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

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



Reference number  
ISO 10961:2010(E)

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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.

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.

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.

ISO 10961 was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 4, *Operational requirements for gas cylinders*.

This second edition cancels and replaces the first edition (ISO 10961:2010), of which it constitutes a minor revision.

## Introduction

For some applications, the contents of an individual gas cylinder may 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.

A cylinder bundle is a portable assembly which is designed to be routinely lifted and which 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 which use cylinder bundle components, but which 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 included in Annex A.

Acetylene cylinder bundles are often filled without disassembly. However, in order to confirm their solvent content, they are disassembled after a defined number of fillings.

In International Standards, weight is equivalent to a force, expressed in newtons. However, in common parlance (as used in terms defined in this International Standard), the word “weight” continues to be used to mean “mass”, even though this practice is deprecated (see ISO 80000-4).



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

## 1 Scope

This International Standard specifies the requirements for the design, construction, testing and initial inspection of a transportable cylinder bundle. It is applicable to cylinder bundles containing compressed gas, liquefied gas and mixtures thereof. It is also applicable to cylinder bundles for acetylene.

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

Some special applications (e.g. electronics) require an alternative design approach. With the agreement of the inspection body, the manifold and its piping components may be designed and tested at a pressure which is appropriate to the service conditions.

Specific requirements for acetylene cylinder bundles containing acetylene in a solvent are included in Annex B. This International Standard does not, however, cover acetylene cylinder bundles with solvent-free acetylene cylinders.

This International Standard is intended primarily for industrial gases other than liquefied petroleum gases (LPGs), but it may also be used for LPGs.

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

## 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 7225, *Gas cylinders — Precautionary labels*

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

ISO 13769, *Gas cylinders — Stamp marking*

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

### 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

- 3.1  
cylinder bundle  
bundle**  
portable assembly which consists of a frame and two or more cylinders, each of a capacity up to 150 l and with a combined capacity of not more than 3 000 l, or 1 000 l in the case of toxic gases, connected to a manifold by cylinder valves or fittings such that the cylinders are filled, transported and emptied without disassembly
- 3.2  
frame**  
structural and non-structural members of a bundle which combine all other components together, whilst providing protection for the bundle's cylinders, valves and manifold and which enable the bundle to be transported
- 3.3  
cylinder valve**  
valve which is fitted into a cylinder and to which a manifold is connected in a bundle
- 3.4  
cylinder fitting**  
component, with no gas shut-off capability, which serves as a method for connecting a bundle's manifold to its individual cylinders when cylinder valves are not fitted to the cylinders
- 3.5  
manifold**  
piping system for connecting cylinder valves or cylinder fittings to the main valve(s) or main connection(s)
- 3.6  
main valve**  
valve which is fitted to the manifold and which is used for the isolation of the bundle
- 3.7  
main connection**  
means of making a gas connection to a bundle
- 3.8  
tare weight**  
weight of the bundle when empty of gas product
- 3.9  
maximum gross weight**  
sum of the tare weight of the bundle and the maximum permissible filling weight
- 3.10  
compressed gas**  
gas which, when packaged under pressure, is entirely gaseous at  $-50\text{ °C}$  (including all gases with a critical temperature  $\leq -50\text{ °C}$ )

[GHS]



**3.11****liquefied gas**

gas which, when packaged under pressure, is partially liquid at temperatures above  $-50\text{ }^{\circ}\text{C}$

[GHS]

NOTE A distinction is made between

a) high-pressure liquefied gas: a gas with a critical temperature between  $-50\text{ }^{\circ}\text{C}$  and  $+65\text{ }^{\circ}\text{C}$ , and

b) low-pressure liquefied gas: a gas with a critical temperature above  $+65\text{ }^{\circ}\text{C}$ .

**3.12****proof test pressure**

hydraulic pressure which demonstrates the structural integrity of the manifold

**3.13****burst pressure**

(gas cylinder bundles) highest pressure reached in a cylinder or the bundle manifold during a burst test

NOTE Adapted from ISO 10286.

