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Road vehicles — Compressed gaseous hydrogen (CGH2) and hydrogen/natural gas blends fuel system components —

Part 10: Pressure relief device (PRD)

Véhicules routiers — Composants des circuits d'alimentation pour hydrogène gazeux comprimé (CGH2) et mélanges de gaz naturel et hydrogène —

Partie 10: Dispositif de surpression

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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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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 41, *Specific aspects for gaseous fuels*.

A list of all parts in the ISO 12619 series can be found on the ISO website.

Road vehicles — Compressed gaseous hydrogen (CGH2) and hydrogen/natural gas blends fuel system components —

Part 10: Pressure relief device (PRD)

1 Scope

This document specifies tests and requirements for the pressure relief device (PRD), a compressed gaseous hydrogen (CGH_2) and hydrogen/natural gas blend fuel system component intended for use on the types of motor vehicles defined in ISO 3833.

It is applicable to vehicles using CGH_2 in accordance with ISO 14687-1 or ISO 14687-2 and hydrogen/natural gas blend using natural gas in accordance with ISO 15403-1 and ISO/TR 15403-2. It is not applicable to the following:

a) liquefied hydrogen (LH_2) fuel system components;

b) fuel containers;

c) stationary gas engines;

d) container mounting hardware;

e) electronic fuel management;

f) refuelling receptacles;

g) fuel cell vehicles.

NOTE 1 It is recognized that miscellaneous components not specifically covered herein can be examined to meet the criteria of this document and tested according to the appropriate functional tests.

NOTE 2 All references to pressure in this document 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 12619-1, *Road vehicles — Compressed gaseous hydrogen (CGH_2) and hydrogen/natural gas blend fuel system components — Part 1: General requirements and definitions*

ISO 12619-2, *Road vehicles — Compressed gaseous hydrogen (CGH_2) and hydrogen/natural gas blend 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 12619-1 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
activation pressure
rupture 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 1 to entry: 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
thermally activated relief device
pressure relief device (PRD) activated by high temperature

3.8
yield temperature
temperature at which the *fusible material* (3.3) becomes sufficiently soft to activate the device and to permit discharge of the cylinder

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 in accordance with Annex A and the rupture disc pressure rating or activation pressure, as appropriate;

c) the type of relief device (thermally activated, 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.

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 12619-1 and ISO 12619-2 and with the tests specified in Clause 6. Tolerances should follow the specifications of ISO 12619-2.

The PRD may be integrated with other components. The other components shall not interfere with the operation/activation of the PRD.

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 12619-2	Specific test requirements of this document
Hydrostatic strength	X	—	X (see 6.2)
Leakage	X	—	X (see 6.3)
Excess torque resistance	X	X	—
Bending moment	X[a]	—	X (see 6.4)
Continued operation	X	—	X (see 6.5)
Corrosion resistance	X	X	—
Oxygen ageing	X	X	—
Ozone ageing	X	X	—
Heat ageing	X	X	—
Automotive fluids	X	X	—
Non-metallic material immersion	X	X	—
Vibration resistance	X	X	—
Brass material compatibility	X	X	—
Accelerated life	X	—	X (see 6.6)
Benchtop activation	X	—	X (see 6.7)
Thermal cycling	X	—	X (see 6.8)
Condensate-corrosion resistance	X	—	X (see 6.9)
Flow capacity	X	—	X (see 6.10)
Impact due to drop and vibration	X	—	X (see 6.11)

[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

6.2.1.1 General

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

6.2.1.2 Test procedure

6.2.1.2.1 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 12619-2 using a pressure of 2,5 times the working pressure at (20 ± 5) °C.

6.2.1.2.2 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 12619-2 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 ± 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 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 to 60 MPa 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, the device is considered to have failed the test.

6.3 Leakage

Follow the procedure for testing leakage given in ISO 12619-2 using the test temperatures and pressures given in Table 2. 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
−40 or −20	15
82 or higher	26

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 12619-2.

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 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 1 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 1 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 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, TL, is given in °C in Formula (1):

$$T_L = 12{,}88 \times T_f^{0{,}420} \qquad (1)$$

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.

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

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 ± 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, the corrosion-resistance and vibration-resistance tests of ISO 12619-2 shall activate to meet the following requirements where t, in minutes, is the time-to-activation of the PRDs not subjected to those tests:

$\leq 5 \times t$

$\leq t + 4$ min

6.7.3 Parallel-combination relief devices

6.7.3.1 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.

6.7.3.2 Requirements

The PRDs subjected to the tests of 6.5, 6.8, 6.9, the corrosion-resistance and vibration tests of ISO 12619-2 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 ± 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 %;

— mercaptan, 0,2 %.

6.10 Flow capacity

6.10.1 General

6.10.1.1 Three random samples of the PRDs 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 to 0,9 MPa.

b) Measure the temperature.

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

The PRD shall be tested to establish its flow capacity in m^3/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.

6.11 Impact due to drop and vibration

6.11.1 Impact due to drop

When subjected to a vertical drop of 1,83 m onto a smooth concrete floor or pad, pressure relief devices shall meet all operational performance requirements without loss of function or degradation of service life or shall exhibit obvious visible exterior (physical) damage which indicates the part is unsuitable for use.

This requirement shall be demonstrated as follows.

a) Six pressure relief device samples selected at random shall be subjected to impact by being dropped from a height of 1,83 m, from the lowest point on the device, at room ambient temperature, onto a smooth concrete pad or floor. For devices having extended flexible elements such as hoses, these shall be dropped with the flexible element in the pre-installation condition, with no packaging material. Each sample shall be allowed to bounce on the concrete pad or floor after the initial impact. One sample shall be dropped in each of the six major axes of orientation (opposing directions of three orthogonal axes, vertical, lateral and longitudinal). After each drop, the sample shall be examined for visible damage. If each of the six dropped samples do not show visible exterior damage that indicates that the part is unsuitable for use, then it shall meet the requirements of 6.11.2.

b) If one or more of the dropped samples exhibits visible exterior damage which indicates that the part is unsuitable for use, the damage signature(s) shall be graphically documented and provided to the container manufacturer as the relative measure for rejection of visibly damaged parts.

6.11.2 Vibration

Each of the six samples of a pressure relief device identified in 6.11.1 a) and one new randomly selected sample not subjected to a drop shall be mounted in accordance with the pressure relief device manufacturer's installation instructions and vibrated 30 min along each of the three orthogonal axes (vertical, lateral and longitudinal) at the most severe resonant frequencies. Devices with long triggering elements shall be mounted and tested with a length that tests all relevant mounting conditions covered by the manufacturer's installation instructions. More than one unit may be used if needed. This shall include at least one end and intermediate mounting if mounts at intervals are used. The frequencies shall be determined by the following: acceleration of 1,5 g with a sweep time of 10 min, within a sinusoidal frequency range of 10 Hz to 500 Hz. If the resonance frequency is not found in this range, the test shall be conducted at 500 Hz.

Following this test, each sample shall not show any indication of fatigue or component damage and shall meet the requirements of 6.3 and 6.7.

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 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.