

GRPE/ISO **N 022**

NEW PROPOSALS FOR
ANNEX 8
REQUIREMENTS AND APPROVAL TEST PROCEDURES
FOR SPECIFIC COMPONENTS OTHER THAN CONTAINERS
&
RELATED CHANGES

RELATED CHANGES IN OTHER SECTIONS OF THE PROPOSALS

<u>Section</u>	<u>Change</u>
Contents	Rename Annex 8: "Requirements And Approval Test Procedures For Specific Components Other Than Containers"
Contents	Delete references to Annexes 8A - 8J & Annex 9, and check references in other parts of the document
2.1.13	Delete "or single valve"
2.1.16	" <u>Flexible Fuel Line</u> ": A flexible tubing or hose of any length through which hydrogen flows.
2.1.20	Reword to: " <u>Hydrogen Component</u> ": A component that is in direct contact with hydrogen or which forms part of a system installed because of the use of hydrogen. A <i>Hydrogen Component</i> can consist of a combination of metallic and non-metallic parts/subcomponents.
2.1.?	Add new definition and check references in other parts of the document: " <u>Leak Test Gas</u> ": Leakage tests shall be conducted with hydrogen, helium or a gas mixture containing at least 5% hydrogen or 10% helium or a demonstrated detectable amount of helium or hydrogen gas. Permitted leakage rates in this Regulation and its Annexes are applicable to tests with 100% hydrogen only. Permitted leakage rates for other gases or gas mixtures shall be converted to an equivalent leakage rate to that for 100% hydrogen.
2.1.33	Reword to and check references in other parts of the document: " <u>Pressure Relief Device</u> ": A non-reclosing thermally activated device that prevents a <i>Container</i> from bursting due to fire effects. N.B. The wording of Para.14.2.5 will be unchanged but the meaning will change, i.e. <i>Pressure Relief Devices</i> to the new definition will provide fire protection for the <i>Container</i> .
2.1.?	Add new definition and check references in other parts of the document: " <u>Pressure Relief Valve</u> ": A reclosing pressure activated device that prevents a <i>Hydrogen Component</i> from bursting due to excessive pressure.
2.4.7, 1 st Para	Delete 2 nd sentence referring to pressure cycles for Class1 & 2 components
2.4.8	Add new section: 2.4.8 Duty Cycles 2.4.8.1 General The number of <i>Duty Cycles</i> for <i>Hydrogen Components</i> approved in accordance with this Regulation and its Annexes shall be 50,000 cycles except as permitted in Paragraph 2.4.8.2 of this Regulation. 2.4.8.2 Reduced or Extended Number of <i>Duty Cycles</i>

The vehicle manufacturer may specify a reduced or extended number of *Duty Cycles* for each *Hydrogen Component* based on the design lifetime mileage of the vehicle divided by 4, i.e.:

Design lifetime mileage of the vehicle, L [km]

Number of *Duty Cycles* = L[km]/4.

- 6.1.1 Reword final sentence to “They shall remain functional under the mechanical, thermal and chemical service conditions specified in **Paragraph 2.4** of this Regulation, and shall also reliably withstand these conditions without leaking or visibly deforming.”
- 6.1.3 Delete section; it gives no benefit as components have to be tested in accordance with the Regulation anyway.
- New 6.1.3 Add new Pt.1: 6.1.3:
“Material compatibility with the service conditions defined in **Paragraph 2.4** of this Regulation shall be demonstrated either by the material tests in **Paragraphs B1 & B2** of **Annex 8** to this Regulation, or by documented material properties provided by the material manufacturer.”
- 6.1.7 Relocate 6.1.7 to 6.1.4, and renumber/cross check as appropriate.
- 6.3 Reword:
6.3 PROVISIONS REGARDING SPECIFIC COMPONENTS OTHER THAN CONTAINERS

Specific Components other than *Containers* shall be type approved according to **Annex 8** to this regulation.
- 6.4 – 6.11 Delete sections and renumber subsequent sections. Check related references throughout the document.
- 14.1.10 “The *Hydrogen System* shall be pressurised to *Working Pressure* using a *Leak Test Gas* and tested for leakage with a surface active agent without formation of bubbles for three minutes, or by using a demonstrated equivalent method.”
- 14.1.15 Delete final part of sentence from and including “and shall...”.
- 14.3.2.8 Delete section as it is covered by the new definition of a PRD.
- Annex 7 Change references to “Test Certificate” to “Test Summary”