**3.14****working pressure**

settled pressure for a compressed or dissolved gas at a uniform temperature of  $288\text{ K}$  ( $15\text{ }^{\circ}\text{C}$ ) for a full bundle

**3.15****bundle test pressure**

test pressure of the cylinder and manifold assembled together

**3.16****maximum permissible filling weight**

product of the minimum guaranteed water capacity of the cylinders of the bundle and the filling ratio of the gas contained

**3.17****very toxic gas**

gas with an  $\text{LC}_{50}$  of less than or equal to  $200\text{ ppm (V/V)}$ , where the  $\text{LC}_{50}$  value corresponds to one hour of exposure to gas and ppm (V/V) indicates parts per million, by volume

NOTE Adapted from ISO 10298.

**3.18****toxic gas**

gas with an  $\text{LC}_{50}$  of more than  $200\text{ ppm}$  but less than or equal to  $5\,000\text{ ppm}$ , where the  $\text{LC}_{50}$  value corresponds to one hour of exposure to gas and ppm (V/V) indicates parts per million, by volume

NOTE Adapted from ISO 10298.

**3.19****filling pressure**

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

**3.20****bundle manufacturer**

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

### 3.21

#### **inspection body**

independent inspection and testing body approved by the competent authority

[UN Model Regulations]

### 3.22

#### **competent authority**

any national body or authority designated or otherwise recognized as such, having jurisdiction for the transport of dangerous goods and the approval of gas cylinders

NOTE Adapted from UN Model Regulations.

## 4 Design

### 4.1 General

The design of the bundle shall take into consideration its ease of assembly, inspection and operation.

All pressurized components shall, as a minimum requirement, be designed to operate safely in the temperature range  $-20\text{ °C}$  to  $+65\text{ °C}$ .

Where service temperatures outside this range are required, the bundle design shall include additional requirements (e.g. specific sealing material). Bundles that are filled by weight shall not feature component parts which are de-mountable without the use of tools, with the exception of the main valve outlet protection cap.

### 4.2 Material

Materials for cylinders, valves and all parts which are in contact with the intended gas shall be selected in accordance with the relevant International Standards on compatibility (e.g. ISO 11114-1 and ISO 11114-2).

### 4.3 Frame

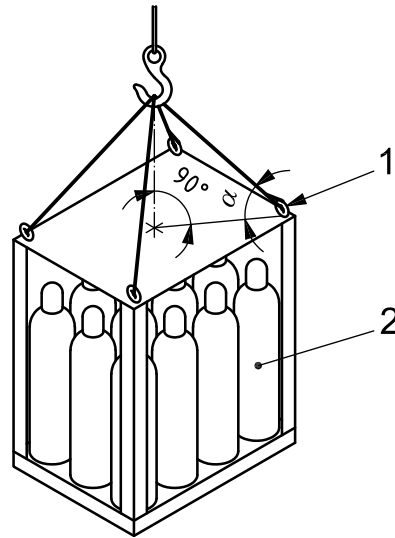
**4.3.1** The frame shall retain securely all the components of the bundle and shall protect them from damage which might cause leaks. Such damage can be caused by vibration, impact loads or handling loads which can be expected in normal operation. The method of cylinder restraint shall minimize any vertical or horizontal movement or rotation of the cylinder. All cylinder displacement which would impose undue strain on the manifold (see 7.2.2.2) shall be prevented. The total assembly shall be capable of withstanding rough handling, including being dropped or toppled.

Additionally, no leakage of gas shall be caused during the lifting of the bundle (see 4.3.2).

**4.3.2** The frame shall include features designed for the handling and transportation of the bundle. Bundles can typically be lifted by fork-lift, 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 might be applicable when lifting eyes are used.

In all cases, lifting eyes shall be designed to withstand a design load of  $2 \times$  maximum gross weight. Bundles with more than one lifting eye shall be designed such that a minimum sling leg angle  $\alpha$  of  $45^\circ$  to the horizontal can be achieved during lifting using the lifting eyes (see Figure 1).

**Key**

- 1 lifting eye
- 2 gas cylinder bundle
- $\alpha$  sling leg angle

**Figure 1 — Minimum sling leg angle**

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

Where 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 fork-lift truck, it shall feature two fork apertures on each side from which it is to be lifted. 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 such 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.

