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Road vehicles — Compressed natural gas (CNG) fuel system components —

Part 13: **Pressure relief device (PRD)**

Véhicules routiers — Composants des systèmes de combustible gaz naturel comprimé (GNC) —

Partie 13: Dispositifs de limitation de pression

Reference number
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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.

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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 15500-13 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 15500-13:2001), which has been technically revised.

ISO 15500 consists of the following parts, under the general title *Road vehicles — Compressed natural gas (CNG) fuel system components*:

— *Part 1: General requirements and definitions*

— *Part 2: Performance and general test methods*

— *Part 3: Check valve*

— *Part 4: Manual valve*

— *Part 5: Manual cylinder valve*

— *Part 6: Automatic valve*

— *Part 7: Gas injector*

— *Part 8: Pressure indicator*

— *Part 9: Pressure regulator*

— *Part 10: Gas-flow adjuster*

— *Part 11: Gas/air mixer*

— *Part 12: Pressure relief valve (PRV)*

— *Part 13: Pressure relief device (PRD)*

— *Part 14: Excess flow valve*

— *Part 15: Gas-tight housing and ventilation hose*

— *Part 16: Rigid fuel line in stainless steel*

— *Part 17: Flexible fuel line*

— *Part 18: Filter*

— *Part 19: Fittings*

— *Part 20: Rigid fuel line in material other than stainless steel*

Introduction

For the purposes of this part of ISO 15500, all fuel system components in contact with natural gas have been considered suitable for natural gas as defined in ISO 15403. However, it is recognized that miscellaneous components not specifically covered herein can be examined to meet the criteria of this part of ISO 15500 and tested according to the appropriate functional tests.

All references to pressure in this part of ISO 15500 are considered to be gauge pressures unless otherwise specified.

This part of ISO 15500 is based on a service pressure for natural gas used as fuel of 20 MPa [200 bar[1)]] 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.

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

Road vehicles — Compressed natural gas (CNG) fuel system components —

Part 13: **Pressure relief device (PRD)**

1 Scope

This part of ISO 15500 specifies tests and requirements for the pressure relief device (PRD), a compressed natural gas (CNG) fuel system component intended for use on the types of motor vehicles defined in ISO 3833.

This part of ISO 15500 is applicable to vehicles (mono-fuel, bi-fuel or dual-fuel applications) using natural gas in accordance with ISO 15403.

It is not applicable to the following:

a) liquefied natural gas (LNG) fuel system components located upstream of, and including, the vaporizer;

b) fuel containers;

c) stationary gas engines;

d) container-mounting hardware;

e) electronic fuel management;

f) refuelling receptacles.

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 15500-1, *Road vehicles — Compressed natural gas (CNG) fuel system components — Part 1: General requirements and definitions*

ISO 15500-2, *Road vehicles — Compressed natural gas (CNG) fuel system components — Part 2: Performance and general test methods*

3 Terms and definitions

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

3.1
activation pressure
rupture pressure
pressure, as specified by the pressure relief device (PRD) manufacturer, at which a PRD is designed to activate to permit the discharge of the cylinder

3.2
activation temperature
temperature, as specified by the pressure relief device (PRD) manufacturer, at which a PRD is designed to activate to permit the discharge of the cylinder

3.3
fusible material
metal, alloy, or other material capable of being melted where the melting is integral to the function of the pressure relief device (PRD)

3.4
parallel-combination relief device
pressure relief device (PRD) activated by high temperature or pressure acting separately

NOTE This device may be integrated into one device that has independent pressure-activated and thermally-activated parts. It may also be formed by two independent devices (one pressure-activated and one thermally-activated) that act independently. Each part of the device shall not interfere with the operation/activation of the other part. The device shall be able to vent the content of the cylinder through any one of the parts of the PRD independently. The device shall be able to vent the content of the cylinder if the pressure- and thermally-activated parts open simultaneously

3.5
pressure-activated relief device
pressure relief device (PRD) activated by pressure

3.6
burst disc
rupture disc
operating part of a pressure-activated pressure relief device (PRD) which, when installed in the device, is designed to burst at a predetermined pressure to permit discharge of the cylinder

3.7
series-combination relief device
pressure relief device (PRD) activated by a combination of high temperature and pressure acting together

3.8
thermally-activated relief device
pressure relief device (PRD) activated by high temperature

3.9
yield temperature
temperature at which the fusible material becomes sufficiently soft to activate the device and to permit discharge of the cylinder

NOTE 1 There are several possible scenarios for a vehicle involved in a fire. The PRD is intended to reduce the risk of cylinder rupture under most of these scenarios while keeping a low risk of accidental activation. Experience shows that the best solution depends on the type of cylinder the PRD is mounted on.

