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Gas cylinders — Flexible hoses assemblies — Specification and testing

Bouteilles à gaz — Flexibles — Spécifications et essais

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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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 58, *Gas cylinders,* Subcommittee SC 2, *Cylinder fittings*.

This second edition cancels and replaces the first edition (ISO 16964:2015), which has been technically revised.

The main changes compared to the previous edition are as follows:

— Test 1 for the safety cable has been clarified;

— the leak test has been corrected;

— the pressure cycle test has been clarified;

— the test apparatus for the torsion test, as shown in Figures A.6 and A.7 has been clarified.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Flexible hose assemblies are used to transfer industrial and medical gases into cylinders, bundles, MEGCs and trailers (battery vehicles), and also to supply such gases to user equipment.

There is a range of existing International Standards to be used for specific applications or hose construction:

— ISO 14113 which covers hoses made with internal rubber or plastics tubing and used to supply gases to customers for welding applications;

— ISO 21969 which covers hoses with an internal corrugated metallic liner and used to supply medical gases to customers;

— ISO 10380 which covers hoses with internal corrugated metallic liner for all applications including non-industrial and medical gases.

ISO 14113 and ISO 21969 cover only specific customer applications and are intended to be used accordingly, while ISO 10380 is general in its approach.

The intent of the document is to describe flexible hoses not defined in the specific applications documents mentioned above.

Gas cylinders — Flexible hoses assemblies — Specification and testing

1 Scope

This document provides specification and testing requirements for high pressure flexible hose assemblies intended to be connected to gas cylinders, bundles of cylinders or trailers (battery vehicles), and MEGCs for use when filling and emptying gas at production sites and also for customer use. This document applies to flexible hose assemblies with rated pressures up to 1 000 bar for use in the temperature range of −40 °C to +65 °C.

This document is not applicable to:

— rubber and plastics flexible hose assemblies for welding, cutting and related processes up to 45 MPa (450 bar) for customer use (see ISO 14113);

— high pressure flexible hose assemblies for use with medical gas systems for customer use (see ISO 21969);

— low pressure hose assemblies for use with medical gases for customer use (see ISO 5359);

— rubber and thermoplastic low pressure hose assemblies for welding, cutting and related processes for customer use (see ISO 3821 or ISO 12170);

— flexible hose assemblies for cryogenic applications (see ISO 21012);

— flexible hose assemblies for liquid petroleum gas (LPG).

NOTE Flexible hose assembly designs which pass the type test approval described in this document can have a lower ratio of burst pressure to rated pressure than stated in other standards.

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 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 10286, *Gas cylinders — Terminology*

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

ISO 14113:2013, *Gas welding equipment — Rubber and plastics hose and hose assemblies for use with industrial gases up to 450 bar (45 MPa)*

ISO 21969:2009, *High-pressure flexible connections for use with medical gas systems*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10286 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
rated pressure
PR
pressure of a hose assembly equal to 1,25 PW, PW being the working pressure of the cylinder as defined in ISO 10286

Note 1 to entry: National and international design codes for pressure systems can specify a higher value of rated pressure.

Note 2 to entry: When cylinders are used (e.g. during filling or product withdrawal), the gas temperature can be higher than 15 °C. This is the reason why the rated pressure is higher than the cylinder working pressure.

3.2
burst pressure
highest pressure reached in a flexible hose assembly during a burst test

4 Requirements

4.1 Production pressure tests

4.1.1 Strength test

Each flexible hose assembly shall first be subjected to a strength test using oil-free water at a pressure at least equal to 1,5 times the rated pressure, PR, for a minimum of 3 min. There shall be no visible sign of leakage, permanent deformation or other sign of failure. Where hydraulic testing would result in unacceptable contamination of the flexible hose assembly, the hydraulic test may be replaced by a pneumatic test using a compatible medium such as dry oil-free air or nitrogen. Appropriate safety measures shall be taken to protect personnel and equipment during testing.

4.1.2 Leak test

Each hose or hose assembly shall be tested for leakage, e.g. by total immersion in water for 3 min at ambient temperature, at a test pressure equal to the PR, except for acetylene where the test pressure shall be no less than 300 bar.