Annex 8

**REQUIREMENTS AND APPROVAL TEST PROCEDURES
FOR SPECIFIC COMPONENTS OTHER THAN CONTAINERS**

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Annex 8: Part A

PROVISIONS REGARDING THE APPROVAL OF SPECIFIC COMPONENTS OTHER THAN CONTAINERS

A1 REFERENCES

The following standards contain provisions that, through reference in this text, constitute provisions of this Annex. Where standards other than ISO standards are referenced they may be replaced by equivalent national standards.

International Organisation for Standardization (ISO) Standards

ISO 37: 1994	Rubber, vulcanised Or Thermoplastic - Determination Of Tensile Stress-strain Properties
ISO 188: 1998	Rubber, Vulcanised Or Thermoplastic - Accelerated Ageing And Heat Resistance Tests
ISO 1307: 1992	Rubber And Plastic Hoses For General purpose Industrial Applications - Bore Diameters And Tolerances, And Tolerances On Length
ISO 1402: 1994	Rubber And Plastic Hoses And Hose Assemblies - Hydrostatic Testing
ISO 1436: 1991	Rubber Hoses And Hose Assemblies - Wire Reinforced Hydraulic Type - Specification
ISO 4672: 1997	Rubber And Plastic Hoses - Sub-ambient Temperature Flexibility Tests
ISO 6957: 1988	Copper Alloys - Ammonia Test For Stress Corrosion Resistance
ISO 9227: 1990	Corrosion Tests In Artificial Atmospheres - Salt Spray Tests
PrEN ISO 11114-4 (??/??)	Transportable Gas Cylinders – Compatibility Of Cylinders And Valve Materials With Gas Contents – Part 4: Test Methods For Selecting Metallic Materials Resistant To Hydrogen Embrittlement
ISO/WD 17268: 20??	Gaseous Hydrogen – Land Vehicle Filling Connectors

American Society for Testing and Materials (ASTM) Standards

ASTM D572:	Test for Accelerated Aging of Vulcanised Rubber by Oxygen Pressure Method
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A2 GENERAL REQUIREMENTS

- A2.1 Unless otherwise stated in this Annex all tests shall be performed at 20°C ± 5°C.
- A2.2 Explosive gas mixtures shall be prevented from developing during the test procedures described in this Annex.
- A2.3 The test period for leakage and pressure tests shall be not less than 3 minutes.

A2.4 Unless otherwise stated the applied test pressure is to be measured at the inlet of the component under test.

A3 APPROVAL REQUIREMENTS

A3.1 GENERAL APPROVAL REQUIREMENTS

A3.1.1 In addition to the requirements given below, the *Manufacturer* shall complete all documents referred to in **Part B** of this Annex and submit them to the Competent Authority when applying for type approval.

A3.1.2 The *Specific Components* shall be subjected to the applicable test procedures laid down in **Table 8A.1** of this Annex. The tests shall be conducted on *Specific Components* that are representative of normal production and complete with identification marks.

A3.1.3 The tests specified in Paragraphs **B3 to B8** of this Annex shall be conducted on the same samples of *Specific Components* in the sequence given in **Table 8A.1** unless otherwise indicated, e.g. for *Fittings* the Corrosion Resistance Test (**B3**) shall be followed by an Endurance Test (**B5**), followed by an External leakage Test (**B7**), and finally by a Hydrostatic Pressure Test (**B8**). If a *Specific Component* does not contain metallic sub-components the testing shall commence with the first applicable test.

A3.1.4 The documentation and test reports shall be sufficiently detailed that an independent third party test facility could reproduce the appropriate type approval tests and test results.

A3.2 SPECIFIC APPROVAL REQUIREMENTS

A3.2.1 Approval for a *Flexible Fuel Line* shall be given for one of any length with a minimum bending radius specified by the *Manufacturer* and when assembled with a specific type of *Fitting*.

