INTERNATIONAL STANDARD

ISO 21012

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Cryogenic vessels — Hoses

Récipients cryogéniques — Tuyaux

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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.

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ISO 21012 was prepared by Technical Committee ISO/TC 220, *Cryogenic vessels*.

Cryogenic vessels — Hoses

1 Scope

This International Standard gives 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 International Standard, but the couplings are subject to other standards.

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

ISO 10806:2003, *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.

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

NOTE 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.

[ISO 6708:1995, definition 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

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

3.9
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

A hose is typically made from corrugated metal, from strip steel. The corrugation may be parallel or helical.

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.

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.

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 meet:

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

— 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);

— contain less than 70 % 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.

4.4 Mechanical properties

4.4.1 Burst pressure

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

4.4.2 Pressure cycles

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

4.4.3 Bending

Hose assemblies shall have a minimum cyclic life of 50 000 cycles when repeatedly flexed at their rated pressure in accordance with 5.3.2.

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 Leak tightness

Hose assemblies shall be leak-tight in accordance with 5.2.4.

4.4.6 Electrical properties

Hose assemblies specified for inflammable products shall be electrically conducting from one end to the other (electric resistance less than 10 Ω).

5 Hose sample tests

5.1 General

The hose test samples shall be representative of production. 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 y 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		4	3	
Crushing test	2	2	—	2
2: Destructive tests				
Hydraulic pressure cycling	3	—	—	–
Rolling bend cycling	—	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 $\leqslant P_R$;

— a nominal diameter $\leqslant$ 1,5 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.

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 documented.

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 $\pm$ 10) °C, equal to 1,5 $\times$ 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^{-3} mbar.l/s.

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 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 ten 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).

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.

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. The tests are described in Annex B.

The test hose assembly shall undergo 50 000 cycles.

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.

The tests are described in Annex C.

The test hose assembly shall undergo 50 000 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 greater than three times the rated pressure, at room temperature (20 ± 10) °C.

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.

6 Production testing

6.1 General

All hose assemblies shall be tested in the condition in which they are to be supplied, i.e. either braided or unbraided. After manufacture every hose assembly shall be subjected to the pressure tests and leak tests described in 6.2 and 6.3.

6.2 Pressure test

See 5.2.4.

6.3 Leak test

The hose assembly shall be leak tested as specified in 5.2.5. A leak test shall be carried out at a pressure no greater than rated pressure. Leak detection may be by water immersion or other methods. Alternative leak test methods may be used (e.g. helium tests) where the maximum leakage shall not exceed a leak rate of 10^{-3} mbar. l/s. (cc/sec).

Hose assemblies designed from materials other than corrugated metal may show increased permeability under pressure or bending. For these materials, an acceptable permeation rate shall be jointly agreed between manufacturer and purchaser, taking into account the product being transferred and the general design conditions.

7 Marking

The following information shall be marked in an indelible manner on the end of the hose at the marking area by the manufacturer (see Annex A):

a) the number of this International Standard, i.e. ISO 21012;

b) rated pressure, P_R;

c) nominal size, DN;

d) test date (year and month) (the test date is the date at the end of manufacturing);

e) manufacturer's reference: name or abbreviations or logo and identification number;

f) hose serial number or type designation;

g) rated minimum temperature if other than − 196 °C;

h) test pressure, P_T;

i) in addition space may be left for additional operational marking if used, e.g. retest dates.

8 Cleaning

Hose assemblies shall be cleaned in accordance with ISO 23208.

NOTE The hose convolutions may accumulate moisture and residues. Cleaning and inspection procedures should ensure their removal and a dryness level acceptable to the intented application.

9 Test certificate

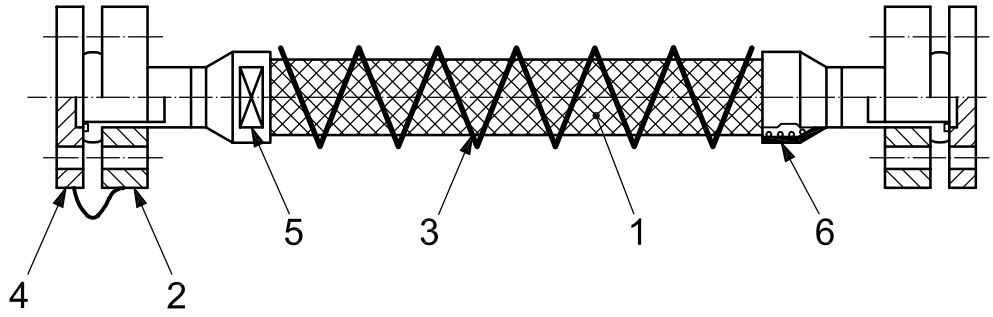
The manufacturer shall provide a production test certificate for each completed hose assembly, or batch of assemblies, if required by the user.