Hose or hose assemblies to be used with hydrogen or helium shall be tested with helium. Hose or hose assemblies to be used with other gases shall be tested with a compatible medium such as dry oil-free air or nitrogen.

The leak rate shall be less than 15 cm^3/h.

4.2 Type tests

4.2.1 General

All test samples shall be manufactured to the same design, material specification and from the same batch of raw material. Records of the tests performed are to be retained by the flexible hose assembly manufacturer.

To carry out the tests described in this document, it is recommended that the nominal length of hose between end fittings be 1 000 mm unless otherwise specified.

Before being type tested, all sample flexible hose assemblies shall be subjected to production pressure tests as specified in 4.1.

For hoses to be used in hydrogen or helium service, the leak test in 4.1.2 shall be carried out using helium.

Tests shall be performed at ambient temperature.

4.2.2 Burst pressure test (3 samples per type)

The flexible hose assembly complete with safety cable and clamps (if applicable), is to be hydraulically pressurized until burst occurs. The pressurization rate shall be adjusted at the beginning of the test to be approximately constant and to reach the burst pressure in not less than 1 min.

For specific applications, hold steps may be required before final burst pressure is reached.

The burst pressure of the flexible hoses assemblies shall not be less than 3 × PR for a value of PR less than 480 bar and [(2 × PR) + 480] bar for a value of PR greater than or equal to 480 bar.

NOTE For acetylene service, hose with a higher burst pressure can be necessary in order to pass the decomposition test described in 4.2.5 for acetylene flexible hose assemblies. The minimum burst pressure for this type of hose is generally given by the hose manufacturer.

4.2.3 Pressure cycle test (3 samples per type)

4.2.3.1 General

The flexible hose assembly complete with safety cable and clamps (if applicable) shall be submitted to a hydraulic pressurization endurance test from a nominal atmospheric pressure (5 bar maximum) to PR at a frequency of no more than 30 cycles per minute.

A pressure cycle consists of a pressure increase starting from a pressure not more than 5 bar to PR and a pressure decrease from PR back to the start condition.

This endurance test shall not apply to acetylene flexible hose assemblies because the construction of these hoses is designed to resist extremely high pressure and stress compared to acetylene's low working pressure PW.

4.2.3.2 General requirement

It shall be checked that the entire flexible hose assembly is exposed to a pressure cycle where:

— the maximum pressure is PR; and

— the minimum of each pressure cycle is no more than 5 bar.

The flexible hose assemblies shall not burst or show any visible leak during the test:

— **Category A**: 5 000 pressure cycles for flexible hose assemblies dedicated to non-filling applications such as customer installations. This applies to flexible hose assemblies with metallic and non-metallic liners.

— **Category B**: 50 000 pressure cycles for flexible hose assemblies with non-metallic liners dedicated to filling centres.

Due to expansion of the hose during the test, the hydraulic pressure can fall. However, the hydraulic pressure shall never fall below PR.

Care should be taken to avoid hose bending during testing as this can reduce the cycle life. The position of the hose during the cycle test should be recorded (e.g. pictures).

4.2.3.3 Specific requirements for metallic hoses used in filling centres

The pressure cycle test shall be performed on hose assemblies with a maximum of 50 000 cycles. No failure should occur before 10 000 cycles.

A leak is accepted above 10 000 cycles but, in such cases, the life of the hose shall be limited proportionally to its performance in this hydraulic pressure cycling test.

Hoses not able to pass the 10 000 pressure cycles minimum requirement, but demonstrating by this test a non-hazardous failure mode, can be used in service following risk assessment provided that the risk assessment includes as a minimum:

— the definition of a specific application;

— the mode of failure of the hose and any mitigation;

— the associated risk created by the escape of gas;

— the protection of personnel.

Following such risk assessment, the life span for the hose can be determined (e.g. use for a given time or until the flexible hose assembly leaks).

If the test has been completed before any leak has been detected (e.g. after 50 000 cycles), then the flexible hose assembly shall be pressurized at PR with compressed dry oil-free air or nitrogen to check for leaks. The leak rate shall be less than 15 cm^3/h. For hoses to be used in hydrogen or helium service, the leak test shall be carried out using helium.