A3.2.2 The construction of *Flexible Fuel Lines* shall be such that any reinforcing interlayer(s) are protected against corrosion by a cover. The cover shall prevent the formation of bubbles between the layer(s).

A3.2.3 The inside diameter of *Flexible Fuel Line* shall be in compliance with Table 1 of **ISO 1307**.

A3.2.4 *Flexible Fuel Lines* shall have an electrical resistance of less than 1 mega-ohm per meter.

A3.2.5 The profile of *Receptacles* shall comply with **ISO 17268**.

SPECIFIC COMPONENT	TYPE OF TEST						
	Material Tests	Corrosion Resistance Test	Hydraulic Pressure Cycle Test	Endurance Test	Internal Leakage Test	External Leakage Test	Hydrostatic Pressure Test
	B1 & B2	B3	B4	B5	B6	B7	B8
<i>Automatic Valves</i>	✓	✓		✓	✓	✓	✓
<i>Fittings</i>	✓	✓		✓		✓	✓
<i>Flexible Fuel Lines</i>	✓	✓		✓		✓	✓
<i>Heat Exchangers</i>	✓	✓				✓	✓
<i>Hydrogen Filters</i>	✓	✓				✓	✓
<i>Manual Valves</i>	✓	✓		✓	✓	✓	✓
<i>Non-Return Valves</i>	✓	✓		✓	✓	✓	✓
<i>Pressure Regulators</i>	✓	✓		✓	✓	✓	✓
<i>Pressure Relief Devices</i>	✓	✓	✓	✓	✓	✓	✓
<i>Pressure Relief Valves</i>	✓	✓		✓	✓	✓	✓
<i>Receptacles</i>	✓	✓		✓	✓	✓	✓
<i>Sensors for Hydrogen Systems</i>	✓	✓		✓		✓	✓

Table 8A.1: Applicable Test Procedures For Specific Components Other Than Containers

Annex 8: Part B

APPROVAL TEST PROCEDURES FOR SPECIFIC COMPONENTS OTHER THAN CONTAINERS

MATERIAL TESTS

B1 HYDROGEN COMPATIBILITY TEST

B1.1 Sampling

The test applies to the materials used in a *Specific Component* where the material is in contact with hydrogen.

Number of material samples to be tested: 3

B1.2 Procedure and Requirements

Hydrogen compatibility testing shall be carried out in accordance with recognised industry practice.

B1.3 Results

The results of the tests shall be presented in a test summary.

B2 AGEING TEST

B2.1 Sampling

All non-metallic materials used in a *Specific Component* shall be tested.

Number of material samples to be tested: 3

B2.2 Procedure and Requirements

Special consideration must be given to safety when conducting this test.

The test shall be undertaken in accordance with **ASTM D572**. The sample shall be exposed to oxygen at 85°C at 2 MPa for a period of 96 hours. No cracking or visible evidence of deterioration of the test piece(s) is allowed.

B2.3 Results

The results of the tests shall be presented in a test summary.

TESTS OF SPECIFIC COMPONENTS

B3 CORROSION RESISTANCE TEST

B3.1 Sampling

Number of *Specific Components* to be tested: 3

B3.2 Procedure and Requirements

Test i) Metallic components shall be submitted to a 144 hour salt spray test in accordance with **ISO 9227** with all connections closed and shall meet the requirements therein.

Test ii) A copper alloy component shall also be submitted to 24 hours immersion in ammonia in accordance with **ISO 6957** with all connections closed and shall meet the requirements therein.

B3.3 Results

The results of the tests shall be presented in a test summary.

B4 HYDRAULIC PRESSURE CYCLE TEST

B4.1 Sampling

This test applies to *Pressure Relief Devices*.
Number of *Specific Components* to be tested: 3

B4.2 Procedure and Requirements

Pressure Relief Devices shall be subjected to 1.5 times the number of *Filling Cycles* calculated in accordance with **Paragraph 2.4.7** of this Regulation at both the minimum and maximum material temperatures in accordance with **Paragraph 2.4.6** of this Regulation.

The pressure shall periodically change from 2 MPa to 1.25 times *Working Pressure* at a rate not exceeding 4 cycles per minute, except when tested at the minimum material temperature when the maximum test pressure shall be *Working Pressure*.

