भारतीय मानक
Indian Standard

IS 16742 : 2018
ISO 12991 : 2012

तरलीकृत प्राकृतिक गैस (एल एन जी) — स्वचल वाहनों के लिए ईंधन के ऑन-बोर्ड भंडारण हेतु टैंक

Liquefied Natural Gas (LNG) — Tanks for On-Board Storage as a Fuel for Automotive Vehicles

ICS 75.200, 23.020.40

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Gas Cylinders Sectional Committee, MED 16

NATIONAL FOREWORD

This Indian Standard which is identical with ISO 12991 : 2012 'Liquefied natural gas (LNG) — Tanks for on-board storage as a fuel for automotive vehicles' issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of the Gas Cylinders Sectional Committee and approval of the Mechanical Engineering Division Council.

This standard specifies the construction requirements for refillable fuel tanks for liquefied natural gas (LNG) used in vehicles as well as the testing methods required to ensure that a reasonable level of protection from loss of life and property resulting from fire and explosion is provided. It is applicable to fuel tanks intended to be permanently attached to land vehicles but can be used as a guide for other mode of transport.

The text of ISO Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain terminology and conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.
b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

This standard also makes a reference to the BIS Certification Marking of the product. Details of which are given in National Annex A.

Being typological error, clause **3.7** may please be read as clause **3.6** and renumber the subsequent clauses.

In this adopted standard, reference appears to the following International Standard for which Indian Standard also exists. The corresponding Indian Standard which is to be substituted in its place is listed below along with its degree of equivalence for the edition indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 1431-1 Rubber, vulcanized or thermoplastic — Resistance to ozone cracking — Part 1: Static and dynamic strain testing	IS 3400 (Part 20) : 1994 Methods of test for vulcanized rubbers : Part 20 Resistance to ozone cracking — Static strain test (*first revision*)	Identical with ISO 1431-1 : 1989

The technical committee has reviewed the provisions of the following International Standards referred in this adopted standard and has decided that they are acceptable for use in conjunction with this standard:

International Standard	*Title*
ISO 1176	Road vehicles — Masses — Vocabulary and codes
ISO 2768-1	General tolerances — Part 1: Tolerances for linear and angular dimensions without individual tolerance indications
ISO 6957	Copper alloys — Ammonia test for stress corrosion resistance
ISO 9227	Corrosion tests in artificial atmospheres — Salt spray tests
ISO 21013-3	Cryogenic vessels — Pressure-relief accessories for cryogenic service — Part 3: Sizing and capacity determination

(*Continued on third cover*)

Indian Standard

LIQUEFIED NATURAL GAS (LNG) — TANKS FOR ON-BOARD STORAGE AS A FUEL FOR AUTOMOTIVE VEHICLES

1 Scope

This International Standard specifies the construction requirements for refillable fuel tanks for liquefied natural gas (LNG) used in vehicles as well as the testing methods required to ensure that a reasonable level of protection from loss of life and property resulting from fire and explosion is provided.

This International Standard is applicable to fuel tanks intended to be permanently attached to land vehicles but can be used as a guide for other mode of transport.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 1431-1, *Rubber, vulcanized or thermoplastic — Resistance to ozone cracking — Part 1: Static and dynamic strain testing*

ISO 2768-1, *General tolerances — Part 1: Tolerances for linear and angular dimensions without individual tolerance indications*

ISO 6957, *Copper alloys — Ammonia test for stress corrosion resistance*

ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests*

ISO 21013-3, *Cryogenic vessels — Pressure-relief accessories for cryogenic service — Part 3: Sizing and capacity determination*

ISO 21014, *Cryogenic vessels — Cryogenic insulation performance*

ISO 21028-1, *Cryogenic vessels — Toughness requirements for materials at cryogenic temperature — Part 1: Temperatures below -80 degrees C*

ISO 21029-1:2004, *Cryogenic vessels — Transportable vacuum insulated vessels of not more than 1 000 litres volume — Part 1: Design, fabrication, inspection and tests*

