INTERNATIONAL STANDARD

ISO 10961

Third edition
2019-11

Gas cylinders — Cylinder bundles — Design, manufacture, testing and inspection

Bouteilles à gaz — Cadres de bouteilles — Conception, fabrication, essais et inspection

Reference number
ISO 10961:2019(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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 4, *Operational requirements of gas cylinders*.

This third edition cancels and replaces the second edition (ISO 10961:2010), which has been technically revised.

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

— the terminology was brought in line with ISO 10286, as far as possible,

— storage was added throughout the document as a possible use case,

— the descriptions of the drop tests were clarified,

— the descriptions of the leak tests were clarified,

— a new figure was added showing the angle for the vertical drop test,

— the rotating drop test has been differentiated by whether the bundle is fitted with cylinders vertically or horizontally,

— the additional requirements for acetylene cylinder bundles were clarified,

— the information for the bundle identification for filling was moved to Annex C.

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 https://www.iso.org/members.html.

Introduction

For some applications, the contents of an individual gas cylinder might not satisfy the gas demand, in which case assemblies of cylinders can be used to supply larger volumes of gas in a single unit. The single unit, which contains a number of cylinders, is known as a cylinder bundle.

Such a cylinder bundle is a portable assembly, designed to be routinely lifted, that consists of a frame and two or more cylinders connected to a manifold by cylinder valves or fittings so that the cylinders can be filled, transported and emptied without disassembly.

A cylinder bundle can be subjected to rough handling in the course of normal operations.

There are types of gas cylinder assemblies that use cylinder bundle components but are designed to be disassembled at each filling to enable the cylinders to be filled individually. Although these assemblies do not conform to the basic definition of a cylinder bundle, they are commonly referred to as bundles. Their special requirements are provided in Annex A.

Acetylene cylinder bundles are often filled without disassembly. The confirmation of solvent content can be achieved with or without disassembling the bundle. Replenishing of solvent is usually done after a defined number of fillings. Their special requirements are provided in Annex B.

In International Standards, weight is equivalent to a force, expressed in Newton. However, in common parlance (as used in terms defined in this document), the word "weight" continues to be used to mean "mass", but this practice is deprecated (see ISO 80000-4).

This document has been written so that it is suitable to be referenced in the UN *Model Regulations*[1].

Gas cylinders — Cylinder bundles — Design, manufacture, testing and inspection

1 Scope

This document specifies the requirements for the design, construction, testing and initial inspection of a transportable cylinder bundle.

It is applicable to cylinder bundles containing cylinders containing compressed gas, liquefied gas and mixtures thereof. It is also applicable to cylinder bundles for acetylene. Additional requirements for acetylene cylinder bundles containing acetylene in a solvent are provided in Annex B. This document does not, however, cover acetylene cylinder bundles with solvent-free acetylene cylinders.

This document specifies the additional requirements that apply when individual cylinders are assembled into a bundle. Unless otherwise stated, individual cylinders within a cylinder bundle conform to applicable standards for single cylinders.

This document is intended primarily for industrial gases other than liquefied petroleum gas (LPG), but it can also be used for LPG.

This document does not apply to packages in which cylinders are manifolded together in a frame that is designed to be fixed permanently to a road vehicle, to a railway wagon or to the ground as a customer storage vessel. It also does not apply to cylinder bundles that are designed for use in extreme environmental or operational conditions (e.g. offshore cylinder bundles) when additional and extraordinary requirements are imposed to maintain safety standards, reliability and performance.

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 3807, *Gas cylinders — Acetylene cylinders — Basic requirements and type testing*

ISO 9606-1, *Qualification testing of welders — Fusion welding — Part 1: Steels*

ISO 10297, *Gas cylinders — Cylinder valves — Specification and type testing*

ISO 10286:2015, *Gas cylinders — Terminology*

ISO 11114-1, *Gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 1: Metallic materials*

ISO 11114-2, *Gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 2: Non-metallic materials*

ISO 13585, *Brazing — Qualification test of brazers and brazing operators*

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

ISO 15607, *Specification and qualification of welding procedures for metallic materials — General rules*

ISO 15615:2013, *Gas welding equipment — Acetylene manifold systems for welding, cutting and allied processes — Safety requirements in high-pressure devices*

ISO 16964, *Gas cylinders — Flexible hoses assemblies — Specification and testing*

EN 13134, *Brazing — Procedure approval*

3 Terms and definitions

For the purposes of this document, the terms and definitions in ISO 10286 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 https://www.iso.org/obp

3.1
cylinder bundle
bundle of cylinders
assembly of cylinders that are fastened together and interconnected by a manifold and transported as a unit having a total water capacity not exceeding 3 000 l

Note 1 to entry: In ISO/TC 58 documents the term “bundle” is frequently used for simplification.

Note 2 to entry: Bundles intended for the transport of toxic gases shall be limited to 1 000 l total water capacity.