NOTE 2 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.

4 Marking

If the PRD is a stand-alone component, marking shall provide sufficient information to allow the following to be traced:

a) the manufacturer’s or agent’s name, trademark or symbol;

b) the fusible material yield temperature or PRD activation temperature (see Annex A), and the rupture disc pressure rating or activation pressure, as appropriate;

c) the type of relief device (thermally-activated, series-combination, parallel-combination, etc.).

If there is a possibility that the PRD could be installed with the flow in the wrong direction, the PRD shall be marked with an arrow to show the direction of flow.

NOTE This information can be provided by a suitable identification code on at least one part of the component when it consists of more than one part.

5 Construction and assembly

The PRD shall comply with the applicable provisions of ISO 15500-1 and ISO 15500-2, and with the tests specified in Clause 6 of this part of ISO 15500.

6 Tests

6.1 Applicability

The tests required to be carried out are indicated in Table 1.

Table 1 — Applicable tests

Test	Applicable	Test procedure as required by ISO 15500-2	Specific test requirements of this part of ISO 15500
Hydrostatic strength	X	X	X (see 6.2)
Leakage	X	X	X (see 6.3)
Excess torque resistance	X	X	
Bending moment	X[a]	X	X (see 6.4)
Continued operation	X	X	X (see 6.5)
Corrosion resistance	X	X	
Oxygen ageing	X	X	
Electrical over-voltages	X	X	
Non-metallic material immersion	X	X	
Vibration resistance	X	X	
Brass material compatibility	X	X	
Accelerated life	X	X	X (see 6.6)
Benchtop activation	X	X	X (see 6.7)
Thermal cycling	X	X	X (see 6.8)
Condensate-corrosion resistance	X	X	X (see 6.9)
Flow capacity	X	X	X (see 6.10)

[a] This test is to confirm proper design and construction of stand-alone, externally-threaded PRD designs and is not required if the PRD is internally imbedded in the valve body.

6.2 Hydrostatic strength

6.2.1 Housing

The manufacturer shall either physically test the housing or prove its strength by calculation.

6.2.1.1 Test procedure

6.2.1.1.1 Inlet passage strength

One piece shall be tested with pressure applied to the inlet, with the internal releasing components in the normally closed position. Pressure-activated elements such as burst discs may be modified, replaced with a plug or removed for the purpose of this test. The test shall be performed according to the procedure given in ISO 15500-2 using a pressure of 2,5 times the working pressure at 20 °C ± 5 °C.

6.2.1.1.2 Outlet passage strength

The outlets or venting orifices shall be plugged in a suitable way, without affecting the housing resistance. The internal triggering components such as fusible material or rupture discs shall be removed or otherwise opened or activated. Pressure shall be applied to the inlet of the device. The test shall be performed according to the procedure given in ISO 15500-2 using a pressure of 1,25 times the working pressure or the working pressure upstream of the outlet passage, whichever is greatest.

6.2.2 Fusible material

6.2.2.1 Test procedure

Test the fusible material in the PRD (thermally-activated or combination) with water at 20 °C ± 5 °C using the following procedure.

a) Subject three randomly selected test specimens to a constant pressure of 1,2 times the working pressure for 30 min. For series-combination relief devices, the burst disc shall not be removed. For parallel-combination relief devices, only the thermally-activated part of the device shall be tested.

During the test, the fusible material shall not begin to extrude out of the PRD.

b) Increase the pressure at a rate of 0,5 MPa/s (5 bar/s) to 60 MPa (600 bar), or to the pressure at which the fusible material starts to extrude.