If fusible metal is used in a *Pressure Relief Device* it shall show no visible sign of extrusion.

B4.3 Results

The results of the tests shall be presented in a test summary.

B5 ENDURANCE TEST

B5.1 Sampling

Number of *Specific Components* to be tested: 3

B5.2 Procedures And Requirements

B5.2.1 Automatic, Manual & Non-return Valves

The *Specific Component* shall be tested in accordance with the following procedure:

- i) Pressurise the *Specific Component* with dry air, nitrogen, or hydrogen to *Working Pressure* and subject it to 96% of the total number of test cycles in accordance with **Table B5.1** of this Annex at $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$. A complete test cycle shall take place over a period of not less than 10 ± 2 seconds. When in the closed position the downstream pressure of the component under test is allowed to decay to 0.5 times the *Working Pressure* of the component. The *Specific Component* shall fulfil the requirements of the Internal and External Leakage Tests (Paragraphs **B6 & 7** of this Annex respectively) at this temperature.
- ii) The *Specific Component* shall then be operated through 2% of the total number of test cycles at the minimum material temperature in accordance with **Paragraph 2.4.6.1** of this Regulation after 2 hours conditioning at this temperature. The *Specific Component* shall fulfil the requirements of the Internal and External Leakage Tests (Paragraphs **B6 & 7** of this Annex respectively) at this temperature.
- iii) The *Specific Component* shall then be operated through 2% of the total number of test cycles at the maximum material temperature in accordance with **Paragraph 2.4.6.1** of this Regulation after 2 hours conditioning at this temperature. The *Specific Component* shall fulfil the requirements of the Internal and External Leakage Tests (Paragraphs **B6 & 7** of this Annex respectively) at this temperature.

B5.2.2 Fittings

Fittings shall be subjected to 25 connection/disconnection cycles.

B5.2.3 Flexible Fuel Lines

The length of the flexible part of the *Flexible Fuel Line* with its fittings attached, to be used in the following test shall be calculated as follows:

$$L = \pi R + 2D$$

where:

L = Length of the flexible part of the *Flexible Fuel Line*
R = Minimum bending radius specified by the *Manufacturer*
D = Outside diameter of the *Flexible Fuel Line*

The *Flexible Fuel Line* shall be bent through 180 degrees to the minimum radius specified by the *Manufacturer* and rigidly attached to a fixture in that position by the *Fittings* with which it is to be approved. One end of the *Flexible Fuel Line* shall be plugged and the other end shall be attached to a hydraulic supply. The *Flexible Fuel Line* shall be pressurised quickly by means of a quick opening solenoid valve, such that one cycle consists of holding the pressure at 1.25 times the *Working Pressure* for 10 ± 1 seconds (except for *Flexible Fuel Lines* with a required material temperature of 120°C where the hold pressure shall be 1.37 times *Working Pressure*) and then reducing it to less than 0.1 times the *Working Pressure* for 5 ± 0.5 seconds. The total number of test cycles shall be equal to 2.0 times the number of *Filling Cycles* or *Duty Cycles* as appropriate to the use of the *Flexible Fuel Line* in accordance with Paragraph **2.4.7 or 2.4.8** of this Regulation as appropriate. 50% of the test cycles shall be performed at the minimum and the remaining 50% at the maximum material temperature in accordance with **Paragraph 2.4.6.1** of this Regulation.

The *Flexible Fuel Line* shall not show any visible signs of damage.

B5.2.4 Pressure Regulators

Pressure Regulators shall be tested in accordance with the following procedure:

- i) The *Pressure Regulator* shall be connected to a source of *Leak Test Gas* at *Working Pressure* and cycled through 95% of the number of *Duty Cycles* calculated in accordance with Paragraph 2.4.8 of this Regulation. One cycle shall consist of flow until stable outlet pressure has been attained, after which the gas flow shall be shutoff by a downstream quick closing valve until stable lockup pressure has been achieved. The *Pressure Regulator* shall fulfil the requirements of the Internal and External Leakage Tests (Paragraphs B6 & B7 of this Annex respectively) conducted at $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$ at intervals of 20, 40, 60, 80 and 100% of the number of cycles required above.
- ii) The inlet of the *Pressure Regulator* shall be pressure cycled through 1% of the number of *Duty Cycles* from *Working Pressure* to 0.5 times the *Working Pressure* or less. Subsequently the *Pressure Regulator* shall fulfil the requirements of the Internal and External Leakage Tests (B6 & B7) conducted at $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$.
- iii) The cycling procedure in i) above shall be repeated at the maximum material temperature in accordance with Paragraph 2.4.6.1 of this Regulation and at 1.25 times the *Working Pressure* for 1% of the number of *Duty Cycles*. Subsequently the *Pressure Regulator* shall fulfil the requirements of the Internal and External Leakage Tests (B6 & B7) conducted at the maximum material temperature.
- iv) The cycling procedure in ii) above shall be repeated at the maximum material temperature and at 1.25 times the working pressure for 1% of the number of *Duty Cycles*. Subsequently the *Pressure Regulator* shall fulfil the requirements of the Internal and External Leakage Tests (B6 & B7) conducted at the maximum material temperature.
- v) The cycling procedure in i) above shall be repeated at the minimum material temperature in accordance with Paragraph 2.4.6.1 of this Regulation and at *Working Pressure* for 1% of the number of *Duty Cycles*. Subsequently the *Pressure Regulator* shall fulfil the requirements of the Internal and External Leakage Tests (B6 & B7) conducted at the minimum material temperature.
- vi) The cycling procedure in ii) above shall be repeated at the minimum material temperature and at *Working Pressure* for 1% of the number of *Duty Cycles*. Subsequently the *Pressure Regulator* shall fulfil the requirements of the Internal and External Leakage Tests (B6 & B7) conducted at the minimum material temperature.

B5.2.5 Pressure Relief Devices

- i) Creep Test
Pressure Relief Devices shall be hydrostatically pressurised to 1.25 times *Working Pressure* and held for 500 hours at a temperature (T_L) calculated from the following equation:

$$T_L = T (0.057)^{(0.34 \log(T/T_f))}$$

where

T_L = Test temperature, °C
 T_f = Activation temperature of the *Pressure Relief Device*, °C
 T = 82°C
Log is base 10

Pressure Relief Devices shall not show signs of creep and shall fulfil the requirements of the Internal Leakage Test (**Paragraph B6** of this Regulation) after being subjected to the above test.

- ii) **Activation Temperature**
Following the Creep Test in i) above, the *Pressure Relief Devices* shall be pressurised with dry air, nitrogen, or hydrogen to *Working Pressure*. Subsequently the *Pressure Relief Devices* shall be exposed to an increasing temperature cycle starting from ambient temperature with a rate not exceeding 10 °C per minute until the specified activation temperature minus 10 °C is reached and then with a rate of not exceeding 2 °C per minute until the *Pressure Relief Devices* activate. The activation temperature shall correspond to the melting temperature of the fusible metal specified by the *Manufacturer* within a range of ± 2 °C. After activation the *Pressure Relief Devices* shall show no evidence of fragmentation.

B5.2.6 Pressure Relief Valves

Pressurise the *Pressure Relief Valve* for 25 cycles. A test cycle consists of pressurising the *Pressure Relief Valve* to the activation pressure causing the *Pressure Relief Valve* to open and vent. Once the *Pressure Relief Valve* is venting the inlet pressure shall be reduced causing the *Pressure Relief Valve* to re-seat. The cycle time shall be a period of 10 ± 2 s. For the final cycle the activation pressure shall be reported and shall correspond to the activation pressure specified by the *Manufacturer* within a range of $\pm 5\%$. Activation pressures shall be least 1.30 times the *Working Pressure*.

B5.2.7 Receptacles

Receptacles shall be submitted to a number of connection/disconnection cycles equal to three times the number of *Filling Cycles* calculated in accordance with **Paragraph 2.4.7** of this Regulation. For each cycle the *Receptacle* shall be pressurised to 1.25 times the *Working Pressure*. Before depressurising, the nozzle shall be rotated by 90^0 .

B5.2.8 Sensors For Hydrogen Systems

If a sensor is intended to be installed into a *Hydrogen Component* and is subjected to the same number of *Duty Cycles* or *Filling Cycles*, it shall be subjected to the same endurance test as the *Hydrogen Component* into which it is installed.