ISO 23208, *Cryogenic vessels — Cleanliness for cryogenic service*

3 Terms and definitions

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

3.1
accessory
device fixed directly to the inner tank or outer jacket of a fuel tank such as a pressure relief valve, shut-off valve, non-return valve or level gauge

3.2
boil-off management system
system that controls the boil-off of gas under normal conditions

3.3
burst pressure
pressure that causes the rupture of a pressure vessel subjected to a constant increase of pressure during a destructive test

3.4
design temperature
temperature of the inner tank, the outer jacket and all other accessories to which fabrication drawings, inspections and physical measurements such as volume are referred

3.5
fuel tank
vessel used for the storage of cryogenic liquefied natural gas (LNG) fuel

3.7
impermissible fault range
pressure range within which an unwanted event is to be expected

3.8
inner tank
part of the fuel tank that contains liquefied natural gas (LNG)

3.9
level gauge
device that measures the level of liquefied natural gas (LNG) in the fuel tank

3.10
maximum allowable working pressure
MAWP
maximum pressure to which a component is designed to be subjected to and which is the basis for determining the strength of the component under consideration

3.11
normal operating range
range planned for the process values

NOTE In the case of inner tanks, the normal operating range of the inner tank pressure is from 0 bar to the set pressure of the primary pressure relief valve, which is lower than or equal to the maximum allowable working pressure (MAWP) of the inner tank.

3.12
outer jacket
part of the fuel tank that encases the inner tank(s) and its insulation system

3.13
outer pressure
pressure acting on the outside of the inner tank or outer jacket

3.14
permissible fault range
range between the normal operating range and the impermissible fault range

3.15
pressure
pressure for which the value is equal to the algebraic difference between the absolute pressure and the atmospheric pressure

NOTE This is also known as gauge pressure.

3.16
holding time
time of the pressure increase in the inner tank measured from a starting pressure of 0 bar at the corresponding boiling point of liquefied natural gas (LNG) (–164° C) up to the maximum allowable working pressure (MAWP) of the inner tank

NOTE The holding time is a measure of the insulation performance of the fuel tank.

3.17
batch inner tank heads
number (no more than 100) of tank heads produced by the same manufacturer, from the same material, and having the same dimensions

3.18
maximum mass
a maximum authorized total mass, as defined in ISO 1176

4 Requirements

4.1 General requirements

The fuel tank and its accessories shall function in a correct and safe way. It shall withstand and remain gas tight when subjected to the mechanical, thermal and chemical stresses specified in this International Standard.

4.2 Mechanical stresses

4.2.1 Inner/outer pressure

4.2.1.1 Inner tank

The inner tank shall be designed to resist the following inner test pressure:

$$p_{\text{test}} = 1{,}3(\text{MAWP}+1)$$

$$\left[p_{\text{test}} = 1{,}3(\text{MAWP}+0{,}1)(MPa)\right]$$

where

p_{test} is the test pressure, expressed in bar

MAWP is the maximum allowable working pressure of the inner tank, expressed in bar. The inner tank and its accessories shall be designed to resist an outer pressure of 1 bar.

4.2.1.2 Outer jacket

The outer jacket shall be designed to resist an outer pressure of 1 bar (see 4.5.2).

4.2.2 Accelerations

4.2.2.1 General

The fuel tank and its accessories shall be mounted and protected so that the accelerations shown in Table 1 can be absorbed without structural damage to the fuel tank and its accessories. No uncontrolled release of LNG is permitted.