4.2.4 Oxygen compatibility test (3 samples per type)

This test shall be performed for all oxygen applications. Follow the procedure given in ISO 21969:2009, 6.2.4.

4.2.5 Acetylene compatibility test (3 samples)

This test shall be performed for all acetylene applications. Follow the procedure given in ISO 14113:2013, 7.1.2.

Flexible hose assemblies passing this test shall be marked to identify they are suitable for acetylene service e.g. “C2H2” or as specified by ISO 14113.

4.2.6 Gas material compatibility

All materials in contact with the gases shall be compatible within the intended pressure and temperature range of the gas application. For guidance, use the requirements of ISO 11114-1 and ISO 11114-2 as applicable.

4.2.7 Test of the safety cable (2 samples)

4.2.7.1 General

This test shall be performed if the flexible hose assembly is equipped with a safety cable. For safety reasons, it is recommended to perform this test in a cage to protect personnel. The hose and the cable shall be fixed. The distance between the horizontal fixed points of the hose ends shall be equal to 75 % of the hose length so that the hose has a gentle bend and is not tight between the fixed points.

If the safety cable is designed to be anchored separately to the hose end fitting, cable ends shall be anchored as they would be in customer use. If not otherwise specified, the safety cable shall be fixed as per the instructions for use.

If hose end fittings are not of the same design (are not identical), the manufacturer shall indicate the upstream fitting the gas will be put through during the test.

The downstream fixed point of the flexible hose shall be plugged.

4.2.7.2 Test 1

The flexible hose assembly is severed by drilling a hole at mid-length on one side without damaging the safety cable or disturbing the clamps. The diameter of the drilled hole shall be equal to 80 % of the internal nominal diameter, DN, of the flexible hose assembly. Air or nitrogen is admitted at PR via a quick opening valve into the hose through one of the end fittings while the other end is open to atmosphere. The gas supplied is cut off not less than 10 s after opening. The cable and its fixings shall be intact and the clamps shall have remained in their original positions on the hose. Their location is recorded before and after testing. The clamps shall remain fixed on the cable but their location can be different. A movement of ±2,5 cm along the hose is accepted.

4.2.7.3 Test 2

A similar test is performed if the safety cable is secured to the hose end fittings. In this case, the flexible hose assembly is severed by drilling the same size hole as in Test 1 but immediately adjacent to the end fitting at the opposite end of the hose to where the test gas is admitted. The same acceptance criteria as in Test 1 shall be used.

If the safety cable is designed to be anchored separately to the hose end fitting, the test is performed with the same requirements and acceptance criteria as above but with the end adjacent to the drilling plugged and not anchored.

The plug (mass and dimensions) should be recorded in the report.

4.2.8 Additional tests

4.2.8.1 General

These tests (see Annex A) are part of the type tests when listed as mandatory in 4.2.8.2 to 4.2.8.7.

4.2.8.2 Kink test (1 sample)

This test (see A.1) is mandatory for non-metallic lined flexible hose assemblies except when other kink prevention safety measures are in place (e.g. external spring protection).

NOTE This test is normally performed by the hose manufacturer, and not necessarily by the hose assembly manufacturer.

With the flexible hose assembly configured with a single loop midway along its length, and with one end connection secured, a longitudinal tensile force shall be applied to the opposite end to create a localized bend and flattening. The tensile force is increased until the cross-section of the hose becomes oval and the shortest cross-sectional dimension is 75 % of the original external diameter. This force shall be recorded. When it is completed, a hydraulic pressure of PR shall be applied and there shall be no leakage evident.

4.2.8.3 Side impact test (1 sample)

This test (see A.2) is mandatory for non-metallic lined flexible hose assemblies with copper alloys or with low impact strength material end fittings except when other side impact prevention safety measures are in place (e.g. external spring protection).

The flexible hose assembly is fixed as specified in A.2.3.3. The impact energy is created with a knife edge impact tool to determine the absorbed energy for failure. Any rupture or crack is classed as a failure. This test shall be repeated at the other extremity (if different) to find the weakest side. The impact energies of both ends should be recorded.

