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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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ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

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Foreword

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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).

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).

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For an explanation on 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.

The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 41, *Specific aspects for gaseous fuels*.

This third edition cancels and replaces the second edition (ISO 15501-1:2012), which has been technically revised.

A list of all parts in the ISO 15501 series can be found on the ISO website.

Introduction

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

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

When necessary, technical solutions regarding functional requirements are given in Annex A.

This document refers to a service pressure of 20 MPa (200 bar).

NOTE 1 1 bar = 0,1 MPa = 10^5 Pa. 1 MPa = 1 N/mm^2.

NOTE 2 This document is based upon a service pressure for natural gas as fuel of 20 MPa (200 bar) settled at 15 °C. Other service pressures can be accommodated by adjusting the pressure by the appropriate factor (ratio). For example, a 25 MPa (250 bar) service pressure system will require pressures to be multiplied by 1,25.

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

Part 1: Safety requirements

1 Scope

This document specifies the minimum safety requirements applicable for the functionality of CNG on-board fuel systems intended for use on the types of motor vehicles defined in ISO 3833. This document is applicable to vehicles using compressed natural gas in accordance with ISO 15403, including mono-fuel, bi-fuel or dual-fuel applications, original-production and converted vehicles.

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

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

ISO 14469 (all parts), *Road vehicles — Compressed natural gas (CNG) refuelling 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 1176, ISO 15500-1 and the following apply.

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

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

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
service pressure
settled pressure of 20 MPa (200 bar) at a uniform gas temperature of 15 °C

3.2
CNG on-board fuel system
compressed natural gas fuel system comprising cylinder, or cylinders according to ISO 11439, mounting, one or more refuelling receptacles according to ISO 14469 (all parts), 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
mono-fuel NGV
vehicle which operates on natural gas only

Note 1 to entry: Also known as “Dedicated Natural Gas Vehicle”.

Note 2 to entry: In Europe and in India the term Mono-Fuel also applies to a light duty NGV with max 15 l gasoline tank.

3.5
bi-fuel NGV
vehicle that has two independent fuel systems (one of them for natural gas) and can run alternatively on either fuel, but only on one at a time

Note 1 to entry: The term bi-fuel also applies to vehicles that run on both fuels simultaneously in limited amount or duration.

3.6
dual-fuel NGV
vehicle that has two independent fuel systems (one of them for natural gas) and can run on both fuels simultaneously

Note 1 to entry: Vehicle also may run on one fuel alone.

3.7 Vehicle mass

3.7.1
kerb mass
complete shipping mass of a vehicle fitted with all equipment necessary for normal operation plus the mass of the following elements for M1, N1 and M2 having a maximum authorized mass not exceeding 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 wheels, wheel chocks, fire extinguishers, spare parts and tool kit

Note 1 to entry: The definition of kerb mass may vary from country to country, but in this document it refers to the definition contained in ISO 1176.

3.7.2
maximum authorized mass
kerb mass plus the maximum allowable payload

3.8 Vehicle categories

3.8.1
category M
power-driven vehicles having at least four wheels and used for the carriage of passengers

3.8.1.1
category M1
vehicles used for the carriage of passengers and comprising no more than eight seats in addition to the driver’s seat

3.8.1.2
category M2
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

3.8.1.3
category M3
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

3.8.2
category N
power-driven vehicles having at least four wheels and used for the carriage of goods

3.8.2.1
category N1
vehicles used for the carriage of goods and having a maximum authorized mass not exceeding 3 500 kg

3.8.2.2
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

3.8.2.3
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

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

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 (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 may be caused by the vehicle itself, by extraneous factors such as heat, road debris, automotive fluids (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 vehicles; otherwise they shall be protected.

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 ensure the proper electrical conductivity throughout the fuel system in order to avoid the electrostatic charges. This provision does not apply to gas-tight housing and ventilation hose.

g) All connections shall be made in locations where access is possible for inspection.

The CNG system shall be installed in such a way that it has suitable protection against damage, such as damage due to moving vehicle components, collision, grit or due to the loading or unloading of the vehicle or the shifting of those loads.

The CNG system shall include automatic valves designed to close when the engine is not running on CNG, and shall be able to be manually opened or closed in case of failure of the automatism (see Annex B).

The CNG on-board fuel system shall include the following:

— an automatic valve to be installed directly on every CNG cylinder with a manual valve rigidly fixed to the CNG cylinder, which may be integrated into the automatic valve. The manual valve shall be able to isolate the cylinder content from the automatic valve;

— a PRD installed on each cylinder, functionally independent from any other component;

— one or more additional PRD as applicable to the approval of the cylinder according to ISO 11439; and

— an excess flow valve inside every cylinder or a functionally equivalent system to control the gas leakage in the event of an abnormal flow (see informative Annex A).

The automatic valve shall be closed when

— the vehicle is not operating on CNG, and

— the engine is not running.

The valve may remain open when the engine stops during the stop phase in start-stop systems where the valve shall remain open by design.