[SOURCE: ISO 10286:2015, 204, modified — preferred term and admitted term reversed, "which are" deleted and requirement for toxic gases moved into Note 2 to entry]

3.2
frame
structural and non-structural members of a bundle that combine all other components together, whilst providing protection for the bundle's cylinders, *valves* (3.3) and *manifold* (3.5) and which enable the bundle to be transported

[SOURCE: ISO 10286:2015, 264]

3.3
cylinder valve
valve that is fitted into a cylinder and to which a *manifold* (3.5) is connected in a *bundle* (3.1)

3.4
cylinder fitting
component with no gas shut-off capability that serves as a method for connecting a bundle's *manifold* (3.5) to its individual cylinders when *cylinder valves* (3.3) are not fitted to the cylinders

3.5
manifold
piping system for connecting pressure receptacle(s) valves or *fittings* (3.4) to the *main valve(s)* (3.6) or the *main connection(s)* (3.7)

[SOURCE: ISO 10286:2015, 265]

3.6
main valve
valve which is fitted to the *manifold* (3.5) of a *bundle* (3.1), isolating it from the *main connection(s)* (3.7)

[SOURCE: ISO 10286:2015, 267, modified — battery vehicle/battery wagon/MEGC deleted]

3.7
main connection
means of making a gas connection to a *bundle* (3.1)

[SOURCE: ISO 10286:2015, 266, modified — battery vehicle/MEGC deleted]

3.8
tare
weight of the pressure receptacle when empty, including accessories fitted as presented for filling

Note 1 to entry: Additional information regarding tare for acetylene cylinder bundles is provided in B.2.

3.9
maximum gross weight
sum of the tare of the *bundle* (3.1) and the maximum permissible filling weight

Note 1 to entry: Maximum gross weight is to be understood as "maximum gross mass" as per regional transport regulations.

[SOURCE: ISO 10286:2015, 743, amended — Note 1 to entry added]

3.10
compressed gas
gas, which, when packaged under pressure for transport, is entirely gaseous at –50 °C

Note 1 to entry: This category includes all gases with a critical temperature less than or equal to –50 °C.

[SOURCE: ISO 10286:2015, 705]

3.11
liquefied gas
gas, which, when packaged for transport, is partially liquid (or solid) at temperatures above –50 °C

Note 1 to entry: A distinction is made between

— high pressure liquefied gas, which is a gas with a critical temperature between –50 °C and +65 °C; and

— low pressure liquefied gas, which is a gas with a critical temperature above +65 °C.

[SOURCE: ISO 10286:2015, 706, modified — Note 1 to entry added to incorporate definitions in ISO 10286:2015, 707 and 708]

3.12
test pressure
required pressure applied during a pressure test

Note 1 to entry: In some cases, the test pressure of the bundle can be different from the test pressure of the cylinders in the bundle.

[SOURCE: ISO 10286:2015, 729, modified — Note 1 to entry added]

3.13
burst pressure
highest pressure reached in a cylinder during a burst test

Note 1 to entry: The burst pressure also applies to hoses and manifolds.

[SOURCE: ISO 10286:2015, 732, modified — Note 1 to entry added]

3.14
working pressure
<compressed gas> settled pressure of a compressed gas at a uniform reference temperature of 15 °C in a full cylinder bundle

Note 1 to entry: In North America service pressure is often used to indicate a similar condition, usually at 21,1 °C (70 F).

Note 2 to entry: In East Asia service pressure is often used to indicate a similar condition, usually at 35 °C.

[SOURCE: ISO 10286:2015, 736, modified — "in a full gas cylinder" substituted with "in a full cylinder bundle"]

3.15
maximum filling weight
product of the minimum guaranteed water capacity of the pressure receptacle and the filling ratio of the gas contained

Note 1 to entry: For liquefied gas.

[SOURCE: ISO 10286:2015, 740]

3.16
toxic gas
gas which is known to be so toxic or corrosive to humans to pose a health hazard or which is presumed to be toxic or corrosive to humans because it has a LC_{50} value for acute toxicity equal to or less than 5 000 ml/m^3 (ppm)

Note 1 to entry: Other risks such as tissue corrosiveness are sometimes associated.

[SOURCE: ISO 10286:2015, 716]

3.17
filling pressure
pressure to which a cylinder bundle is filled at the time of filling

Note 1 to entry: It varies according to the gas temperature in the cylinder, which is dependent on the charging parameters and the ambient conditions. It is normally higher than the working pressure (because of the heat of compression) and always less than the test pressure.

[SOURCE: ISO 10286:2015, 734, modified — "cylinder" substituted with "cylinder bundle"]

3.18
bundle manufacturer
entity that assembles the various components of the bundle into its final configuration

3.19
inspection body
body that performs inspection

Note 1 to entry: An inspection body can be an organization, or part of an organization.

[SOURCE: ISO/IEC 17020:2012, 3.5]

3.20
competent authority
any body or authority designated or otherwise recognized as such for any purpose in each country by its government

Note 1 to entry: "Competent body" is not to be used; UN *Model Regulations*[1] only use "competent authority" and "inspection body."