6.2.2.2 Requirement

If the extrusion of the fusible material begins at less than 45 MPa (450 bar), the device is considered to have failed the test.

6.3 Leakage

Follow the procedure for testing leakage given in ISO 15500-2, using the test temperatures and pressures given in Table 2, below. The PRD shall be either bubble-free or have a leakage rate < 2 Ncm^3/h.

Table 2 — Test temperatures and pressures

Temperature °C	**Pressure** MPa [bar]
−40 or −20	15 [150]
82 or higher	26 [260]

6.4 Bending moment

The purpose of this test is to confirm proper design and construction of stand-alone, externally-threaded PRD designs. Test the PRD according to the corresponding procedure given in ISO 15500-2.

6.5 Continued operation

6.5.1 Test procedure

a) Randomly select five test specimens.

b) Cycle the PRD according to Table 3, with water at between 10 % and 100 % of the working pressure, at a maximum cyclic rate of 10 cycles per minute.

Table 3 — Test temperatures and cycles

Temperature °C	Cycles
82 or higher	2 000
57 ± 2	18 000

6.5.2 Requirements

Following the test, there shall be no extrusion of the fusible material from the PRD.

At the completion of the test, the PRD shall comply with the requirements of 6.3 and 6.7. The rupture pressure will be > 75 % and < 105 % of the activation pressure of a PRD not subjected to any previous testing.

6.6 Accelerated life

6.6.1 General

Fusible materials can creep and flow within the operating temperature range of natural gas vehicle PRDs.

Accelerated-life testing is performed to verify that the rate of creep is sufficiently low in order that the device can perform reliably for at least one year at 82 °C and for at least 20 years at 57 °C. Accelerated-life testing shall be performed on new PRD designs or designs in which the fusible material melt temperature or device activation mechanism is modified. For devices not using activation materials that can creep, testing and analysis shall be performed to verify that the device will perform reliably for at least one year at 82 °C and at least 20 years at 57 °C.

6.6.2 Test procedure

a) Place the test specimens in an oven or liquid bath, holding the specimens' temperature to within ±1 °C throughout the test.

b) Elevate the pressure on the PRD inlet to 100 % of the working pressure and hold this constant to within ±0,7 MPa (7 bar) until activation. The pressure supply may be located outside the controlled temperature oven or bath. Limit the volume of liquid or gas to prevent damage to the test apparatus upon activation and venting.

Each device may be pressurized individually or through a manifold system. If a manifold system is used, each pressure connection shall include a check valve to prevent pressure depletion of the system if one specimen fails.

6.6.3 Accelerated-life test temperature

The accelerated-life test temperature, T_L, is given in °C by the expression:

$$T_L = 12{,}88 \cdot T_f^{0{,}420}$$

where

T_f is the manufacturer's specified activation temperature, in °C.

6.6.4 Requirements

6.6.4.1 Three PRDs shall be tested at the manufacturer's specified activation temperature to verify that they activate in less than 10 h.

6.6.4.2 Five PRDs shall be tested at their accelerated-life test temperature. The time-to-activation for accelerated-life test devices shall exceed 500 h.

6.7 Benchtop activation

6.7.1 General

6.7.1.1 The purpose of the benchtop-activation test is to demonstrate that a PRD will activate consistently throughout its life.

6.7.1.2 Test two PRDs without subjecting them to other tests in order to establish a baseline time for activation. The PRDs that have undergone the tests of 6.5 and 6.9 shall be tested according to 6.7 and meet the requirements of 6.7.2 or 6.7.3, as applicable.

6.7.1.3 Test thermally-activated relief devices in accordance with 6.7.2. Series-combination relief devices, activated by a combination of high pressures and temperatures acting together, shall be tested in accordance with 6.7.3. Parallel-combination relief devices, activated by high pressure and temperatures acting separately, shall be tested in accordance with 6.7.4.

6.7.2 Thermally-activated relief devices

6.7.2.1 Test setup

The test setup shall consist of either an oven or chimney capable of maintaining a gas temperature at 600 °C ± 10 °C in the area of the oven or chimney into which the PRD is inserted for testing. The PRD shall not be exposed directly to flame.