The certificate should state conformity of the hose assembly to this International Standard.

Annex A
(informative)

Typical hose assembly

A typical hose assembly is shown in Figure A.1.



Key

1 braid
2 end coupling
3 protection coil
4 protective cap
5 marking
6 ferrule

Figure A.1 — Typical hose assembly

Annex B
(normative)

Rolling bend cycling test for metallic hose assemblies and hose assemblies made of materials with a record of satisfactor use in cryogenic service

A bend fatigue test shall be carried out with the hose assembly maintained at its rated pressure.

The hose assembly shall be set up so that its bend radius is maintained (as shown in Figures B.1 and B.2) throughout the test.

The test shall be conducted at room temperature using hose assemblies mounted to form a horizontal or vertical loop as shown in Figures B.1 and B.2 and the length of hose assembly for test as shown in Table B.1.

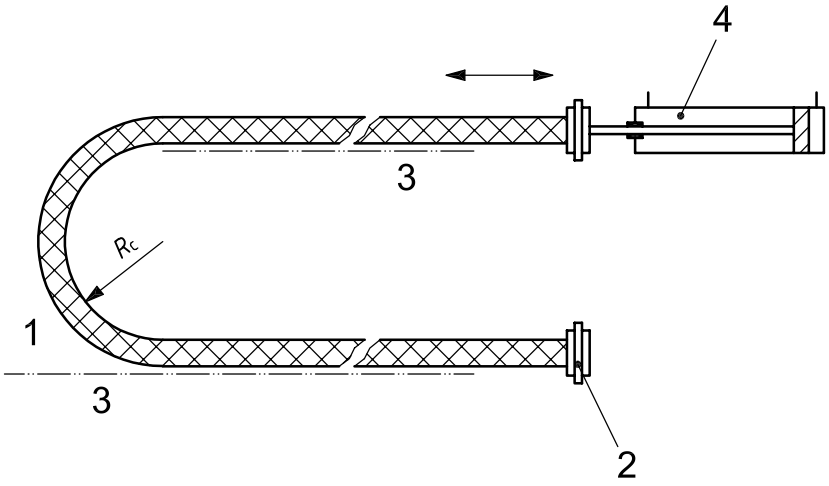
One end of the hose assembly shall be fixed. The other end shall be stroked at a rate between 20 cycles/min and 60 cycles/min in a direction parallel with the axis of the flexible hose.

The total stroke length shall be 250 mm.

Table B.1 — Length of hose assembly for test

Dimensions in millimetres

Nominal size (DN)	**10**	**12**	**15**	**20**	**25**	**32**	**40**	**50**	**65**	**80**	**100**
Maximum bend radius, R_c	190	210	250	290	325	380	430	490	580	680	750
Maximum length of hose assembly for test	885	965	1 125	1 250	1 425	1 645	1 845	2 085	2 445	2 845	3 125

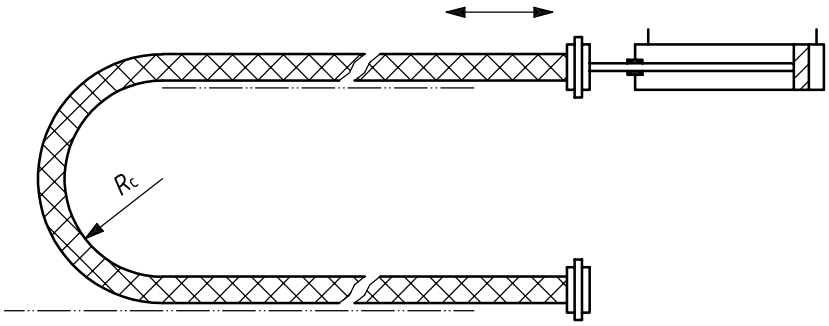


Key

1 test hose assembly
2 fixed end
3 hose assembly support
4 pneumatic cylinder (travel 250 mm)

R_c bend radius

Figure B.1



Key

R_c Bend radius

Figure B.2

Annex C
(normative)

Rolling bend cycling test for hose assemblies constructed from materials or composites not commonly used in cryogenic service

A bend fatigue test shall be carried out with the flexible hose assemblies maintained at its rated pressure.

The hose assembly shall be set up so that its bend radius is maintained (as shown in Figures C.1 and C.2) throughout the test.

