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Cryogenic vessels — Hoses

Récipients cryogéniques — Tuyaux flexibles

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by ISO/TC 220, *Cryogenic vessels*.

This second edition cancels and replaces the first edition (ISO 21012:2006), which has been technically revised.

This edition includes the following significant changes with respect to the previous edition:

— Subclause 4.2: Added “any austenitic stainless steel hoses shall be annealed after formation for hydrogen service.”;

— Subclause 4.4.3: Replaced shall with should;

— Subclause 4.4.3: Replaced 50 000 cycles with 10 000 cycles;

— Subclause 4.4.3: Added “This test is only required if the flexible hose is subject to multiple wide/significant moves when under pressure.”;

— Subclause 5.3.2.1: Replaced 50 000 cycles with 10 000 cycles;

— Subclause 5.3.2.2: Replaced 50 000 cycles with 10 000 cycles;

— Annex B: Changed from Normative to Informative;

— Annex C: Changed from Normative to Informative;

— Annex C: Changed last sentence in second last paragraph to “Sufficient liquid nitrogen shall be used to ensure the flexible hose assembly reaches liquid nitrogen temperature.”.

Cryogenic vessels — Hoses

1 Scope

This document specifies design, construction, type and production testing, and marking requirements for non-insulated cryogenic flexible hoses used for the transfer of cryogenic fluids within the following range of operating conditions:

— working temperature: from –270 °C to +65 °C;

— nominal size (DN): from 10 to 100.

End fittings for mounting of any couplings are within the scope of this document, but the couplings are subject to other standards.

It is intended that the hose be designed and tested to satisfy the generally accepted rated pressure i.e. at least PR 40. Hoses may be then selected with a PR equal to or greater than the maximum allowable pressure (PS) of the equipment to which it is to be used.

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 7369, *Pipework — Metal hoses and hose assemblies — Vocabulary*

ISO 10806, *Pipework — Fittings for corrugated metal hoses*

ISO 21010, *Cryogenic vessels — Gas/materials compatibility*

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7369 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
hose
flexible leak-tight inner tube of either corrugated metal, elastomer or plastic

3.2
braid
layer, or layers, of cylindrically woven wires covering the hose and permanently attached to the flexible hose assembly end fittings, serving the function of restraining the flexible hose against elongation

3.3
protection coil or cover
outer coil or cover fitted to protect the main hose and braid against damage and abrasion

3.4
end fittings
fitting (of material compatible with material and product transferred) attached to each end of the hose and braid (when fitted)

3.5
hose assembly
hose with end fittings attached, complete with braid and/or other covering, ready for service

3.6
nominal size
DN
alphanumeric designation of size for components of a pipework system, is used for reference purposes

Note 1 to entry: It comprises the letters DN followed by a dimensionless whole number that is indirectly related to the physical size, in millimetres, of the bore or outside diameter of the end connections.

[SOURCE: ISO 6708:1995, 2.1]

3.7
rated pressure
PR
<of a hose> lowest maximum allowable working pressure (MAWP) of any component of the hose at 20 °C

Note 1 to entry: PR > PS (as defined in PED).

Note 2 to entry: See also the last sentence of Clause 1.

3.8
rated minimum temperature
lowest temperature to which the hose assembly is rated by the manufacturer

3.9
working temperature range
highest and lowest temperature to which the hose assembly is to be subjected

3.10
cyclic life
minimum number of complete cycles which, at the test conditions, the hose assembly is designed to withstand without failure

4 General requirements

4.1 Design and construction

The test pressure used during tests (see Clause 5) shall be greater than or equal to the rated pressure (PR) specified. In addition, the rated pressure (PR) shall not be less than the maximum allowable pressure (PS) of the equipment to which it is to be used. A hose is typically made from corrugated metal, from strip steel. The corrugation may be parallel or helical. The maximum pressure in service shall be lower than or equal to the rated pressure stamped on the hose assembly.

If elastomers or composites are used, additional requirements shall be applied in accordance with 5.3.2.2.

A braid is commonly fitted over the hose. This generally consists of woven wire in one or two layers in stainless steel, or a high strength copper alloy. It may have a cover that shall be compatible with the surroundings and with the conveyed fluid.

The design shall ensure that pressurization, or corrosion, between the inner tube and the outer braid or sheath is prevented.

End fittings shall be designed as a rigid seal to the ends of a hose to ensure:

— a tight fit to the hose;

— a strong joint between the braid, hose and end fitting to stabilize the hose against elongation at rated pressure.

Fittings for corrugated metal hose assemblies shall conform to ISO 10806.

An area for marking shall be provided on one of the end fittings or on an attachment.

All joining methods used in corrugated hose assemblies shall be qualified. Manual welds shall be in accordance with applicable standards.