[SOURCE: ISO 10286:2015, 620]

3.21
saturation gas
<acetylene> amount of acetylene needed to saturate the solvent at atmospheric pressure and a temperature of 15 °C

4 Design

4.1 General

The design of the bundle shall allow for the:

— inspection of all parts of the manifold for leaks during filling without obstructions;

— operation of all valves without requiring removal of any items such as shielding or a grill for the protection of the manifold.

All pressurized components shall, as a minimum requirement, be designed to operate safely (e.g. impact transition temperature for steels) in the temperature range of −20 °C to +65 °C. Operating at temperatures outside this range can require that cylinders, valves and fittings be designed for the appropriate temperature range.

Bundles that are filled by weight shall use component parts that are removable only with the use of tools, with the exception of the main valve outlet protection cap.

If the bundle is intended for acetylene or toxic liquefied gas service, it shall be designed to allow individual cylinders to be removed from the frame for filling in accordance with Annex A to ensure that these cylinders are not overfilled.

4.2 Materials

Materials for cylinders, valves and all parts that are in contact with the intended gas shall be selected in accordance with ISO 11114-1 or ISO 11114-2. Specific requirements for materials for dissolved acetylene are given in B.3.7.

The materials of construction of the frame shall be verified to be in accordance with the approved drawings.

4.3 Frame

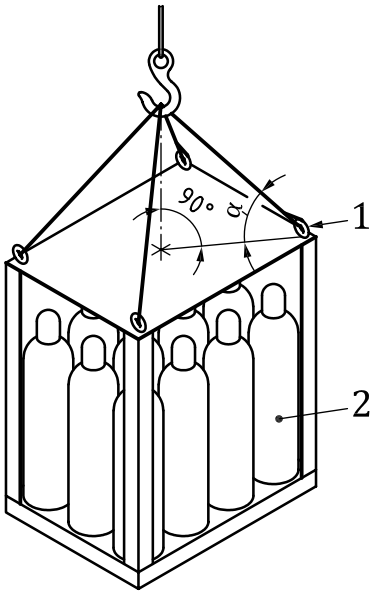
4.3.1 The frame shall securely retain all components of the bundle, protect them from damage that can cause leaks, and minimize corrosion on all external surfaces of the cylinder. Such damage can be caused by environment, vibration, impact loads, storage loads or handling loads that can be expected in normal operation. The method of cylinder restraint shall minimize any vertical or horizontal movement or rotation of the cylinder. Any cylinder displacement that would impose undue strain on the manifold shall be prevented (see 7.2.2). The total assembly shall fulfil the requirements given in 7.2.

Additionally, lifting of the bundle shall cause no leakage of gas (see 4.3.2).

4.3.2 The frame shall include features designed for the handling, storage and transportation of the bundle. Bundles can typically be lifted by forklift, lift-jack trolley or overhead crane. If the bundle is designed to be lifted by an overhead crane, lifting eyes shall be provided on the frame. Different designs with one or more lifting eyes are permitted.

NOTE National regulations can be applicable when lifting eyes are used.

In all cases, lifting eyes shall be designed to withstand a design load of 2 times the maximum gross weight of the bundle. Bundles with more than one lifting eye shall be designed so a minimum sling leg angle α of 45° to the horizontal can be achieved during lifting using the lifting eyes (see Figure 1).



Key

1 lifting eye

2 gas cylinder bundle

α sling leg angle

Figure 1 — Minimum sling leg angle

When four lifting eyes are used, their design shall be so that they are strong enough to allow the bundle to be lifted by only two lifting eyes.

When two or four lifting eyes are used, diametrically opposite lifting eyes shall be aligned with each other to allow correct lifting using shackle pins.

Lifting equipment shall be designed so that it does not interfere with any pressurized component (e.g. the manifold).

When a bundle is designed to be moved by a forklift truck, it shall feature two fork apertures, one on each side, that are to be used to lift the bundle. The fork apertures shall be positioned symmetrically about the centre of gravity and their size shall be appropriate to the forks used to move the bundle. The fork apertures shall be designed so that the bundle cannot accidentally disengage from the forks.

4.3.3 Frame structural members shall be designed for a vertical load of 2 times the maximum gross weight of the bundle. Design stress levels shall not exceed 0,9 times the yield strength of the material of the frame. Stacking of bundles is not addressed in this document; however, when it is foreseen that the bundle will be stacked for storage or transportation, the resulting forces shall be considered.

4.3.4 The frame design shall ensure that there are no protrusions from the exterior frame structure that could cause hazards.

4.3.5 Care shall be taken to minimize corrosion on all external surfaces of the cylinders. There shall be no features where water and debris can collect that would increase the tare of bundles filled by weight or cause corrosion.

4.3.6 The floor of the frame shall not buckle under normal operational and storage conditions and shall facilitate the drainage of water and debris from around the base of the cylinders.