The hose assembly shall also be set up so that it is subjected to some torque by off-setting the inlet and outlet connections by one degree after fixing each end of the hose flexible assembly.

The test shall be conducted at room temperature using hose assemblies mounted to form a horizontal or vertical loop as shown in Figures C.1 and C.2 and the length of hose assembly as shown in Table C.1.

The hose assembly shall be subjected to repeated cycling at a rate between 20 cycles/min and 60 cycles/min in a direction parallel with the axis of the flexible hose.

The total stroke shall be 250 mm.

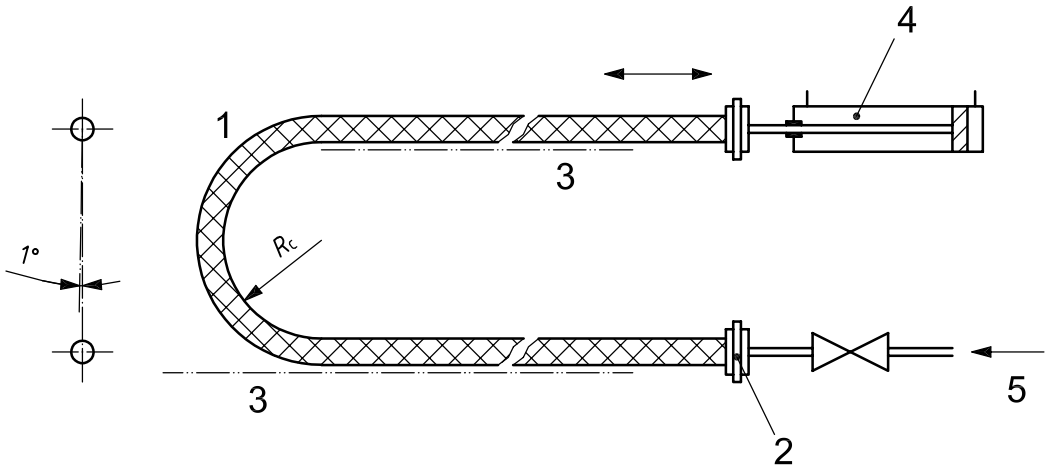
The hose assembly shall also be subjected to an intermittent thermal shock by introducing cryogenic fluid at the start of the test and after every 1 000 cycles. Sufficient cryogenic fluid shall be injected to ensure the flexible hose assembly reaches its design temperature.

Liquid nitrogen may be used for all types of hose assemblies.

Table C.1 — Length of hose assembly for test

All dimensions in millimetres

Nominal size (DN)	**10**	**12**	**15**	**20**	**25**	**32**	**40**	**50**	**65**	**80**	**100**
Maximum bend radius, R_c	190	210	250	290	325	380	430	490	580	680	750
Maximum length of hose assembly for test	885	965	1 125	1 145	1 425	1 645	1 845	2 085	2 445	2 845	3 125

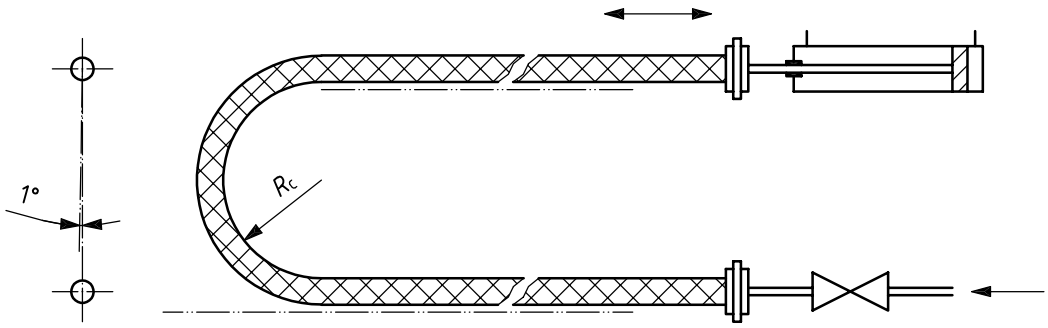


Key

1 test hose assembly
2 fixed end
3 hose assembly support
4 pneumatic cylinder (travel 250 mm) resistant to rotation
5 cryogenic liquid inlet

R_c bend radius

Figure C.1



Key

R_c bend radius

Figure C.2

Bibliography

[1] ISO 6708:2005, *Pipework components — Definition and selection of DN (nominal size*)

[2] ISO 10380, *Pipework — Corrugated metal hoses and hose assemblies*

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