6.7.2.2 Test procedure

a) Pressurize the PRD to 25 % of working pressure or 2 MPa, whichever is less. The temperature shall remain within the acceptable range for 2 min prior to running the test.

b) Insert the PRD in the oven or chimney and record the time-to-activation, t.

6.7.2.3 Requirements

The PRDs subjected to the tests of 6.5, 6.8, 6.9, and the corrosion-resistance and vibration-resistance tests of ISO 15500-2, shall activate to meet the following requirements where t, in minutes, is the time-to-activation of the PRDs not subjected to those tests:

$\leq 5 \cdot t$

$\leq t + 4$ min

6.7.3 Series-combination relief devices

6.7.3.1 Test procedure

a) Place the PRD in an oven heated to a temperature 11 °C ± 1 °C above the yield temperature of the fusible material, until the temperature of the PRD is stabilized.

b) Pressurize the PRD until it activates.

6.7.3.2 Requirements

The PRD subjected to the tests of 6.5, 6.8, 6.9, and the corrosion resistance and vibration resistance tests of ISO 15500-2, shall activate at a pressure $>$ 75 % and $<$ 105 % of the activation pressure of a PRD not subjected to any previous testing.

6.7.4 Parallel-combination relief devices

6.7.4.1 Test procedure

a) Test the thermally-activated part of the PRD following the tests of 6.7.2.

b) Activate the pressure-activated part of the PRD by pressurizing until the rupture disc bursts.

6.7.4.2 Requirements

The PRDs subjected to the tests of 6.5, 6.8, 6.9 and the corrosion-resistance and vibration tests of ISO 15500-2, shall be subjected to the test procedure in 6.7.2.2 and meet the following requirements:

a) the thermal part of the PRDs shall meet the requirements of 6.7.2.3;

b) the pressure-activated part shall activate at a pressure $>$ 75 % and $<$ 105 % of the activation pressure of a PRD not subjected to any previous testing.

The PRD assembly shall be cycled 1,000 times between not more than 10 % of the manufacturer's specified service pressure and not less than 100 % of the manufacturer's specified working pressure. This test shall be conducted at ambient temperature. The maximum pressure cycling rate is 10 cycles per minute. Following this test, the PRD shall be activated by pressurizing until the device relieves pressure.

The PRDs subjected to pressure cycling, thermal cycling, salt corrosion resistance, gas condensate corrosion resistance and impact due to drop and vibration, shall activate at a pressure which is at least 130 % of the manufacturer's specified service pressure, and is at least 75 % of the activation pressure, but is not more than 105 % of the activation pressure, of the PRD which had not been subjected to previous design qualification tests.

6.8 Thermal cycling

6.8.1 Test procedure

Thermally cycle the PRD between −40 °C or −20 °C as applicable and 82 °C or higher, as follows:

a) Place a depressurized PRD in a fluid bath maintained at −40 °C or −20 °C as applicable or lower for a period of 2 h or more. Then transfer the device to a fluid bath maintained at 82 °C or higher within 5 min of having removed it from the cold bath.

b) Leave the depressurized PRD in the fluid bath maintained at 82 °C or higher for a period of 2 h or more. Then transfer the device to the fluid bath maintained at −40 °C or −20 °C as applicable or lower within 5 min of having removed it from the hot bath.

c) Repeat steps a) and b) until a total of 15 thermal cycles have been achieved.

d) With the PRD conditioned for a period of 2 h or more in the fluid bath of −40 °C or −20 °C as applicable, cycle the PRD between no more than 10 % and no less than 100 % of the service pressure for a total of 100 cycles.

6.8.2 Requirements

At the completion of the test, the PRD shall meet all the requirements of 6.3 and 6.7.

6.9 Condensate-corrosion resistance

6.9.1 Test procedure

a) Seal the outlet port of the PRD.

b) Fill the PRD with the test solution given in 6.9.2 and soak the device for 100 h at 21 °C ± 2 °C.

c) Empty the solution from the PRD and reseal the outlet port, then heat the device for an additional 100 h at 82 °C or higher.