4.3.7 The design shall ensure stability under normal operating and storage conditions. The centre of gravity shall stay within the footprint of the bundle when rotated to an angle of not more than 12° along each edge of the base.

4.3.8 If the frame design includes movable doors or covers, they shall be capable of being secured in position with latches that shall not be capable of being dislodged by operational impact loads.

4.3.9 Access shall be maintained to all valves that need to be operated in normal service or in an emergency.

4.4 Cylinders

All cylinders within a bundle shall be suitable for the intended gas service. They shall all have the same test pressure, be of similar size and conform to the standards recognized by the competent authority in the country of use.

4.5 Cylinder valves and cylinder fittings

4.5.1 Either cylinder valves or cylinder fittings shall be fitted into the inlet threads of the cylinders within the bundle. The items selected will depend on the gas service within the bundle and the operational requirements (e.g. for gases not covered under 4.5.4, cylinder valves are not required).

Requirements for the design of valves and fittings used on acetylene cylinder bundles containing acetylene in a solvent shall be as specified in Annex B.

4.5.2 Cylinder valves and cylinder fittings shall be compatible with the gas (see 4.2) and pressure for which the bundle is intended.

4.5.3 Cylinder valves and cylinder fittings shall be compatible with the inlet threads of the cylinders.

4.5.4 Each cylinder within the bundle shall be fitted with a valve when the bundle contains a toxic gas or toxic gas mixture, a pyrophoric gas or a flammable mixture with more than 1 % of pyrophoric components.

NOTE Some national regulations require each cylinder within the bundle to be fitted with a valve when containing flammable gases or flammable gas mixtures.

4.5.5 Cylinders within the bundle for non-toxic liquefied gases (e.g. carbon dioxide) shall not be fitted with a valve.

4.5.6 When each cylinder within the bundle is fitted with a valve, its outlet connection shall be of a form appropriate to the product within the bundle, or of a form that cannot lead to an incorrect connection to equipment designed for other products.

4.5.7 For non-toxic, non-flammable gases (e.g. carbon dioxide), when the use of a safety relief device is required by regulation, the safety relief device shall be designed to avoid cylinder burst.

4.6 Manifold

4.6.1 The manifold and its material shall be compatible with the gas (see 4.2) and the pressure for which the bundle is intended.

Additional requirements for the design of manifolds used on acetylene cylinder bundles containing acetylene in a solvent are provided in Annex B.

4.6.2 For compressed and liquefied gases, the manifold shall be designed so that its burst pressure is greater than or equal to 1,5 times the test pressure of the cylinders in the bundle.

4.6.3 The test pressure of the manifold shall not be less than the test pressures of the cylinders in the bundle.

With approval by a competent authority, the hydraulic pressure test may be replaced by a pneumatic pressure test, provided such an operation does not entail any danger.

4.6.4 No part of the manifold shall bear against other components in the bundle except at cylinder valve/fitting interfaces or at defined attachment points to the frame. Contact between dissimilar metals that could result in damage by galvanic corrosion shall be avoided.

4.6.5 Piping shall be designed, constructed and installed to avoid damage due to expansion and contraction, corrosion, mechanical shock and vibration. When the manifold is made of metal, the necessary flexibility shall be achieved by the use of bends or coils. Flexible hoses or non-metallic pipework should only be used as part of the manifold's pipework on the bundle after trials have proved their acceptability. The length of such hoses and pipework shall be kept to a minimum.

4.7 Main connection(s) and main valve(s)

The main connection(s) and main valve(s) shall be compatible with the gas (see 4.2) and the pressure for which the bundle is intended and be protected by the frame (e.g. the main connection and main valve shall not protrude).

All main valves shall be designed, manufactured and tested in accordance with ISO 10297.

4.8 Assembled bundle

The assembled bundle shall be designed so that it withstands the following statically applied loads:

— 2 times the maximum gross weight in all horizontal directions and vertically downwards; and

— 1 times the maximum gross weight in the vertical direction upwards.

This is confirmed by carrying out the drop tests described in 7.2.4.

Special care shall be taken concerning protection of the exterior of the assembled bundle.

5 Manufacturing

A bundle shall be manufactured in accordance with the design criteria listed in Clause 4.

For this condition to be satisfied, the bundle manufacturer shall

— use welding procedures in accordance with ISO 15607 or equivalent standards,

— use approved welders in accordance with ISO 9606-1 or equivalent standards,

— use brazing procedures in accordance with EN 13134 or equivalent standards, and

— use approved brazers in accordance with ISO 13585 or equivalent standards.

NOTE The bundle manufacturer is not necessarily the same as the manufacturer(s) of the components.

6 Identification

6.1 General

The requirements for labelling and colour coding for gas cylinders as defined in ISO documents do not apply to the cylinders of a bundle.

However, markings on the individual cylinders can be obscured. Therefore, certain information which must be checked at the time of filling shall be duplicated on the outside of the bundle (see 6.3). It is not required that the tare be marked on cylinders in accordance with ISO 13769 for bundles filled by weight unless the cylinders are removed from the frame for filling. See 4.1 and Annex A.