4.2.8.4 Tensile pull test (1 sample)

This test is mandatory for non-metallic lined flexible hose assemblies except when other tensile prevention safety measures are in place (e.g. safety wire designed to take the load).

The flexible hose assembly should be capable of withstanding a longitudinal pull force of 2 670 N while in a non-pressurized state without the end fitting pulling out of, or separating from, the hose.

4.2.8.5 Fatigue cycling test under pressure (cyclic bending test)

This test is mandatory, and performed at the relevant bending radius, for all type of flexible hose assembly at PR where the hose is subjected in service to cyclic bending under pressure.

For the procedure, refer to the U-bend cyclic test given in ISO 10380.

4.2.8.6 Torsion test

In principle, all risk of torsion of all types of flexible hose assemblies should be avoided.

This test (see A.3) is mandatory for non-metallic lined flexible hose assemblies except when used with other torsion prevention safety measures, e.g. swivel joints.

Flexible hose assemblies can be subjected to torsion during use, potentially causing the hose liner to be damaged (e.g. connection and disconnection to cylinders, mishandling of equipment while flexible hose assembly is connected).

When the torsion test is completed, the flexible hose assembly should be removed from the test rig. Then perform:

a) a visual inspection of the test piece and end connections for surface damage;

b) a pneumatic test to PR to detect leakage (no more than 15 cm^3/h);

c) a hydrostatic burst test as specified in 4.2.2.

4.2.8.7 Permeability test

This test is to be performed according to ISO 4080:2009, Method 1, with the intended gas at PR.

This test is recommended for applications such as high pressure hydrogen and helium in non-metallic lined hoses.

5 Marking

The flexible hose assemblies complying with this document shall be marked with the following as a minimum:

— "ISO 16964" and "A" or "B" as a reference to the appropriate category (see 4.2.3.2);

— "PR" followed by the value of PR and the unit (e.g. PR 250 bar);

— the year and month of manufacture (production test date);

— the batch number;

— the manufacturer part number;

— the manufacturer identification;

— the mark for hydrogen compatibility "H" (if applicable, see 4.2.6);

— the mark for acetylene service "C2H2" (if applicable, see 4.2.5).

Annex A
(informative)

Examples of kink test, side impact test and torsion test

A.1 Kink test

A.1.1 Apparatus

A typical set-up of test apparatus is shown in Figure A.2 and shall consist of:

a) a test rig base incorporating a fixed and moveable skid. Each skid shall have a pipe clamp or equivalent end connection to suit the flexible hose assembly to be tested fitted to it;

b) an actuator (e.g. hydraulic) able to apply a longitudinal load via a moveable skid with the flexible hose assembly under test installed;

c) a means (e.g. mechanical or digital counter) able to record the load, the pulling force and the number of test cycles completed.

A.1.2 Test pieces

The kink test shall be carried out mid-length of the flexible hose assembly under test (see Figure A.2 and Figure A.3).

A typical test piece is shown in Figure A.1.

A.1.3 Test

A.1.3.1 The test shall be conducted under ambient test area conditions.

WARNING — The kink test is potentially dangerous as test samples can fracture or break causing debris. For this reason, tests are performed in a suitable location with operators given adequate protection (e.g. personal protective equipment and screen guards).

A.1.3.2 The flexible hose assembly shall not be pressurized during the kink test.

A.1.3.3 Secure one end of the flexible hose assembly under test to the fixed part of the test fixture and a loop formed in the centre of the test piece (see Figure A.2). The free end of the flexible hose assembly shall be attached to the moving part of the test fixture. The flexible hose assembly shall be supported between side panels to ensure that a localized bend strain is achieved and that the loop remains approximately vertical during flexing.

A.1.3.4 A longitudinal load shall be applied to the flexible hose assembly under test and the load shall be increased until the cross-section of the hose has become oval and the shortest cross-sectional dimension is 75 % of the original external diameter.

