure. When tested in accordance with ISO 15501-2, the cylinder shall remain attached to the vehicle under the following accelerations, where g is the gravitational acceleration:

- a) vehicles of categories M1 and N1:
 - 1) 20 g in the direction of travel;
 - 2) 8 g horizontally, perpendicular to the direction of travel;
- b) vehicles of categories M2 and N2:
 - 1) 10 g in the direction of travel;
 - 2) 5 g horizontally perpendicular to the direction of travel;
- c) vehicles of categories M3 and N3:
 - 1) 6,6 g in the direction of travel;
 - 2) 5 g horizontally, perpendicular to the direction of travel.

A calculation method may be used instead of practical testing if its equivalence can be demonstrated.

For each category, if the cylinders are mounted under the vehicle, the structure shall be able to withstand an acceleration of 5 g in the vertical downward direction without damage.

4.5 Heat protection

Components (except gas cylinders and appurtenances, which shall comply with 4.1.2.2) 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 over cylinder valve fittings shall be suitable for hazardous areas as defined in IEC 60079-10-1.

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

4.7 Venting system

There is no optimum direction for releasing gas through the PRD. The gas should be released in a dispersed manner. The dispersion method shall not restrict the venting capacity of any PRD.

Vent systems shall be constructed to ensure that no water or debris accumulates in the tubes or in the PRD as this can cause the PRD to fail or prevent proper venting after activation. Ice in particular can damage PRDs or vent lines. Care shall be taken to ensure that any vent line closures are durable and not damaged by use, including exposure to power washers and brushes, impact from overhead branches, or other handling.

In addition, the PRD vent ports on each fuel cylinder shall be arranged such that no gas jet can impinge directly on other CNG cylinders in the on-board fuel storage systems.

5 Instructions for use

An instruction manual shall be provided which includes specific instructions regarding CNG operation and alerts the owner to the cylinder inspection or expiration date.

6 Marking

If different from the original equipment manufacturer (OEM), a label or plate identifying the installer of the CNG system, with reference to this part of ISO 15501, shall be permanently attached to the vehicle.

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Annex A (informative)

Technical solutions to functional requirements

A.1 Prevention of hydrate and ice formation

As a guideline, in order to prevent hydrate and ice formation,

- a) the gas quality designation should be as defined in ISO 15403, and
- b) the high-pressure regulator should be heated.

A.2 Ventilation

Ventilation of the valves, connections and pipework may be achieved by either

- a) placing the cylinder and its fittings in a durable enclosure which is sealed such that it is gas-tight to the compartment or space and which is provided with permanent ventilation, or
- b) enclosing the neck of the cylinder and its fittings with a specially designed durable envelope which is gas-tight to the compartment and which is provided with permanent ventilation, or
- c) installing a self-venting valve that vents every possible leakage source (including the connection between the valve and the cylinder) through internal passages; and enclosing pipework, connections and the valve's venting outlets in venting hoses that direct the gas to a safe location outside the vehicle, or
- d) using any ventilation method that does not impede proper functioning of the PRD, by separating it from the heat to which the cylinder is exposed; fire testing of the cylinder and PRD combination should be carried out with representative ventilation enclosures.

A.3 Control of gas escape in the event of pipe fracture or rupture

There are three schools of thought in practice globally with regard to action following rupture of a CNG fuel system:

- a) gas flow is completely shut off in each cylinder;
- b) gas flow is limited by the use of a flow limiter;
- c) gas is allowed to escape without any restriction.

No method has been proven safer than another.