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

**4.3.5** There shall be no features in which water and debris can collect to increase the tare weight of bundles filled by weight, or to cause corrosion.

**4.3.6** The floor of the bundle frame shall not buckle under normal operational 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 conditions. The centre of gravity shall stay within the footprint of the bundle when rotated to an angle of not more than  $12^\circ$  in both directions.

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

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

#### **4.4 Cylinders**

Cylinders within a bundle shall be suitable for the intended gas service. They shall all have the same test pressure, shall be of similar size and shall conform to the appropriate standards covering individual cylinders.

#### **4.5 Cylinder valves and cylinder fittings**

**4.5.1** Either cylinder valves or a cylinder fitting 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).

For acetylene, see Annex B.

**4.5.2** Cylinder valves and cylinder fittings shall be compatible with the gas 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** A cylinder valve shall be used when the bundle contains a very toxic gas or gas mixture, a pyrophoric gas or a flammable mixture with more than 1 % of pyrophoric components.

**4.5.5** A cylinder valve shall not be used for non-toxic liquefied gases.

**4.5.6** If the gas is a very toxic liquefied or toxic liquefied gas, the individual cylinders shall be removed from the frame for filling in accordance with Annex A to ensure that individual cylinders are not overfilled.

**4.5.7** When cylinder valves are fitted, their outlet connections shall be of a form appropriate to the product within the bundle, or of a form which cannot lead to the incorrect connection to equipment designed for other products.

**4.5.8** For non-toxic, non-flammable gases (e.g. CO<sub>2</sub>), 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 and the pressure for which the bundle is intended.

For acetylene, see Annex B.

**4.6.2** For compressed and liquefied gases, the manifold shall be designed in such a way that the burst pressure shall be greater than or equal to  $1,5 \times$  the test pressure of the cylinders in the bundle.

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

With the agreement of the inspection body, the hydraulic pressure test may be replaced by a test using a gas, 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 which could result in damage by galvanic corrosion shall be avoided.

**4.6.5** Piping shall be designed, constructed and installed so as to avoid damage due to expansion and contraction, mechanical shock and vibration. Where 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 fixed pipework on the bundle after trials have proved their acceptability, and the length of such hoses and pipework shall be kept to a minimum.

#### 4.7 Main connection(s)/main valve(s)

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

#### 4.8 Assembled bundle

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

- 2 × the maximum gross weight in all horizontal directions and vertically downwards;
- 1 × the maximum gross weight in the vertical direction upwards.

NOTE This is checked by carrying out the drop tests described in 7.2.2.3.4.

### 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 standards recognized in the country of manufacture, e.g. ISO 15607,
- use approved welders in accordance with standards recognized in the country of manufacture, e.g. ISO 9606-1,
- use brazing procedures in accordance with standards recognized in the country of manufacture, e.g. EN 13134, and
- use approved brazers in accordance with standards recognized in the country of manufacture, e.g. EN 13133.

NOTE The bundle manufacturer is not necessarily identical with the manufacturer(s) of the components.

### 6 Identification

#### 6.1 General

The requirements for labelling and colour coding as defined in ISO 7225 and ISO 32 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). For bundles filled by weight with products other than acetylene, it is not required that the tare weight be marked on cylinders in accordance with ISO 13769.

## 6.2 Product and hazard identification

### 6.2.1 Precautionary labels

Individual cylinders in bundles are not required to have labels attached. The appropriate precautionary labels and other information in accordance with ISO 7225 shall be attached to the bundle adjacent to the main connection. The minimum size of the side of the precautionary label shall be 100 mm and shall be in accordance with the regulations for the transportation of dangerous goods.

### 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 bundle frame itself.

## 6.3 Bundle identification for filling

### 6.3.1 General

In addition to the information on individual cylinders in accordance with the relevant marking regulations of the countries of use, the information specified in 6.3.3 to 6.3.5 shall be clearly identified on a corrosion-resistant plate permanently fixed on the outside of the bundle. Where there is no conflict with such regulations, all markings shall be in accordance with ISO 13769.