6.2 Product and hazard identification

6.2.1 Precautionary labels

Individual cylinders in bundles are not required to have labels. Precautionary labels with a minimum size of 100 mm × 100 mm shall be attached to the bundle adjacent to the main connection in order to meet the UN *Model Regulations*[1].

6.2.2 Colour coding

The use of the cylinder colours defined in applicable standards, e.g. ISO 32, is not mandatory for cylinders assembled into a bundle or for the frame itself, with an exception for dissolved acetylene, as given in B.4.2.

A colour code on the frame may be used to identify the contents of the bundle.

6.3 Bundle identification for filling

The requirements for bundle identification for filling are given in the UN *Model Regulations*.[1] Examples of bundle identification are given in Annex C.

6.4 Other useful information

The following information is useful in practice and may be marked on the bundle in addition to the information required in 6.3:

— The maximum gross weight of the bundle in kilograms, which should be visible from all directions from which lifting can be performed. The minimum height of the lettering should be 30 mm.

— Other critical operating instructions, e.g. closure of individual cylinder valves in transit when this is required.

— The name or identification of the owner.

7 Type approval procedure

7.1 General

Tests and examinations performed to demonstrate compliance with this document shall be conducted using instruments calibrated before being put into service and thereafter according to an established programme.

Bundle testing and inspection shall be considered in two distinct phases:

— prototype testing of the frame, the manifold and the fully assembled bundle (see 7.2); and

— initial inspection/production testing of the frame, the manifold and the fully assembled bundle (see 7.3).

Additional requirements for the testing and inspection of acetylene cylinder bundles containing acetylene in a solvent are provided in Annex B.

Either tests or design calculations are necessary for the type approval of a bundle. In both cases, all documentation being used (e.g. design calculations, drawings and specifications of the frame and the manifold, or test reports) shall be part of the type approval.

Bundle assembly drawings and build specifications shall also be part of the type approval.

7.2 Type testing

7.2.1 Frame

A prototype frame shall be constructed and checked for conformance to 7.3.1. If the frame includes lifting eyes, it shall be proof load tested to 2 times the maximum gross weight of the bundle. All primary structural joints shall be subjected to crack detection in accordance with standards recognized in the country of manufacture (e.g. ISO 17638, ISO 23278 or ASTM standards) prior to coating of the frame.

7.2.2 Manifold

A prototype manifold shall be constructed to drawings and specifications which are part of the type approval and checked for conformance to 4.6. The manifold shall be subjected to a hydraulic pressure test with a pressure as specified in 4.6.3.

7.2.3 Bundle

7.2.3.1 A fully assembled bundle shall be checked for ease of access to valves, free routing of the manifold and operation of doors and covers, when applicable.

7.2.3.2 The identification markings/plates/labels/tags shall be checked for conformance to Clause 6.

7.2.3.3 The stability of the bundle at a minimum angle of 12° shall be demonstrated by calculation or physical test.

7.2.4 Drop tests

7.2.4.1 General

Bundles shall be tested both with a vertical and a rotating drop test, as described in 7.2.4.2 and 7.2.4.3, which shall be performed onto a concrete surface of sufficient thickness to withstand the impact of the bundle without breaking up. One bundle may be used for both tests. The bundle shall contain an inert gas at a nominal pressure of at least 5 bar and the cylinders shall be ballasted (e.g. with water) to represent its maximum gross weight. The bundle shall be in the same condition as it would be during transport (e.g. with the cylinder valves either open or closed).

7.2.4.2 Vertical drop test

The bundle shall be dropped vertically onto a corner of the frame from a height of 100 mm. The angle between the frame base members and the ground shall be a minimum of 5°, which represents normal rough operation (see Figure 2). The pass/fail criteria for the vertical drop test are:

— the primary frame structure shall remain capable of subsequent movement by a forklift or sling;

— the cylinders and manifolds shall remain constrained in the frame, though deformation of components is acceptable;

— no part of the bundle shall leak (to be checked e.g. by leak detection fluid),

— in the case of composite cylinders, the integrity of the composite material is unaffected.

Dimensions in millimetres

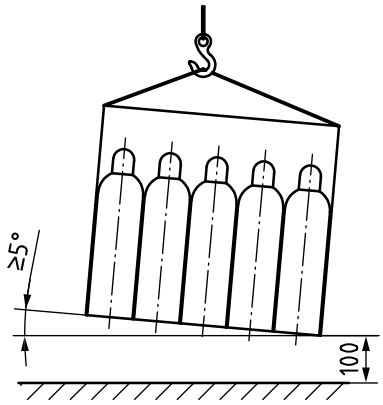


Figure 2 — Vertical drop test arrangement

7.2.4.3 Rotating drop test

The bundle shall be dropped from a height of 1 200 mm in a rotating manner so the manifold end hits the ground first, which represents an exceptional situation (see Figure 3). The pass/fail criteria for the rotating drop test are:

— the primary frame structure shall remain capable of subsequent movement by forklift or sling;

— the cylinders and manifolds shall remain constrained in the frame, although deformation of components and a slight separation of the cylinders are acceptable;

— no part of the bundle shall leak (to be checked e.g. by leak detection fluid),

— in the case of composite cylinders, the integrity of the composite material is unaffected.