A.1.3.5 The corresponding load shall be recorded and the flexible hose assembly shall be subjected to a hydraulic pressure test at PR and there shall be no evidence of leakage. The flexible hose assembly shall then be subjected to a burst test (see 4.2.2).

Dimensions in millimetres

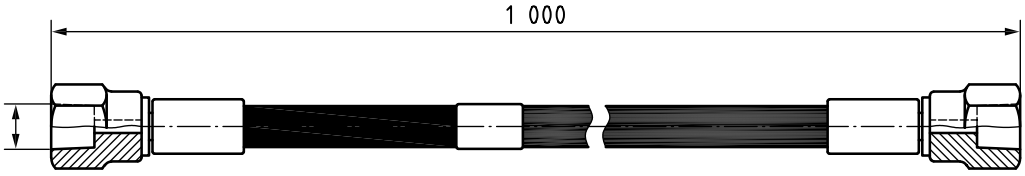
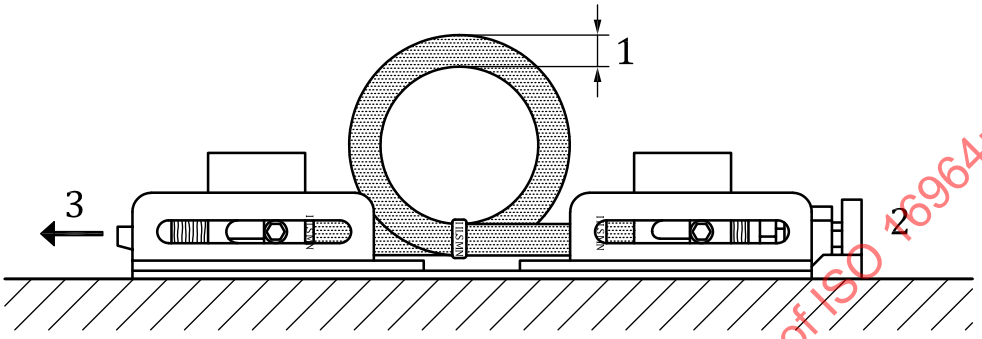


Figure A.1 — Test piece sample



Key

1 diameter of the flexible hose
2 fixed point
3 a means to apply the load

Figure A.2 — Test apparatus and set-up (or equivalent)