Table 1 — Accelerations

Vehicle categories	Accelerations
Vehicles of categories M1 and N1	20 g in the direction of travel
	8 g horizontally perpendicular to the direction of travel
Vehicles of categories M2 and N2	10 g in the direction of travel
	5 g horizontally perpendicular to the direction of travel
Vehicles of categories M3 and N3	6,6g in the direction of travel
	5 g horizontally perpendicular to the direction of travel
The vehicle categories include the following:	
— Category M1: Vehicles used for the transportation of passengers and comprising not more than eight seats in addition to the driver's seat.	
— Category M2: Vehicles used for the transportation of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass that does not exceed 5 000 kg.	
— Category M3: Vehicles used for the transportation of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass exceeding 5 000 kg.	
— Category N1: Vehicles used for the transportation of goods and having a maximum mass that does not exceed 3 500 kg	
— Category N2: Vehicles used for the transportation of goods and having a maximum mass exceeding 3 500 kg, but not exceeding 12 000 kg.	
— Category N3: Vehicles used for the transportation of goods and having a maximum mass exceeding 12 000 kg.	

4.2.2.2 Inner and outer support

When exposed to the accelerations described in Table 1, the stress in the support elements shall not exceed the minimum ultimate tensile strength of the material (R_m, calculated according with the linear stress model).

The allowable stress in the support elements may not have to be calculated if it can be demonstrated that the fuel tank supports the accelerations given in Table 1 without any structural damage to the inner tank or its supports.

Acceptable calculation methods include

— finite element,

— finite difference,

— boundary element, and

— established calculation method.

In these calculations static loads shall be substituted for static plus dynamic loads.

4.3 Thermal stresses

4.3.1 Design temperature

The design temperature of the inner tank, the outer jacket and the accessories shall be 20°C. In addition, the inner tank, the outer jacket and the accessories shall be designed to withstand a temperature range from the lowest to the highest possible operating temperatures that will be encountered in service.

4.3.2 Ambient temperature

The fuel tank shall be designed to withstand ambient temperatures ranging from −40°C to 85°C. If the fuel tank is to be installed in areas of internal heat sources such as the internal combustion engine compartment of a vehicle, the fuel tank shall be designed for an ambient temperature of 120°C, or a lower value if substantiated by calculations.

4.3.3 Operating temperature

The thermal stresses produced by the operating conditions shall be considered. The inner vessel and the other components that may be in contact with LNG shall be designed to operate at –196 °C.

4.4 Materials

The materials of the fuel tank and its accessories shall be compatible, as applicable, with

a) LNG, and

b) other media and fluids found in a vehicle environment, such as coolants, brake fluid and battery acid.

Materials used at low temperatures shall meet the toughness requirements of ISO 21028-1. For non-metallic materials, low temperature suitability shall be validated by an experimental method, taking into account the service conditions.

The materials used for the outer jacket shall ensure the integrity of the insulation system and shall be made of austenitic stainless steel

For the inner vessel if materials other than austenitic stainless steels are used it shall be ensured that the materials will resist all the in service fatigue load

A corrosion allowance does not need to be added for the inner tank. A corrosion allowance does not need to be added on other surfaces, if they are protected against corrosion.

For welded vessels, welds shall have properties equivalent to those specified for the parent material for all temperatures that the material may encounter.

4.5 Design

4.5.1 Design validation

Each type of vessel shall be validated in accordance with the design options specified in 10.1 of ISO 21029-1:2004 and in accordance with one of options given in 4.5.1.1 and 4.5.1.2.

4.5.1.1 Validation by calculation

This option requires calculation in accordance with 10.3 of ISO 21029-1:2004. Additional calculations are required to validate the design for accelerations in 4.2.2.

4.5.1.2 Validation by experiment method

This option requires validation in accordance with 10.4 of ISO 21029-1:2004 with the following modification; drop tests shall include a 9 m drop test of the fuel tank on the most critical area of the tank (other than the piping end) and a 3 m drop test on the piping end.

4.5.2 Inner tank and outer jacket

For the design of inner and outer tank the only acceptable options are

— the design is validated as per option 10.1.3 of ISO 21029-1:2004, especially the requirements of Table 3;

— the design of the inner tank and the outer jacket shall meet all the design rules specified in 10.3 of ISO 21029-1:2004. In this case if the minimum thickness is less than per 10.1.3 Table 3 an experimental validation shall be performed (see Annex A).

Unless indicated otherwise, the general tolerances of ISO 2768-1 shall apply.

