INTERNATIONAL STANDARD

ISO 19723-2

First edition
2018-07

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

Part 2: Test methods

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

Partie 2: Méthodes de test

Reference number
ISO 19723-2:2018(E)

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Published in Switzerland

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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).

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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.

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.

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

Part 2: Test methods

1 Scope

This document specifies performance and general test methods for liquefied natural gas fuel system components 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 gas in accordance with the ISO 15403 series. It is not applicable to the following: original-production and converted vehicles.

This document is only applicable on the components in the "LNG system" meaning an assembly of components (tanks, valves, flexible fuel lines, etc.) 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.

NOTE All references to pressures, given in megapascals and bar (1 bar = 0,1 MPa = 105 Pa; 1 MPa = 1 N/mm^2) are considered gauge pressures, unless otherwise specified.

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 898-1, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs with specified property classes — Coarse thread and fine pitch thread*

ISO 6487, *Road vehicles — Measurement techniques in impact tests — Instrumentation*

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

ISO 12991:2012, *Liquefied natural gas (LNG) — Tanks for on-board storage as a fuel for automotive vehicles*

ISO 19723-1:2018, *Road vehicles — Liquefied natural gas (LNG) fuel systems — Part 1: Safety requirements*

3 Terms and definitions

No terms and definitions are listed in this document.

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/

4 Test methods

4.1 Tank mounting strenght tests

4.1.1 General

When a vehicle is equipped with several tanks, they should be tested as a unit.

When a tank or groups of tanks are installed on a vehicle such that they are separately anchored to the original structure of the vehicle, then each tank or separate group of tank can be tested individually.

When performing these tests, accessories and piping shall not contribute to reinforcing the tank mounting.

The requirements of ISO 19723-1:2018, 4.4.3, shall be verified by the test specified in 4.1.1, 4.1.2 or 4.1.3.

4.1.2 Inertia test

The tank or group of tanks to be tested shall be mounted on the vehicle body or a part of the vehicle body, according to the specifications of the original equipment manufacturer (OEM) or after-market converter.

The vehicle body or part of the vehicle body shall be firmly anchored to the test trolley. The method used for anchoring the vehicle body to the test trolley shall not result in reinforcement of the tank anchorages or the part of the vehicle structure participating in anchoring the tank or tanks. Testing performed with a trolley shall geometrically match original vehicle conditions.

The test shall be carried out using the following procedure.

a) Fill the tank or tanks with an equivalent full weight of liquid nitrogen saturated to one-half the working pressure.

b) Measure the trolley deceleration with data channels of channel frequency class (CFC) 60 corresponding to the characteristics given in ISO 6487.

c) Maintain the value of the deceleration as defined in ISO 19723-1:2018, 4.4.3, for at least 30 ms.

4.1.3 Static test

This test may be carried out on a vehicle body or on a part of a vehicle body.

The tank or group of tanks to be tested shall be mounted on the vehicle body or on part of the vehicle body, according to OEM or after-market converter specifications.

The method used for anchoring the vehicle body or the part of the vehicle body in this test shall not:

— submit the anchorages and anchorage area (300 mm diameter circle) to abnormal stresses and/or deformation;

— result in reinforcement of the tank or group of tanks anchorages, or the part of the vehicle structure participating in anchoring the tank or group of tanks.

The traction force is defined by Formula (1):

$$F = (M_c + 0{,}9\,\rho V)a \quad (1)$$

where

F is the traction force, in newtons;

M_c is the mass of empty tank(s), in kilograms;

a is the acceleration as defined in ISO 19723-1:2018, 4.4.3;

V is the volume of the tank(s) in litres;

ρ is the density of LNG at 20 MPa 0,2 kg/l.

The test shall be carried out using the following procedure.

a) Apply the traction force to the tank or tanks' centre of gravity in the specified directions within 0,2 s.

b) Hold the specified traction force for at least 0,2 s.

c) Release the traction force.

4.1.4 Acceptance criteria

4.1.4.1 By testing

At the conclusion of either of these tests, the tank or group of tanks shall:

— remain attached to the vehicle body or part of the vehicle body;

— not interfere with the seat structure.