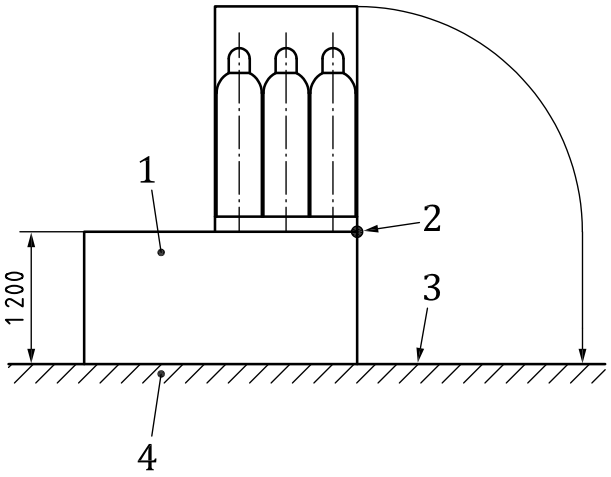
Different procedures are required for the rotating drop test based on whether the cylinders are fitted vertically or horizontally.

a) Rotating test for bundles with vertically fitted cylinders:

The bundle shall be placed on a platform with a minimum height of 1 200 mm in a position that is usually used during transport on a truck, and shall be dropped from the platform, rotating around point 2 in Figure 3, until it falls freely to the ground. Horizontal movement of the bundle shall be avoided to make sure that it falls in a rotating manner only. Particular attention shall be paid when testing bundles with cylinders longer than 2 m.

If the ground plate of the bundle is rectangular in shape, the bundle shall be rotated around its longest edge.

Dimensions in millimetres



Key

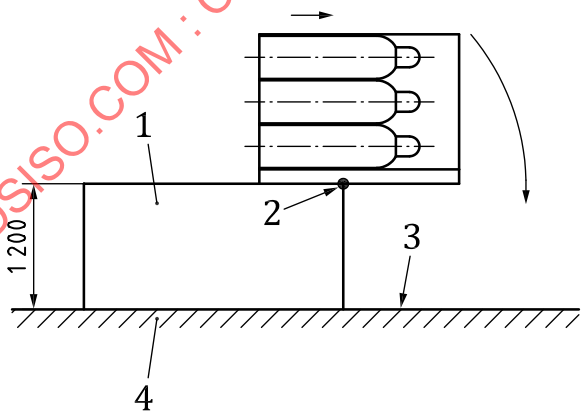
1 platform
2 point of rotation of bundle
3 drop point of bundle
4 ground

Figure 3 — Bundle drop test arrangement for vertically fitted cylinders

b) Rotating test for bundles with horizontally fitted cylinders:

The bundle shall be placed on a platform with a minimum height of 1 200 mm in a position that is usually used during transport on a truck and shall be pushed from the platform until its centre of gravity moves over the edge of the platform and the bundle topples freely to the ground (see Figure 4).

Dimensions in millimetres



Key

1 platform
2 point of rotation of bundle
3 drop point of bundle
4 ground

Figure 4 — Bundle drop test arrangement for horizontally fitted cylinders

7.3 Testing and inspection at time of manufacture

7.3.1 Frame

One frame out of a maximum of ten manufactured shall be proof load tested to 2 times the maximum gross weight and inspected as follows:

— lifting eyes shall be tested for crack defects in accordance with standards recognized in the country of manufacture (e.g. ISO 17638, ISO 23278 or ASTM standards) prior to coating of the frame; and

— all primary structural welded joints shall be subjected to crack detection in accordance with standards recognized in the country of manufacture (e.g. ISO 17638, ISO 23278 or ASTM standards) prior to coating of the frame.

The frame shall be visually inspected to ensure that there is no deviation from the design drawings and that there is full and free movement of panels and covers, when applicable.

If the tested frame fails one of these two tests, all the frames of the corresponding lot (nine maximum) shall be tested. All defective frames shall be either rendered unserviceable or repaired and then submitted to new tests.

7.3.2 Manifold

Each manifold shall be pressure tested as described in 4.6.3.

Manifolds that fail this test shall be either rendered unserviceable or repaired and then tested again.

Additional requirements for the testing and inspection at time of manufacture of manifolds of acetylene cylinder bundles containing acetylene in a solvent are provided in Annex B.

7.3.3 Bundle

7.3.3.1 General

A pneumatic leak test shall be performed using a gas compatible with the materials used for the bundle.

7.3.3.2 Assembly leak test

Following manufacture but prior to the first fill, the completed bundle shall be leak tested at a minimum of 10 % of the working pressure to check the tightness of all joints and gas connections, e.g. by leak detection fluid or equipment.