4.6 Insulation – General requirements

The insulation system installed on a fuel tank shall be evaluated in accordance with ISO 21014 and stated.

4.7 Accessories

4.7.1 General requirements

Accessories shall have a minimum working pressure equal to the MAWP of the inner tank (see ISO 21011 and ISO 21013-1.

4.7.2 Pressure relief valves for the inner tank

The inner tank shall be protected by a pressure relief valve set to open at MAWP with a full flow at no more than 110 % of MAWP.

The inner tank shall also be protected by a second pressure relief valve that shall not operate below 115 % of the MAWP and that limit the pressure inside the inner tank to no more than the test pressure.

The inner tank pressure relief valves shall, after discharge, close at a pressure higher than 90 % of the set pressure of the pressure relief valve and remain closed at all lower pressures.

The sizing of each inner tank pressure relief valves shall be done in accordance with ISO 21013-3, for the following conditions:

— loss of vacuum;

— loss of vacuum with simultaneous external fire;

— loss of vacuum with pressure build regulator fully open.

The rating of the inner tank pressure relief valves shall be clearly marked. A lead seal or equivalent system shall be installed on these pressure relief valves in order to provide a physical impediment to tampering.

4.7.3 Lines incorporating pressure relief valves

No isolating valve shall be installed between the inner tank and its pressure relief valves. The primary and the secondary pressure relief valves of the inner tank may be connected to the inner tank by separate line.

The lines in front of and behind the pressure relief valves shall not impede their function.

4.7.4 Protection of the outer jacket

The outer jacket shall be protected by means of a pressure relief device preventing bursting of the outer jacket or collapsing of the inner tank (see ISO 21029-1:2004, Annex B).

4.7.5 Shut-off valves and non-return valves

The fuel tank shall be provided with shut-off valves for the purpose of securing the fuelling lines and the fuel supply lines to the LNG conversion system(s).

In addition, all LNG fuel supply lines to the LNG conversion system(s), except the lines to the boil-off management system, shall be secured with automatic shut-off valves or excess flow valves. These valves shall be mounted directly on or within the fuel tank.

The fuelling line shall be secured by either a manually or an automatically operated shut-off valve, which shall always be closed except during the fuelling process. If the fuelling connector receptacle is not mounted directly on the fuel tank, a second isolation valve shall be used. This valve may be a manual shut-off valve, an automatic shut-off valve or a non-return valve. When two isolation valves are required, one shall be mounted directly on or within the fuel tank.

The automatic shut-off valves shall close with loss of motive power.

4.7.6 Content measuring system

The fuel tank shall be equipped with a measuring device that measures the quantity of LNG in the inner tank.

4.7.7 Overfill protection

A system shall be provided for preventing the fuel tank from being overfilled. This system may work in conjunction with the fuelling station.

The fuelling process shall not cause any pressure relief valve to operate during the fuelling process. The fuelling process shall not lead to operating conditions that the boil-off management system is not designed for, and therefore cannot handle.

Under all circumstances and regardless of the fuel condition and the maximum operating pressure of the inner tank, the fuelling volume of LNG shall not exceed the maximum fuelling level of the inner tank specified by the fuel tank manufacturer.

4.7.8 Pressure maintaining system

The fuel tank shall be equipped with a pressure maintaining system that is capable of maintaining the fuel tank at its required operating pressure at the maximum product consumption and duration, as specified by the manufacturer.

4.7.9 Inspection openings

Inspection openings shall not be provided on the inner tank or the outer jacket.

4.8 Manufacturing and assembly

The manufacturing of the fuel tank (e.g. forming, heat treatment, welding) shall be carried out according to Clause 11 of ISO 21029-1:2004.

The number of joints on the fuel tank should be minimized. For metallic materials, joints within the annular space between the inner tank and outer jacket shall be welded.

The accessories of the fuel tank shall be mounted in a way that the system and its components function properly and are gas tight.