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 ISO 14469 (all parts).

The receptacle shall be provided with a protective cap, to prevent the entry of dust, fluid or other foreign matter. The protective cap shall be attached in such a way that will prevent loss of the cap.

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

— type of fuel (i.e. "CNG" for compressed natural gas);

— periodic inspection date for gas cylinders according to ISO 11439 or applicable regulations; and

— service pressure for the vehicle.

4.1.2.2 Gas cylinder

Gas cylinders shall be provided with cylinder valves, automatic valves, excess flow valves (or a functionally equivalent system) 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, valves (including PRD) or cylinder manufacturers and in accordance to ISO 11439 and ISO 15500. If no shielding is provided, there shall be a clearance of at least 100 mm between the fuel container and the exhaust system.

All fibre-reinforced gas cylinders (types 2, 3, and 4 according to ISO 11439) shall be protected from ultraviolet radiation and automotive fluids.

4.1.2.3 Pressure regulator

Components located downstream of the pressure regulator shall be protected from over pressurization due to regulator failure. This protection may be provided by components inside the pressure regulator (i.e. pressure relief valve) as specified in ISO 15500-9.

4.1.2.4 PRD and PRV

The suggested configuration for PRDs is parallel combination or thermal relief device for every type of cylinder. Series PRDs may only be used in type 1 steel cylinders and shall not be used in type 2, type 3 and type 4 cylinders.

The PRD 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 protect cylinder rupture.

The PRV shall be used to prevent over pressurization of the system downstream of the first stage of the pressure regulator or regulators. If multiple regulators are used it may be necessary to provide additional PRVs.

PRVs may be used upstream of the first stage of the pressure regulator.

PRVs shall be protected from dirt and water ingress.

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 there are no friction points. The intervals 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 to minimize the pressure drop along the lines, and hence minimize the filling time of, and maximize the fill volume into, the CNG 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 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 or possible ignition sources.

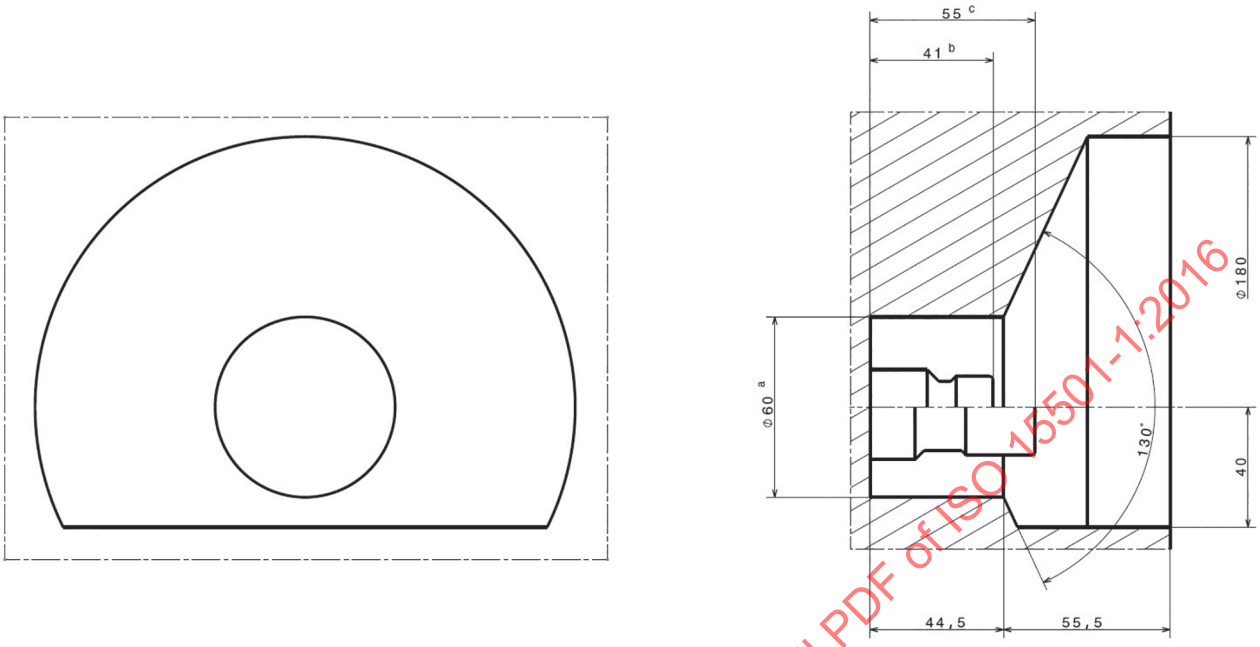
The receptacle shall not be installed in a wheel arch, or close to a heat source such as the exhaust.