NOTE Depending upon the gas type, a higher pressure could be suitable for the assembly leak test.

7.3.3.3 Final leak test

The completed bundle shall be pneumatically tested for leaks at the working pressure, using appropriate methods and acceptance criteria as defined by the user, considering the various valve/gas types which might be present. This operation may be performed at the facility of the bundle manufacturer or in a filling centre during the first fill.

NOTE Depending upon the gas type, a more sophisticated leak test method could be suitable.

WARNING — Attention shall be paid to the consequences of leakage in case the bundle is being used for flammable and toxic gases.

Additional requirements for the testing and inspection at time of manufacture of acetylene cylinder bundles containing acetylene in a solvent are provided in Annex B.

8 Documentation

8.1 Records of the components used to produce a bundle and of the history of how and where the bundle was assembled and tested shall be maintained for every new bundle. The records shall contain the following information:

— a reference to this document and approved design drawings;

— the unique serial number of the bundle;

— the unique serial number of the frame, when available;

— the model of the main valve(s);

— the gas type (or types) for which the bundle is intended;

— the test pressure of the bundle (in accordance with the test pressure of the cylinders);

— the serial numbers of the cylinders in the bundle;

— the name and address of the bundle manufacturer; and

— the date of manufacture (in the format YYYY/MM).

8.2 Original test records and/or certificates of individual components or batches of components shall also be maintained so they can be cross referenced to individual bundle records.

8.3 All records shall be maintained at least as long as the bundle and/or its components exist.

Annex A
(normative)

Special requirements for design, manufacture and testing of bundles when cylinders are removed from the frame at the time of filling, including acetylene cylinders

The bundle shall be designed to facilitate the following:

— easy and safe access for maintenance (making connections, changing joint gaskets, checking for leaks, etc.), removal and assembly of the manifold without damaging or straining any of the components; and

— easy and safe disassembly and reassembly of the individual cylinders.

Manifold pipework shall be designed with adequate flexibility to allow easy cylinder exchange.

Individual cylinders shall be marked, labelled and valved as applicable for a single cylinder.

Care shall be taken to protect the valve during manual handling (e.g. a threaded neck ring to attach a cap or guard).

Additional requirements for acetylene cylinder bundles containing acetylene in a solvent are provided in Annex B.

Annex B
(normative)

Additional requirements for acetylene cylinder bundles

B.1 General

In addition to the design requirements specified in the main body of this document, acetylene cylinder bundles that contain acetylene in a solvent shall meet the design requirements specified in B.3. The design of the bundle's manifold shall conform to B.3.4, and the materials shall be chosen in accordance with B.3.7.

In addition to the identification requirements specified in the main body of this document, acetylene cylinder bundles that contain acetylene in a solvent shall meet the identification requirements specified in B.4.

The testing requirements specified in the main body of this document are applicable to acetylene cylinder bundles that contain acetylene in a solvent unless otherwise specified in Annex B.

B.2 Bundle tare

For acetylene cylinder bundles that contain either acetone or dimethylformamide (DMF) as solvent, the maximum quantity of acetylene and of solvent shall be identified on each individual cylinder of the bundle.

The following four tares are used:

— tare BA_{max}, which is the sum of the weight of all the cylinders in the bundle, each filled with the maximum allowable weight of solvent, plus the weight of the frame, the manifold and all other equipment;

— tare BA_{min}, which is the sum of the weight of all the cylinders in the bundle, each filled with the minimum allowable weight of solvent, plus the weight of the frame, the manifold and all other equipment;

— tare BS_{max}, which is the sum of the weight of all the cylinders in the bundle, each filled with the maximum allowable weight of solvent and its associated saturation gas, plus the weight of the frame, the manifold and all other equipment; and

— tare BS_{min}, which is the sum of the weight of all the cylinders in the bundle, each filled with the minimum allowable weight of solvent and its associated saturation gas, plus the weight of the frame, the manifold and all other equipment.

B.3 Design

B.3.1 Frame

The frame of an acetylene cylinder bundle shall not impair the distribution of water onto the tops of the cylinders for cooling purposes.

B.3.2 Cylinders

Cylinders in an acetylene cylinder bundle shall all be of the same size and shell type, i.e., do not use both seamless cylinders and welded cylinders in a bundle. They shall contain the same porous material

and solvent so that their absorption and desorption rates are similar. The cylinder shell and the porous material shall conform to ISO 3807.

B.3.3 Cylinder valves and cylinder fittings

Each cylinder shall be equipped with an acetylene cylinder valve that meets the requirements of ISO 10297.

B.3.4 Manifold

B.3.4.1 General

Manifolds may be designed either by calculation (see B.3.4.2) or by means of an experimental method (see B.3.4.3). If the calculation method is used, the design shall be verified by either a hydraulic or a pneumatic test.