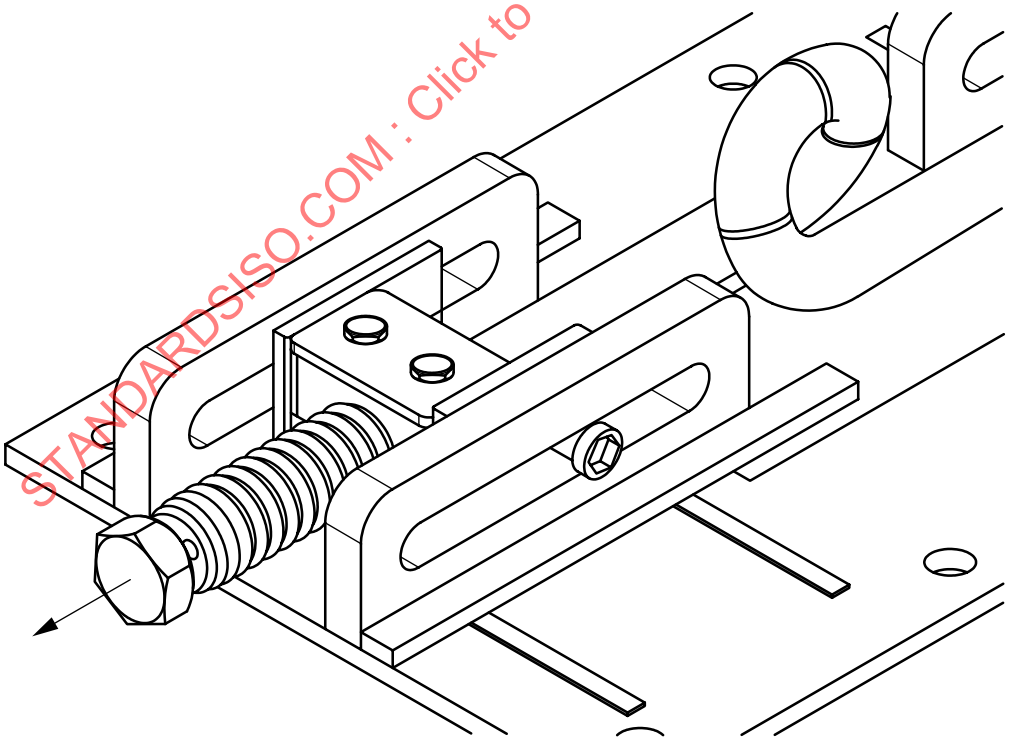


Figure A.3 — Test apparatus

A.2 Side impact test

A.2.1 Apparatus

A typical set-up of test apparatus is shown in Figure A.4 and shall consist of:

a) an impact tester (e.g. a Charpy impact tester or equivalent) meeting the requirements of ISO 148-1 and incorporating gauge or digital readout to record the impact results. The impact tester used shall be capable of producing an impact energy of 15 Joules;

b) a V-notch or U-notch impactor (or equivalent).

A.2.2 Test pieces

The side impact test shall be performed on each of the flexible hose assembly end connections. Each end connection shall be tested one after the other.

A typical test piece is shown in Figure A.1.

A.2.3 Test

A.2.3.1 The test shall be conducted under ambient test area conditions.

WARNING — Impact testing is potentially dangerous as test samples can fracture or break causing debris. For this reason, the test is performed in suitable location with operators using appropriate personal protective equipment (PPE) and screen guards.

A.2.3.2 The flexible hose assembly shall not be pressurized during the side impact test.

A.2.3.3 Secure one end connection of flexible hose assembly to be tested in the test apparatus as shown in Figure A.4 by securely clamping the ferrule. The impact point of the impactor shall be directly on the side of the end connection on the centre line of the hose (see Figure A.6). It shall be on the extremity of the ferrule where the flexible hose emerges from the ferrule (see Figure A.5). Apply an impact load of 15 Joules at this point.

A.2.3.4 The flexible hose assembly end connection shall not show any signs of fracture, or damage after the test impact of 15 Joules has been applied.

A.2.3.5 Once the test has been completed successfully on one end connection of the flexible hose assembly, it shall be removed from the test apparatus and rotated to allow the opposite end connection to be tested.

A.2.3.6 Repeat the test as described in A.2.3.1 to A.2.3.4.