At the end of this test, the PRD shall meet all the requirements of 6.3 and 6.7.

6.9.2 Test solution

The test solution, by volume percentage, shall consist of:

— Stoddard solvent, 84,8 %,

— benzene, 10,0 %,

— phosphate ester compressor oil, 2,5 %,

— water, 1,5 %,

— methanol 1,0 %, and

— mercaptan, 0,2 %.

6.10 Flow capacity

6.10.1 General

6.10.1.1 Three random samples of the PRD shall be tested for flow capacity. Each device tested shall be made to operate by temperature, by pressure or a combination of temperature and pressure.

6.10.1.2 After activation, and without cleaning, removal of parts or reconditioning, each PRD shall be subjected to an actual flow test wherein the amount of air released by the device is measured. The rated flow capacity of the device shall be the average flow capacity of the three samples, provided the individual flow capacities fall within 10 % of the highest flow capacity recorded.

6.10.2 Test procedure

a) Conduct flow testing with air at 0,8 MPa (8 bar) to 0,9 MPa (9 bar).

b) Measure the temperature.

c) Correct the calculation of flow rate to 0,7 MPa (7 bar) absolute and 15 °C.

The PRD shall be tested to establish its flow capacity in m3/h (normal conditions) of natural gas flow with an accuracy of ±10 %. One acceptable method is to measure the temperature and pressure of a known volume of compressed air or gas, both before and after conducting a flow test, and measure the time during flow.

7 Production batch inspection and acceptance testing

The PRD manufacturer shall institute a production batch inspection and acceptance testing programme that ensures consistent safety performance of the product.

Annex A
(normative)

Determination of fusible material yield temperature and PRD activation temperature

A.1 General

Clause 4 of this part of ISO 15500 gives PRD manufacturers a choice of marking their products with either the fusible material yield temperature or the PRD activation temperature [see b) in Clause 4]. In A.2 and A.3 the methods are given for obtaining these values.

A.2 Fusible material yield temperature

A.2.1 Sample selection

Select at random two samples of the fusible material from each batch (heat) in the manufactured form (e.g. ingot, wire).

A.2.2 Test setup

For fusible material supplied in ingot form, two specimens, each 50 mm in length and approximately 6 mm in diameter, shall be taken from each ingot for test purposes. For fusible material supplied in wire form, two test specimens shall be taken from each coil with each specimen no less than 38 mm, and no greater than 50 mm, in length. Each test specimen shall be positioned horizontally on two knife edges spaced apart so that the ends of the specimen overhang the knife edges by 12 mm. The supported specimens shall be immersed in a glycerine bath at a minimum distance of 6 mm from the bottom of the container.

A.2.3 Test procedure

a) Test two samples from a given ingot or coil of wire at one time. The bath temperature may be raised at a rate of 3 °C/min up to 5 °C/min below the yield temperature of the material.

b) After the temperature has stabilized at this level, raise the bath temperature at a much slower rate so as not to exceed 0,6 °C/min.

Measure the temperatures using a suitable sensing device inserted in the bath, between and closely adjacent to the specimens, so that the sensor is immersed at the same level as the specimens.

A.2.4 Requirements

The yield temperature shall be taken as the temperature at which the second of the four ends of the specimens loses its rigidity and droops, or at which there is drooping of the sections of the two specimens between the knife edges, or both. After the temperature of the bath and fusible metal have stabilized, yielding shall occur before the allowable yield temperature has been exceeded.

A.3 PRD activation temperature determination

A.3.1 Differential scanning calorimetry (DSC) method

The activation temperature of the fusible material shall be measured by DSC.

A.3.2 Thermocouple method

Slowly heat the PRD, subjected to working pressure, by immersing it in a bath or using a hot air stream, until it activates. Measure the temperature using a thermocouple.

Bibliography

[1] ISO 3833, *Road vehicles — Types — Terms and definitions*

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

[3] ISO 15403-1, *Natural gas — Natural gas for use as a compressed fuel for vehicles — Part 1: Designation of the quality*

[4] ISO/TR 15403-2, *Natural gas — Natural gas for use as a compressed fuel for vehicles — Part 2: Specification of the quality*

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