B.3.4.2 Design by calculation of pipe wall thickness

An inspection body could approve a method for the wall thickness calculation, such as ASME B31.3. Currently, the most commonly used method is described in Formulae (B.1), (B.2) and (B.3). This method calculates the wall thickness (e.g. of pipes and fittings) necessary for the entire system to withstand shock reflection occurring at any point in the system.

NOTE An acetylene detonation travels along a manifold pipe as a shock wave. Particularly high stresses are caused at or near those places in the manifold pipe such as sharp bends, valves and closed ends of pipes where the shock wave can be reflected.

Formula (B.1) is used to calculate the necessary wall thickness of the pipes:

$$t = \frac{P \cdot D}{20F + P} \tag{B.1}$$

where

t is the necessary wall thickness, in mm;

P is the dimensioning pressure (gauge pressure), in bar;

The value of 1 bar in this formula is the atmospheric pressure.

D is the external diameter of pipe, in mm;

F is the allowable stress in the material, in MPa.

The dimensioning pressure P, which for acetylene takes into account the pressure increase caused by the decomposition of acetylene, and the allowable stress F are calculated using Formulae (B.2) and (B.3):

$$P = f_1 \left(P_f + 1 \right) - 1 \tag{B.2}$$

$$F = \frac{R_e}{1{,}1} \tag{B.3}$$

where

P_f is the maximum filling pressure (gauge pressure), in bar (the maximum filling pressure equals 25 bar);

The value of 1 bar in this formula is the atmospheric pressure.

R_e is the stress at yield point of the material, in MPa;

f_1 is the safety factor (at least 35).

B.3.4.3 Design by means of an experimental method

Three complete manifolds shall be subjected to an acetylene decomposition test. All openings shall be blind plugged except the opening for the main valve. The acetylene decomposition test shall be carried out in accordance with ISO 15615:2013, 6.4, considering the conditions described in ISO 15615:2013, 6.1 to 6.3.

The ignition tube shall be attached to the opening of the main valve. The initial pressure shall be 25 bar. The manifold has passed the test if:

a) no visible permanent deformation of the manifold occurred;

b) no leakage is detected during the test; and

c) no leakage is detected after the test using a leak detection fluid.

B.3.4.4 Design of flexible hoses

Flexible hoses used in bundles for acetylene shall comply with either ISO 14113 or ISO 16964.

They shall withstand the attack of the solvents used together with acetylene in accordance with ISO 14113.

The electrical resistance of the hose material between the connecting ends shall be $\leq 10^6\ \Omega$.

B.3.5 Valves (excluding cylinder valves) and seals

The main valve(s) shall comply with the requirements of ISO 10297.

The design of the valve or the method of installation shall minimize the risk of ignition due to friction between valve components. Filters may be used to eliminate the possibility of contamination getting into the valve seat.

B.3.6 Flame arrestor with flow cut-off device

Each acetylene cylinder bundle shall be protected against acetylene decomposition. This can be achieved by means of a flame arrestor, a flow cut-off device or both. The placement of both at the customer manifold is recommended.

B.3.7 Material compatibility

Particular attention shall be given to the copper content of any materials that would come into contact with dissolved acetylene (see ISO 11114-1 and ISO 11114-2). In addition, materials shall be resistant to acetylene, acetone and DMF.

B.4 Identification

B.4.1 General

The tare may be shown on each cylinder by the use of a plastic or metal ring, a label or another suitable means.

The original cylinder stamp marking should not be changed for this purpose.

B.4.2 Colour coding

Some national regulations include requirements for the colour coding for single acetylene cylinders in a bundle (e.g. EN 1089-3).

B.4.3 Bundle identification for filling

The tare based on the maximum solvent content for each individual cylinder used in a bundle shall be shown on the cylinder.

An identification plate shall be permanently fixed to the frame. The plate shall include, at a minimum, in a suitable order, the following data:

— the identification “UN1001 acetylene, dissolved” and the chemical formula C_2H_2;

— the maximum acetylene content, in kilograms, of the bundle;

— the type of porous material;

— the type of solvent (acetone or DMF);

— the previous test date (shown as either YY/MM or YYYY/MM) of the cylinder within the bundle that is first due for periodic inspection;

— the tare BS_{min}, in kilograms, rounded down to the nearest whole number, followed by the letters “KG” as shown in the two examples below:

EXAMPLE 1 A weight of 1 282,6 kg will be rounded down to “1 282 kg.”

EXAMPLE 2 A weight of 653,4 kg will be rounded down to “653 kg.”

— the working pressure, in bar, preceded by the letters “PW” as stamped on the cylinders.

NOTE Some transport regulations specify the order in which the information is to be given.

B.4.4 Other useful information

The following information is useful in practice and may be marked on the bundle in addition to that listed in B.4.3:

— the serial numbers of the individual cylinders within the bundle (alternatively, these numbers may be recorded in a bundle file);

— instructions for handling of the cylinder bundle (including that cylinder valves should be closed only in special circumstances);

— the tare BS_{max}, in kilograms, rounded down to the nearest whole number, followed by the letters “KG” (see the examples in B.4.3);

— the owner of the bundle.