5 Type tests

5.1 Approval of new designs

Type tests shall be conducted on each new design, and on finished fuel tanks that are representative of normal production, complete with identification marks. All fuel tanks subjected to burst pressure and Holding time tests shall be made unserviceable after the tests are completed.

The fuel tank manufacturer shall retain the type test results for the intended life of the fuel tank design. The test data shall also document the dimensions, wall thickness and weight of each of the test fuel tanks. If more fuel tanks are subjected to the tests than are required, all results shall be documented.

The type approval procedure shall be repeated in the event of an increase in at least one of the following parameters:

— maximum allowable pressure;

— density of the LNG for which the vessel is designed;

— maximum tare weight of the inner vessel;

— nominal length and/or diameter of the inner vessel;

or, in the event of any change relative to the

— manufacturing plant,

— type of material or grade (e.g. stainless steel to aluminium or change of stainless steels grades),

— fundamental shape,

— decrease in the minimum mechanical properties of the material being used, and

— modification of the design of an assembly method concerning any part under stress, particularly as far as the support systems between the inner vessel and the outer jacket or the inner vessel itself or the protective frame, if any, are concerned.

The initial design validation programme shall be repeated to take account of these modifications.

In addition, if any changes affect the orientation and/or mode of fixation, the appropriate tests or the relevant calculations, shall be repeated to take account of these changes.

5.2 Inner tank burst pressure test

One sample of a finished inner tank shall be subjected to a burst pressure test in accordance with B.1 and meet the requirements therein.

5.3 Holding time test

Two finished fuel tanks shall be subjected to a Holding time test in accordance with B.2 and meet the requirements therein.

5.4 Maximum fuelling level test

Two finished fuel tanks shall be subjected to a maximum fuelling level test in accordance with B.3 and meet the requirements therein.

5.5 Accessory type tests

Each fuel tank accessory, with the exception of pressure relief valves (see 4.7.2) and cryogenic valves (see 4.7.5), shall be subjected to type tests according to Annex B.

6 Routine tests and inspection

6.1 General

The tests and inspections specified in 6.2 to 6.6 shall be performed on each fuel tank.

6.2 Pressure test

The inner tank and the pipework situated between the inner tank and the outer jacket shall be subjected to an inner hydrostatic or pneumatic pressure test at room temperature with a suitable test media.

The test pressure shall be:

p_{test} = 1,3 (MAWP + 0,2)

(p_{test} = 1,3 (MAWP + 0.1 0,2) (MPa))

where

p_{test} is the test pressure, expressed in bar;

MAWP is the maximum allowable working pressure of the inner tank, expressed in megapascals (MPa).

The pressure test shall be performed before the outer jacket is mounted. The pressure in the inner tank shall be increased at an even rate until the test pressure is reached. The inner tank shall remain under the test pressure without the addition of test media for at least 10 min to establish that the pressure is not decreasing.

After the test, the inner tank shall not show any signs of visible permanent deformation nor leaks. Inner tanks that do not pass the test because of permanent deformation shall be rejected and shall not be repaired. Inner tanks that do not pass the test because of leakage may be accepted after repair and retesting.

Upon completion of the test, the inner tank shall be emptied, cleaned, and dried according to ISO 23208.

A test report shall be drawn up and the inner tank shall be marked if accepted.

6.3 Leak test

After final assembly, the fuel tank shall be helium leak tested with a gas mixture containing a minimum of 10 % of helium using a mass spectrometer leak detector capable of detecting leaks ranging from 1 x 10^{-9} cm^3/s at 20 °C and 101,325 kPa to 1 x 10^{-9} cm^3/s at 20 °C and 101,325 kPa. There shall be no detectable leak. The fuel tank accessories shall be leak tested in accordance with B.2, except that the test shall be performed only at 20 °C ± 5 °C.

6.4 Verification of the dimensions

The following dimensions shall be verified at a frequency in accordance with the manufacturer quality system for each batch of no more than 50 tanks made from the same batch of inner tank heads.

a) for cylindrical fuel tanks, the roundness of the inner tank shall be measured and not exceed the requirements specified in 11.5.4.2 of ISO 21029-1:2004;

b) departure from a straight line of the inner tank and outer jacket shall be measured and not exceed the requirements specified in 11.5.4.3 of ISO 21029-1:2004.