4.1.4.2 By calculation

Appropriate calculations shall be carried out, depending on the individual technical parameters. The method of calculation shall be approved by the relevant authority.

4.1.4.3 By engineering experience (steel tanks)

For details of a practical means of compliance for tanks (in accordance with ISO 12991), determined as a result of calculations and substantiated by experience over time, see Annex A.

4.2 Leak test

This test may be conducted at ambient temperature. It shall be performed on each vehicle after the fuel system installation has been completed.

a) Fill the vehicle fuelling system with an appropriate medium at 90 % of working pressure.

b) During this test, provisions shall be made to have the main shut-off valve open as well as the other automatic valves on the system that should be open during the normal operation of the vehicle.

c) Check all components (valves, fittings excluding re-cosable components) with a bubble-producing liquid. No bubbles shall be detected during three minutes or have a leakage rate less than 20 Ncm^3/h. Other equivalent methods are acceptable.

If the tank and all components upstream the pressure regulator have already been leak tested, the leak test shall be performed with the tank valve closed.

Stop the test if any leakage occurs during the filling from 1 MPa (10 bar) to the manufacturer declared working pressure. Where a leak is detected, it shall be rectified by first relieving any pressure, then resealing. The system shall then be re-tested.

4.3 Functional LNG/CNG automatic valve test

The purpose of this test is to ensure that the LNG/CNG automatic valve is in the closed position when:

— the ignition key is off;

— the engine stalls, (as required for a vehicle that is equipped with start stop system);

— cranking on fuel other than LNG; or

— the engine is not running on LNG.

4.4 Receptacle

4.4.1 General

The receptacle shall comply with ISO 12617.

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 a way that will prevent loss of the cap.

4.4.2 Receptacle clearance test

Ensure that free space around the receptacle conforms to ISO 19723-1:2018, 4.2.4.

4.4.3 Receptacle mounting tests

This test can be performed at ambient temperature either on a vehicle, or as a bench test using a LNG fuel system equivalent in geometry and anchoring to the vehicle. In either case, connect the nozzle to the receptacle and pressurize the LNG fuel system to service pressure and temperature.

The gas tightness of the LNG fuel system shall not be affected after:

a) a 670 N pull is applied along the longitudinal axis of the receptacle;

b) a moment of 200 N · m is applied in a worst-case manner.

Following the above test the gas tightness of LNG fuelling system shall be checked with an appropriate leak testing method.

4.5 Hold time test

The reason for this test is to verify if the system is designed to have a hold time of minimum 120 hours.

This test is performed on a tank filled within 10 per cent of the maximum allowed net quantity of LNG at manufacturer's specified highest point in the design filling temperature/pressure range.

During the test the test the hydrostatic pressure shall be recorded every minute for at least 120 hours at ambient temperature of 20 °C ± 5 °C. In case there is no relief of the LNG during this 120 hour, the test shall continue until that the pressure of the primary relief valve setting is reached.

The hydrostatic pressure inside the tank shall be stable (within 10 KPa) or increasing throughout the duration of the test. The tank including all accessories on the tank necessary for good operation shall be measured and verified to be stable (within ±2 % reading) throughout duration of the test.

Release of any fluid during duration of the test shall be unacceptable (tank including all accessories need to stay bubble-tight).

4.6 Acceptable test results

Acceptable measured hydrostatic pressure at 120 hours or more hours shall be less than nominal primary relief valve pressure setting of the tank.

4.7 Venting system check

The venting system shall be designed so that the following conditions are taken into account.

— The primary relief valve is piped away to a high level of the vehicle.

— The relief valves (primary and secondary) are protected against:

  — fouling by dirt;

  — debris;

  — influence by atmosphere like ice, water and/or snow.

— The venting system shall be sized to prevent flow restriction due to pressure drop.

— Methane escaping the vent stack or secondary relief valve shall not impinge on enclosed areas, trailers, other vehicles, exterior-mounted systems with air intake (i.e. cooling systems, air-conditioning systems), engine intakes or engine exhaust.