4.2.3 Receptacle mounting

The vehicle's CNG on-board fuel system shall be able to withstand the values of force and torque specified in ISO 15501-2 of loading 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

The minimum receptacle clearances are shown in Figure 1.



a For minimum coupling clearance only. System designers should ensure that the dust or pressure-tight cap freely in provided space.

b Minimum length of the B200 and B250 receptacles clear of provision for attachment of receptacle or protective cap.

c Minimum length of the C200 and C250 receptacles clear of provision for attachment of receptacle or protective cap.

NOTE Depending on the vehicle design, the overall depth of the refuelling cavity need not be as large as is indicated here.

Figure 1 — Receptacle/nozzle interface envelope

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.

4.3.2 Connections shall either be bubble-free for 3 min or have a leak rate for each connection that is in compliance with the leak test in ISO 15501-2.

After assembly, the vehicle's CNG on-board fuel system shall be tested for leakage in accordance to ISO 15501-2.

4.3.3 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 or other spaces not sufficiently ventilated. Alternatively, it shall be ensured that any leaked gas will be directed safely to the atmosphere (see Annex A).

4.3.4 Where a cylinder 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. When the valves are self-venting, the gas tight housing/ventilation hose 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 case of fire, the requirement of venting gas to the outside of the vehicle does not apply.

4.3.5 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.

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

4.4 Mounting of the cylinders

4.4.1 The cylinder or cylinders shall be securely attached to the vehicle to prevent slipping, rotating and dislodging.

The installation shall be according to the cylinder manufacturer's instructions and ISO 11439.

The cylinder shall be mounted on the same vehicle as the engine and any equipment being fuelled by the fuel container.

The cylinder shall be mounted in a manner that prevents contact of the container with other vehicle components that would lead to container damage or abrasion over time.

The cylinder shall be at two support points designed to minimize the effects of external loads on the fuel container.

Mounting hardware and instructions specified by the cylinder manufacturer shall be used, if available. The mounting system shall minimize damage or corrosion between the cylinder and the mounting system.

A resilient gasket that does not retain water shall be installed between the supports or clamping bands and a fuel cylinder such that there is no direct contact between metal on the bracket and the fuel cylinder. The gasket material shall be of a thickness and hardness such that the fuel cylinder will remain secure at all fuel cylinder fill pressures and all operating temperatures.

When the cylinder is clamped by the neck, a resilient gasket might not be required.

When installing the cylinder, consideration should be given to factors such as the undue stresses created in an overwrap by cylinder expansion against a metal support, the need to specify a gasket material to prevent support damage to cylinders, and the required properties of any gasket material. Type 2, Type 3, and Type 4 designs should be provided with shielding arrangements to protect the composite wrapping from mechanical damage.

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

4.4.3 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.

The fuel containers or cylinders shall be mounted and fixed so that the following accelerations can be absorbed (without damage occurring) when the containers are full at the service pressure.

Vehicles of categories M1 and N1:

a) 20 g in the direction of travel (forward/backward);

b) 8 g horizontally perpendicular to the direction of travel;

c) if the cylinders are mounted under the vehicle, 5 g in the vertical downward direction.

Vehicles of categories M2 and N_2:

a) 10 g in the direction of travel;

b) 5 g horizontally perpendicular to the direction of travel;

c) if the cylinders are mounted under the vehicle, 5 g in the vertical downward direction.

Vehicles of categories M3 and N3:

a) 6,6 g in the direction of travel;

b) 5 g horizontally perpendicular to the direction of travel;

c) if the cylinders are mounted under the vehicle, 5 g in the vertical downward direction.

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

Cylinders 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

Components (excepting 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

4.7.1 There is no general best direction to release the gas through the PRV or PRD, 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 or PRD.

Vent systems should prevent the accumulation of water or debris in the tubes or in the PRV or PRD, as this may cause the PRV or PRD to fail or prevent proper venting after activation. Ice in particular can damage PRDs or vent lines. Care should 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 or 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.

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 PRDs and PRVs.

If a ventilation line is installed on a pressure relief device or 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 device/valve discharge openings, and the diameter shall be of sufficient size to not be obstructed by any material discharged by the PRD or 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 service pressure of the fuel cylinder. 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 lose its gas-carrying capability when exposed for 12 min to a temperature of 590 °C. The vent lines may be shielded or sleeved to comply with this requirement;

e) not direct the discharge into or toward the passenger or luggage compartment, into or toward wheel housings, toward CNG storage systems, or toward the front of the vehicle;

f) minimize the possibility of external hazards (e.g. projectiles) resulting from activation of the device;

g) be constructed of materials that mitigate the risk of corrosion, and shall not cause galvanic corrosion at the interface connection to the pressure relief device/valve.

5 Instruction for use

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

6 Marking

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

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

— the gas quality designation should be as defined in ISO 15403-1 and ISO/TR 15403-2, and

— 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,

b) enclosing the neck of the cylinder and its fittings with a specially designed durable envelope that is gas tight to the compartment and that is provided with permanent ventilation,

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) any ventilation method used should not prevent proper function of the PRD, particularly by separating it from the heat that the cylinder is exposed to. Fire testing of the cylinder and PRD combination should be done with representative ventilation enclosures.