6.5 Destructive and non-destructive tests of welded joints

The destructive and non-destructive tests of welded joints shall be performed and meet the requirements specified in 12.2 to 12.4 of ISO 21029-1:2004.

All welded joints of the internal pipe work between the inner tank and the outer jacket shall be subjected to 100 % non-destructive inspection. When radiographs can be interpreted, radiographic inspection shall be used. When radiographs cannot be interpreted, ultrasonic inspection shall be used. When both radiographs and ultrasonic inspection techniques cannot be applied, visual inspection of welds using penetrant techniques shall be used.

In addition to the non-destructive inspection requirement above, helium mass spectrometer leak testing shall be used to verify the integrity of the annular piping as well (see 6.3).

6.6 Visual inspection

The welded joints on the outer surfaces of the inner tank and outer jacket shall be visually inspected. The surfaces shall not show any damage nor defects.

7 Marking and labelling

7.1 Marking method

The marking method shall not cause localized stress concentrations in either the structure of the inner tank or the outer jacket.

7.2 Inner tank markings

The inner tank shall be marked with the following information:

a) name and address of inner tank manufacturer;

b) serial number;

c) mark confirming successful routine pressure test (see 6.2).

7.3 Outer jacket markings

The outer jacket of the fuel tank shall be marked with the following information:

a) "For LNG use only";

b) "Additional welding, milling and stamping are forbidden";

c) Allowed orientation of the fuel tank on board the vehicle.

An identification plate marked with the following information shall be placed on the outer jacket:

d) name of the manufacturer;

e) serial number;

f) volume of the inner tank at the design temperature, expressed in litres (l);

g) MAWP of the inner tank, expressed in megapascals (MPa);

h) year and month of manufacturing in the YYYY and MM format (e.g. 2000-01);

i) ambient temperature range as per 4.3.2;

j) reference to this International Standard.

7.4 Temporary markings for first fuelling

A label shall be placed on the outer jacket of the fuel tank with the following information:

a) Read and Understand the Operating Manual for this LNG fuel tank prior to installation and use;

b) "Servicing of the fuel tank shall be done by trained and qualified personnel";

c) "Air and other gases shall be removed under the following circumstances:

   1) before fuelling the fuel tank for the first time;

   2) after the fuel tank is serviced;

   3) any time the fuel tank is emptied and its pressure reduced to 0 MPa".

Annex A
(normative)

Fuel tank type tests

A.1 Inner tank burst pressure test

The design of the fuel tank shall be validated through tests specified in 10.4 of ISO 4706:2008.

A.2 Holding time test

A.2.1 Procedure

The inner tank shall be at the same temperature as the temperature of the LNG. This requirement shall be deemed met if, during the previous 24 hours, the fuel tank has contained a volume of liquid LNG at least equal to half of the volume of the inner tank.

The fuel tank shall be filled with LNG or liquid Nitrogen so that the quantity of cryogenic liquid measured by the mass measurement system shall be within 10 % of the maximum allowed quantity that may be contained in the inner tank.

The length and the width of the fire shall exceed the plan dimensions of the fuel tank by 0,1 m. ISO 11439 contains directions to produce a suitable fire test. The average temperature of space 10 mm below the fuel tank as measured by two or more thermocouples shall be at least 590 °C. The average temperature shall remain above 590 °C for the duration of the test.

The pressure of the fuel tank at the beginning of the test shall be from 0 MPa to 0,01 MPa at the boiling point of LNG in the inner tank.

The lapse of time, from the moment that the average temperature first reaches 590 °C until the opening of the primary pressure relief valve, shall be measured.

Once the pressure relief valve opens, the test shall continue until the blow off of the pressure relief valve is complete.

A.2.2 Acceptance criteria

The Holding time of the fuel tank, which is the lapse of time before the opening of the pressure relief valve, shall not be less than 5 min under an external fire.