— In case of multiple tanks or group of tanks, the venting line of each primarily pressure relief valve may be manifold to a common stack.

Any appropriate method may be used to ensure test results.

4.8 LNG accumulation system check

LNG systems used in vehicles having enclosed areas (i.e. cargo area) that can result in the possibility of gas trapping shall be equipped with appropriate measurements such as:

— natural gas detector. The detection system shall:

  — activate a visual alarm within the driver's compartment of the vehicle at a gas concentration not exceeding (25 ± 5) % of the LEL; and

  — sound an audible and visual alarm at a gas concentration not greater than (55 ± 5) % of the LEL;

— gas tight housing.

Any appropriate method may be used to ensure test results.

4.9 Bonfire test

The LNG tank shall comply with the requirments of ISO 12991:2012, A.2 on the same layout of tank and its accessories.

5 Marking

The following data shall be displayed with permanent marking:

— the type of fuel (i.e. "LNG" for liquefied natural gas);

— the periodic inspection date for LNG tank according to ISO 12991;

— the service pressure for the vehicle.

Annex A
(informative)

Engineering experience for the mounting of LNG tanks

A.1 Single tank

a) 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 tank.

b) Where the tank is anchored to sheet metal, the sheet metal shall be reinforced at each attachment point with metal plates of areas of no less than 3 600 mm^2 and a thickness of no 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 at least 0,5 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.

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

c) The mounting method shall not significantly weaken the vehicle structure.

d) Where anchorage bolts pass through a hollow section, a spacer tube shall be provided to prevent collapse of that section under load.

e) All fasteners shall have a diameter of no less than that shown in Table A.1 and shall comply with property class 8.8 in accordance with ISO 898-1.

f) Where clamping bands are used, at least two steel bands shall be provided, the dimensions of which shall be no less than those shown in Table A.1. However, in the case of multiple tanks mounted together, Table A.1 does not apply.

   To prevent the possibility of external corrosion where clamping bands are used, a non-moisture-retaining hard rubber or equivalent material shall be provided on the inner side of the bands. Similar protection shall be provided if the tank rests against other metal objects.

g) Where parts are joined (e.g. by welding a stud to a band), the strength of the joint shall be not less than the strength of either component.

h) Where the attachment is by means of clamping bands, there shall be a positive means of resisting longitudinal end loads on the tank due to the vehicle impact. The friction grip of the clamping bands is not normally an acceptable means of endwise retention, unless the clamping bands can be demonstrated to meet the requirement of ISO 15501-1:2016, 4.4.3. An acceptable form of retention is to secure a 200 mm length of 50 × 50 structural steel angle to the vehicle at each end of the tank. Each length of steel angle shall be at right angles to the longitudinal axis of the tank with one leg vertical and fitted so as to provide a gap of 7 mm ± 3 mm to the end of the tank. The other leg of each angle shall be secured to the vehicle by at least two 10 mm diameter bolts. Where suitable body or structural members of the vehicle construction are available and these components are capable of withstanding the required loading, they may be used, provided the 7 mm ± 3 mm gap is maintained.

NOTE The attachment of a tank to the roof of the vehicle, and particularly to the gutters, is generally considered to be of inadequate strength, and unsatisfactory for a number of other reasons, and is sometimes specifically banned. Such installations require specific approval, which is usually given only for special vehicles, and take into account such aspects as vehicle speed, tank protection mounting strength, and vehicle handling characteristics.

A.2 Multiple tanks

For installations with more than one tank, a specific design may be required for the mounting attachment.

Table A.1 — Dimensions of attachment

Tank capacity *L*		**Band dimensions** (minimum nominal size) mm	**Bolt or stud diameter for band or flange mountings** (minimum nominal size) mm
Over	**Up to and including**		
0	100	30 × 3	10
100	150	50 × 6	12
150	—	Approved by the relevant authority	

A.3 Tank mountings

Figure A.1 shows examples of typical preferred arrangements, while Figure A.2 shows unacceptable arrangements.