A typical cryogenic hose assembly is shown in Annex A.

4.2 Materials

All materials shall be compatible with the fluid conveyed and shall be controlled by the manufacturer of the hose assembly by a specification ensuring control of chemical content and physical properties, and quality at least equivalent to an internationally recognized standard. Materials for the manufacture of corrugated metal hose assemblies shall be selected on the basis of their suitability for fabrication, e.g. cold forming and welding, etc. and for the conditions under which they shall be used. In addition, the following requirements shall be met:

— end connections and couplings shall be made of materials compatible with the other materials of the hose assembly;

— a material is compatible when it does not lead to any violent reaction (ignition, etc.) or any slow reaction with the conveyed gases, and permeability shall be appropriate for intended use;

— a test certificate providing the chemical content and physical property test results shall be provided with the hose assembly.

The materials used in a cryogenic hose assembly shall:

— maintain sufficient ductility at the rated minimum temperature (as specified in ISO 21028-1);

— be oxygen compatible, if specified for oxygen or nitrous oxide service (as specified ISO 21010);

— any austenitic stainless steel hoses shall be annealed after formation for hydrogen service;

— contain less than 65 % copper, in the alloy as well as the soldering materials, if it is specified for mixtures containing acetylene.

4.3 Cleanliness

Hose assemblies specified for all cryogenic fluids shall be cleaned in accordance with ISO 23208 to remove hydrocarbons, moisture, particles or other contaminations from inside the hose assembly.

4.4 Mechanical properties

4.4.1 Burst pressure

The burst pressure shall be at least three times the rated pressure at ambient temperature. Failure shall occur only in the body of the hose and braid and not in their connections. See 5.3.3 for burst test.

4.4.2 Pressure cycles

Hose assemblies shall have a minimum cyclic life of 10 000 cycles when repeatedly pressurized from <1 bar to their rated pressure in accordance with 5.3.1.

4.4.3 Bending test (optional, upon request of purchaser)

Hose assemblies should have a minimum cyclic life of 10 000 cycles when repeatedly flexed at their rated pressure in accordance with 5.3.2.

NOTE Actual life cycle of hose will depend on actual operating conditions.

This test is only required if the flexible hose is subject to multiple wide/significant moves when under pressure.

4.4.4 Resistance to abuse

Hose assemblies should have sufficient resistance to deterioration of the braid when they are dragged on the ground. For additional protection of the braid, a coil can be used.

Hose assemblies shall withstand a crushing test, simulating a person stepping on the hose assembly, in accordance with 5.2.6.

4.4.5 Low temperature resistance

All components of the hose assemblies which become cold during operation shall retain their toughness at the lowest design temperature.

4.4.6 Leak tightness

Hose assemblies shall be leak-tight in accordance with 5.2.5.

4.4.7 Electrical properties

Hose assemblies specified for flammable products shall be electrically conducting from one end to the other (electric resistance less than 25 Ω).

5 Hose sample tests

5.1 General

The hose test samples shall be representative of production. In case of a connection breaking pre-programmed system, testing will be performed on flexible hoses without these connections. The hose sample test procedures shall include:

a) inspection and non-destructive tests:

— inspection: dimensions, cleanliness, material identification and marking;

— tests: pressure test, leak and crushing tests;

b) destructive tests:

— pressure cycling, bursting test, rolling bend cycling and examination of sectional cut.

The tests shall be recorded in a written report which shall be retained for 10 years after the last hose has been placed on the market.

Four sample hose assemblies (A, B, C and D) are necessary to perform the tests.

The tests and order of tests are summarized in Table 1.

(The numbers 1 to 5 give the order of the tests).

Table 1 — Testing scope and sequence

Tests	Hose sample			
	A	B	C	D
1) Non-destructive tests				
Documentation of materials	1	1	1	1
Dimensional check	1	1	1	1
Cleanliness check	1	1	1	1
Pressure test	1	1	1	1
Leak test	2	4	3	2
Crushing test	3	2	—	
2) Destructive tests				
Hydraulic pressure cycling	3	—	—	—
Rolling bend cycling (optional, if requested by purchaser)	—	3	2	—
Hydraulic bursting test	4	5	—	3
Examination of a sectional cut	—	—	4	—

The hydraulic bursting test shall be carried out to qualify all DN hose assemblies.

When a hose assembly with a given DN and a given rated pressure, P_R, has been successfully sample tested, any hose assembly of the same type, having:

— a rated pressure P_R;

and

— a nominal diameter up to 1,25 DN

can be considered as approved except each DN hose assembly shall be hydraulic burst tested.

A hose assembly is said to be of the same type when the design and its characteristics are similar to the tested hose; similarity is defined as having the same

— materials;

— welding method;

— type of corrugation (shape and method of manufacturing);

— method of joining (hose and end fitting);

— braid (type of braiding, i.e. calculated – according to diameters to obtain the same maximum tensile stress in each wire, same materials, same welding method).