SPECIFIC COMPONENT	NO. OF TEST CYCLES
<i>Automatic Valve</i>	1.5 times <i>Duty Cycles</i> or <i>Filling Cycles</i> as appropriate to the use of the valve, in accordance with Paragraph 2.4.7 or 2.4.8 of this Regulation
<i>Manual Valve</i>	50
<i>Non-return Valve</i>	2.0 times <i>Duty Cycles</i> or <i>Filling Cycles</i> as appropriate to the use of the valve, in accordance with Paragraph 2.4.7 or 2.4.8 of this Regulation

Table B5.1: Test Cycles For Valves

B5.3 Results

The results of the test shall be presented in a test summary.

B6 INTERNAL LEAKAGE TEST

B6.1 Sampling

Number of *Specific Components* to be tested: 3

B6.2 Procedure

The *Specific Components* shall be tested using *Leak Test Gas* and shall be pressurised at the inlet of the component when it is in its characteristic closed position and with the corresponding outlet port open.

The *Specific Component* shall be tested at the following conditions:

- i) At $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$ and at 0.02 times *Working Pressure* and at *Working Pressure*. Where an External Leakage Test (Paragraph B7 of this Annex) is also required at this temperature it may be undertaken before the next stage of this test.
- ii) At the minimum material temperature in accordance with Paragraph 2.4.6.1 of this Regulation, after 2 hours conditioning at this temperature and at 0.02 times *Working Pressure* and at *Working Pressure*. Where an External Leakage Test (Paragraph B7 of this Annex) is also required at this temperature it may be undertaken before the next stage of this test.
- iii) At the maximum material temperature in accordance with Paragraph 2.4.6.1 of this Regulation, after 2 hours conditioning at this temperature and at 0.02 times *Working Pressure* and 1.25 times *Working Pressure*, except for components with a required material temperature of 120°C where the higher test pressure shall be 1.37 times *Working Pressure*.

The component shall be observed for leakage with its outlet port open. The leakage can be determined by a flowmeter installed on the inlet side of the component or by another test method, which has been demonstrated to be equivalent.

B6.3 Requirements

When pressurised the *Specific Component* shall stay bubble free for three minutes or shall not leak internally at a rate exceeding 10 Ncm³/hour.

B6.4 Results

The results of the test shall be presented in a test summary.

B7 EXTERNAL LEAKAGE TEST

B7.1 Sampling

Number of *Specific Components* to be tested: 3

B7.2 Procedure

The *Specific Components* shall be tested using *Leak Test Gas* at the following conditions:

- i) At 20°C ± 5°C and at 0.02 times *Working Pressure* and at *Working Pressure*.
- ii) At the minimum required material temperature, in accordance with Paragraph 2.4.6.1 of this Regulation, after 2 hours conditioning at this temperature and at 0.02 times *Working Pressure* and at *Working Pressure*.
- iii) At the maximum required material temperature, in accordance with Paragraph 2.4.6.1 of this Regulation, after 2 hours conditioning at this temperature and at 0.02 times *Working Pressure* and 1.25 times *Working Pressure*, except for components with a required material temperature of 120°C where the higher test pressure shall be 1.37 times *Working Pressure*.

For heat exchangers this test shall only be undertaken on the hydrogen circuit.

B7.3 Requirements

Throughout the test the *Specific Component* shall be free from leakage through stem or body seals or other joints, and shall not show evidence of porosity in casting, demonstrated by a surface active agent without formation of bubbles for 3 minutes or measured with a combined leakage and permeation rate less than 10 Ncm³/hour (for *Flexible Fuel Lines* only 10 Ncm³/hour per meter) or it shall be tested by using a demonstrated equivalent test method.

B7.4 Results

The results of the test shall be presented in a test summary.

B8 HYDROSTATIC PRESSURE TEST

B8.1 Sampling

Number of *Specific Components* to be tested: 3

B8.2 Procedure And Requirements

The *Specific Component* shall be pressurised to 1.5 times *Working Pressure* for a period of 10 minutes with the outlets plugged.

The *Specific Component* shall not leak nor show any visible evidence of rupture or permanent distortion.

B8.3 Results

The results of the test shall be presented in a test summary.