The fuel tank shall not burst and the pressure inside the inner tank shall not exceed the permissible fault range of the inner tank. The test pressure and weakening of the material at elevated temperature (e.g. 590 °C) shall be considered. The secondary pressure valve shall limit the pressure inside the inner tank to the values specified in 4.7.2.

A.2.3 Test records

The test conditions, Holding time and maximum pressure reached within the fuel tank during the test, shall be recorded.

A.3 Maximum fuelling level test

A.3.1 Procedure

The inner tank shall be brought to the same temperature as the temperature of the LNG. This requirement shall be deemed as met if, during the previous 24 h, the fuel tank has contained a volume of LNG at least equal to half of the volume of the inner tank at operating pressure.

A system shall be used to measure either the mass of LNG or the mass flow rate at the inlet and outlet of the inner tank with an accuracy of at least 1 % of the maximum fuelling mass of the fuel tank under test.

The fuel tank shall be completely filled 10 times with LNG at equilibrium with its vapour. Between each fuelling, at least 25 % of the LNG shall be emptied from the fuel tank.

A.3.2 Acceptance criteria

The level of LNG shall never exceed the nominal maximum fuelling level of the inner tank as specified in 4.7.7.

A.3.3 Test records

The test conditions and the 10 maximum levels measured by the added system shall be recorded and kept on file for 10 years.

Annex B
(normative)

Accessory type tests

B.1 General requirements

Leakage tests shall be conducted with pressurized gas such as air or nitrogen containing at least 10 % helium.

Water or other fluids may be used to obtain the required pressure for hydrostatic pressure tests.

All test records shall indicate the type of test medium used, when applicable.

The test period for leakage and pressure tests shall be at least 10 min more than the response time of the pressure measuring device.

Unless otherwise stated, all tests shall be performed at an ambient temperature of 20 °C ± 5 °C.

Alternative tests or alternative test conditions to the ones given hereafter can be agreed between the parties provided that the revised testing protocols are validated by a formal risk assessment.

B.2 External leakage test

The component under test shall be free from leakage at any pneumatic pressure from 0 MPa to its MAWP.

The test shall be repeated on the same component at the following conditions:

a) ambient temperature of 20 °C ± 5 °C;

b) minimum design temperature specified for the component under test or at the temperature of liquid nitrogen after 3 h of conditioning at this temperature;

c) maximum design temperature specified for the component under test after 3 h of conditioning at this temperature.

In order to perform this test, the component under test shall be dried and connected to a pneumatic source of pressure. A positive shut-off valve pressure limiting control and a pressure gauge having a pressure range of not less than 1,5 times nor more than 2 times the test pressure shall be installed in the pressure supply piping.

The pressure gauge shall be installed between the positive shut-off valve and the sample under test. The accuracy of the pressure gauge shall not be less than 1 % of the test pressure range.

Throughout the test, the sample shall be checked for leaks. The leakage rate shall be less than 2 cm^3/h at 20 °C and 101,325 kPa per accessory. If a flow meter is used, it shall be capable of measuring, for the test fluid employed, the maximum leakage rate permitted with an accuracy of ± 1 %.

B.3 Seat leakage test

The seat leakage test shall be conducted with the inlet of the sample valve connected to a pneumatic source of pressure, the valve in the closed position, and with the outlet open. A positive shut-off valve and a pressure gauge having a pressure range of not less than 1,5 times and not more than 2 times the test pressure shall be installed in the pressure supply piping. The pressure gauge shall be installed between the positive shut-off valve and the sample under test. The accuracy of the pressure gauge shall not be less than 1 % of the test pressure range.

In order to perform the test, the pressure shall be gradually increased to the MAWP of the component under test. Observations for leakage shall be made with the open outlet submerged in water or with a flow meter installed on the inlet side of the valve under test.

If leakage is measured with the open outlet submerged in water, no detectable leak shall be observed.