Bend radius and minimum hose length for sample hose assemblies are defined in Annexes B and C.

Hose assemblies used for crushing test and destructive tests shall not be placed on the market.

5.2 Non-destructive tests and inspection

5.2.1 Documentation of materials

The materials, assembly methods, weld procedures and welder qualification for the manufacture of the hose assemblies shall be identified and recorded.

5.2.2 Dimensional check

The outside diameter and total length of hose assemblies shall be measured, as delivered, to check conformity with the drawings.

5.2.3 Cleanliness check

The hose assembly shall satisfy the requirements of ISO 23208.

5.2.4 Pressure test

All flexible hose assemblies shall be subjected to a hydraulic pressure test, at room temperature (20 ± 10) °C, equal to 1,5× the rated pressure. The pressure shall be held for a minimum of 3 min. There shall be no leaks. Under pressure, the overall length shall not increase by more than 3 %.

As an alternative to the hydraulic test it is also permissible to perform a pneumatic test, at the same pressure, provided that the necessary safety precautions are met.

5.2.5 Leak test

The hose assembly shall be leak tested by immersion in water and pressurized with gaseous nitrogen or air to the rated pressure.

The pressure shall be maintained for a minimum of 5 min. There shall be no leaks detected (i.e. no release of bubbles of gas in water). This corresponds approximately to a leak rate of less than 10^{-4} Pa m^3/s.

Table 2 — Conversion factors

Pa m^3/s	Torr l/s	Atm cm^3/s or Std cm^3/s	µ Hg l/s	ft^3 (STP)/h	mbar l/s
10^{-4}	7,501 × 10^{-4}	9,869 × 10^{-4}	7,501 × 10^{-1}	1,255 × 10^{-4}	10^{-3}

Other methods of equivalent or greater accuracy may be used for standard hose assemblies. Hose assemblies specified for more stringent applications may have more stringent leak requirements (e.g. helium leak testing under pressure).

5.2.6 Crushing test

This test is only carried out for hose assemblies made without corrugated stainless steel.

This test shall be performed on hose assemblies to simulate risks of damage when walking on a hose. The hose assembly shall be held between two 200 mm × 200 mm rigid plates and a force of 1 000 N shall be applied 10 times at the same location in the middle of each flexible hose.

The hose assembly shall then be examined to check if there is any pronounced damage caused by this test (a reduction in diameter greater than 20 % and appreciable damage to the braid is unacceptable).

After that, the destructive testes shall be carried out on these same hose assemblies.

5.3 Destructive tests

5.3.1 Hydraulic pressure cycling

This test shall be carried out on one hose assembly of the tested lot with pressure cycling from 1 bar to rated pressure, at room temperature and at a frequency of <10 cycles per minute.

The test shall be stopped at 10 000 cycles and the hose assembly be subjected to a hydraulic burst test.

There shall be no leakage in the hose during the test.

5.3.2 Rolling bend cycling test

5.3.2.1 Corrugated metal hose assemblies

A rolling bend cycling test shall be carried out with the flexible hose assembly maintained at its rated pressure, as described in Annex B.

The test hose assembly shall undergo 10 000 cycles without failure and then be subjected to a leak test (leak rate higher than the one required in 5.2.5).

There shall be no leakage in the hose during the test.

5.3.2.2 Hose assemblies constructed from non-metallic materials or composites

A rolling bend cycling test shall be carried out (with the addition of some induced torque and intermittent thermal shock) with the hose assembly maintained at its rated pressure as described in Annex C.

The test hose assembly shall undergo 10 000 cycles.

5.3.3 Hydraulic bursting test

The tested samples shall be pressurized up to rupture as follows:

— subject a straight, unconstrained sample assembly of minimum length 1 m to a hydraulic pressure applied gradually in increments over a minimum period of 1 min until the assembly fails by visible leakage or rupture of any of the components;

— bursting pressure values shall be equal to or greater than three times the rated pressure, at room temperature (20 ± 10) °C.

This test shall be carried out:

— on one hose assembly after non-destructive tests (flexible hose D);

— on one hose assembly subjected to a hydraulic pressure cycling test (flexible hose A);

— on a flexible hose assembly subjected to rolling bend cycling test (flexible hose B).

Bursting pressure values shall be greater than three times the rated pressure, at room temperature (20 ± 10) °C. Furthermore, bursting is to occur only in the body of the hose assembly and may in no case affect the end fittings and their connections.

5.3.4 Examination of sectional cut

A section shall be cut through the hose assembly local to the end fitting and the end connection to examine the correct connection between end fittings and hose, as well as the shape and thickness of corrugations.