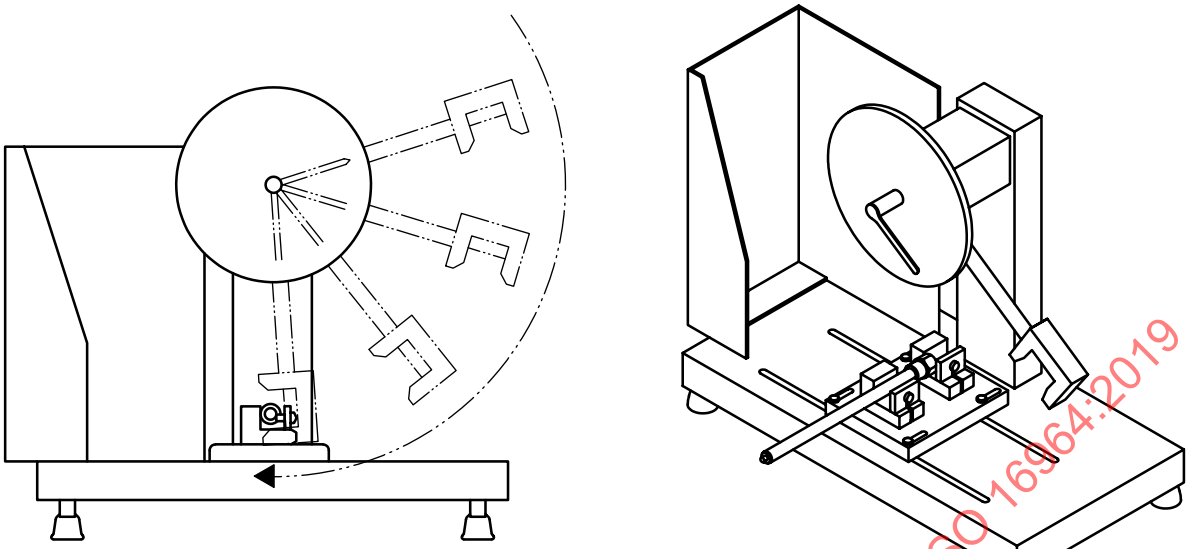


Figure A.4 — Test apparatus and set-up

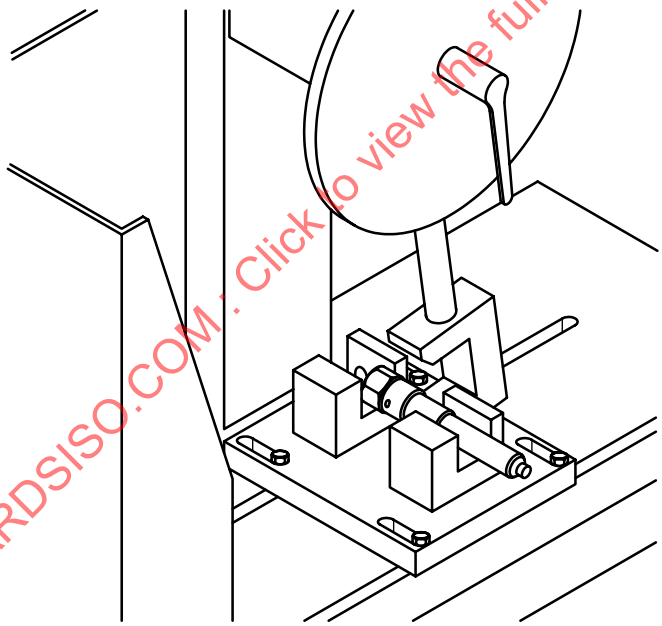


Figure A.5 — Impact point on flexible hose assembly

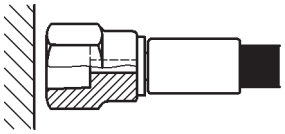


Figure A.6 — Impact point of the impactor

A.3 Torsion test

A.3.1 Apparatus

A typical set-up of test apparatus is shown in Figure A.7 and Figure A.8 and shall consist of:

a) a test rig base incorporating a fixed part and a movable part. The movable part rotates around the long axis of the flexible hose assembly under test. Both parts shall have pipe clamps or equivalent end connections to suit the flexible hose assembly to be tested;

b) an actuator (e.g. hydraulic) capable of turning the rotatable part through ±90° from the vertical axis;

c) a means (e.g. a mechanical or digital counter) of recording the number of completed test cycles.

See also Figure A.9.

A.3.2 Test pieces

The torsion test shall be carried out on one end connection of the flexible hose assembly under test. Only one end connection is tested per flexible hose assembly.

A typical test piece is shown in Figure A.1.

A.3.3 Test

A.3.3.1 The test shall be conducted under ambient test area conditions.

WARNING — Torsion testing is potentially dangerous as test samples can fracture and break causing debris. For this reason, the test is performed in suitable location with operators using appropriate personal protective equipment (PPE) and screen guards.

A.3.3.2 The flexible hose assembly shall not be pressurized during the test.

A.3.3.3 Secure one end of the flexible hose assembly under test to the fixed part of the test apparatus and the other to the rotatable part (see Figure A.7 and Figure A.8). Both vertical and horizontal lengths should be nominally the same.

A.3.3.4 Starting from a local vertical position, rotate the movable end of the test apparatus through 90° angle in one direction, then through 180° angle in the other direction and then 90° angle to get back to the starting point without allowing the hose to move from its original vertical plane. This is one test cycle.

A.3.3.5 Rotate the flexible hose assembly through 10 000 cycles at a rate of 30 cycles ± 2 cycles per minute.

A.3.3.6 Once the 10 000 test cycles have been completed, remove the hose from the test apparatus and allow the flexible hose assembly to remain stationary (in its untwisted starting position) for 60 min.