If a flow meter is used, it shall be capable of measuring, for the test fluid employed, the maximum leakage rate permitted with an accuracy of 0,02 cm^3/h at 20 °C and 101,325 kPa. The maximum leakage rate shall be less than 2 cm^3/h at 20 °C and 101,325 kPa.

B.4 Pressure test

The component under test shall withstand without any visible evidence of leak or deformation a test pressure of 1,5 times its MAWP with the openings plugged or capped. The pressure shall then be increased from 1,5 to 3 times the MAWP. The component under test shall not show any visible evidence of rupture or cracks.

The pressure supply system shall be equipped with a positive shut-off valve and a pressure gauge, having a pressure range of not less than 1,5 times nor more than 2 times the higher test pressure. The accuracy of the gauge shall not be less than 1 % of the higher test pressure.

B.5 Endurance test (continuous operation)

The component under test shall be securely connected to a pressurized source of dry air or nitrogen and subjected to 20 000 cycles unless an alternative cycle number is agreed between all the parties. Such alternative cycle number shall be justified by the manufacturers of the tank based on the duty of the component. A cycle shall consist of one opening and one closing of the component within a period of not less than 10 s ± 2 s. During the off cycle, the downstream pressure of the test fixture shall be allowed to decay to 50 % or less of the MAWP of the component.

The component under test shall be operated for 2 % of the specified number of cycles at its MAWP and at its maximum design temperature after 3 hours conditioning at this temperature. After the completion of the specified number of cycles and while still at the maximum design temperature, the component shall be subjected to the tests specified in B.2 and B.3 and meet the requirements therein.

The component under test shall be operated for 2 % of the specified number of cycles at its MAWP and at its minimum design temperature or at the temperature of liquid nitrogen after 3 h conditioning at this temperature. After the completion of the specified number of cycles and while still at the minimum design temperature, the component shall be subjected to the tests specified in B.2 and B.3 and meet the requirements therein.

The component under test shall be operated for 96 % of the specified number of cycles at its MAWP and an ambient temperature of 20 °C ± 5 °C.

Immediately after being subjected to the number of operation cycles specified for that component, the component shall be subjected to the tests specified in B.2 and B.3 at an ambient temperature of 20 °C ± 5 °C and meet the requirements therein.

B.6 Temperature cycle test

The component under test shall be submitted to 24 temperature cycles. Each temperature cycle shall range from the minimum design temperature up to the maximum design temperature and back to the minimum temperature in a period of about 4 h. At the levels of maximum and minimum design temperature, the pressure shall be increased to its MAWP and left constant for at least 10 min. The component under test shall meet the leak requirements specified in B.2.

After the completion of the specified number of temperature cycles, the component shall be subjected to the tests specified in B.2 and B.3 and meet the requirements therein.

Bibliography

[1] ISO 188, *Rubber, vulcanized or thermoplastic — Accelerated ageing and heat resistance* tests

[2] ISO 12617[1)], *Liquefied natural gas vehicles — Connector for reflueling vehicles*

[3] ISO 21010, *Cryogenic vessels — Gas/materials compatibility*

[4] ISO 21011, *Cryogenic vessels — Valves for cryogenic service*

[5] ISO 21013-1, *Cryogenic vessels — Pressure-relief accessories for cryogenic service — Part 1: Reclosable pressure-relief valves*

1) Under preparation.

NATIONAL ANNEX A
(*National Foreword*)

A-1 BIS CERTIFICATION MARKING

Each tank may also be marked with the Standard Mark.

A-1.1 The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

(*Continued from second cover*)

International Standard	*Title*
ISO 21014	Cryogenic vessels — Cryogenic insulation performance
ISO 21028-1	Cryogenic vessels — Toughness requirements for materials at cryogenic temperature — Part 1: Temperatures below –80 degrees C
ISO 21029-1 : 2004	Cryogenic vessels — Transportable vacuum insulated vessels of not more than 1 000 litres volume — Part 1: Design, fabrication, inspection and tests
ISO 23208	Cryogenic vessels — Cleanliness for cryogenic service

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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Review of Indian Standards

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