### 6.3.2 Grouping and size of marks

The following marks shall be placed in three groups:

- manufacturing marks shall constitute the top group and shall appear consecutively in the sequence given in 6.3.3;
- the middle group (see 6.3.4) shall include the test pressure, which shall be immediately preceded by the working pressure when the latter is required;
- certification marks shall constitute the bottom group and shall appear in the sequence given in 6.3.5.

The minimum size of the marks shall be 5 mm.

For additional data for acetylene, see Annex B.

### 6.3.3 Manufacturing marks

These shall include the following:

- The bundle manufacturer's mark as registered by the competent authority. When the country of manufacture is not the same as the country of approval, the bundle manufacturer's mark shall be preceded by the character(s) identifying the country of manufacture as indicated by the distinguishing signs of motor vehicles in international traffic. The country mark and the bundle manufacturer's mark shall be separated by a space or slash.
- The serial number assigned by the bundle manufacturer.
- In addition, each frame shall include a unique identification number which shall be permanently marked. This number may be independent from the bundle serial number.

#### 6.3.4 Operational marks

These shall include the following:

- the test pressure in bars, preceded by the letters “PH” and followed by the letters “BAR”;
- for bundles filled by weight, the tare weight and the maximum permissible filling weight or the gross weight;
- for compressed gases which are filled under pressure, the working pressure in bars, preceded by the letters “PW”;
- in the case of liquefied gases, the water capacity in litres rounded down to three significant digits, followed by the letter “L”.

#### 6.3.5 Certification marks

These shall include the following:

- a reference to this International Standard;
- the character(s) identifying the country of approval as indicated by the distinguishing signs of motor vehicles in international traffic, except if the country of approval can be indicated by other means (e.g. by a specific identification number of an inspection body);
- the identity mark or stamp of the inspection body that is registered with the competent authority in the country authorizing the marking;
- the date of the initial inspection, written as the year (four digits) followed by the month (two digits), the year and the month being separated by a slash (i.e. “/”).

#### 6.4 Other useful information

The following information is useful in practice and may be marked on the bundle in addition to the information given 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 Testing and inspection

#### 7.1 General

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

Additional and specific requirements for acetylene are included in Annex B.

## 7.2 Prototype testing of the frame, the manifold and the fully assembled bundle

### 7.2.1 Approvals

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 approved by the inspection body.

Bundle assembly drawings and build specifications shall also be approved by an inspection body.

### 7.2.2 Tests

#### 7.2.2.1 Frame

A prototype frame shall be constructed and checked for conformance to 7.2.1. If the frame includes sling 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. EN 1290, EN 1291 or ASTM standards (see Bibliography), prior to coating of the frame.

#### 7.2.2.2 Manifold

A prototype manifold shall be constructed to drawings and specifications and checked for conformance to 4.6. The manifold shall be subjected to a hydraulic proof test with a pressure as specified in 4.6.3.

#### 7.2.2.3 Bundle

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

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

**7.2.2.3.3** The stability of the bundle at a minimum angle of  $12^\circ$  shall be demonstrated by calculation or physical test.

**7.2.2.3.4** Two types of drop test, as follows, shall be performed, both onto a concrete surface. One bundle may be used for both tests. The bundle shall contain inert gas at a nominal pressure of at least 5 bar and the cylinders shall be ballasted (e.g. with water) to represent the maximum gross weight. The bundle shall be in the same condition as during transport, e.g. with the cylinder valves either open or closed.

**Vertical drop:** The bundle shall be dropped vertically onto a corner of the frame from a height of 0,1 m. The angle between the frame base members and the ground shall be a minimum of  $5^\circ$ , which represents normal rough operation. The pass criteria are as follows:

- the primary frame structure shall not fail such that subsequent movement by fork-lift truck or slinging is not possible;
- the cylinders and manifolds shall remain constrained in the frame, though deformation of components is acceptable;
- the bundle shall not leak.

**Rotating drop:** The bundle shall be dropped from a height of 1,2 m in a rotating manner such that the top hits the ground first, which represents an exceptional situation. The pass criteria are as follows:

- the primary frame structure shall not fail such that subsequent movement by fork-lift truck or slinging is not possible;

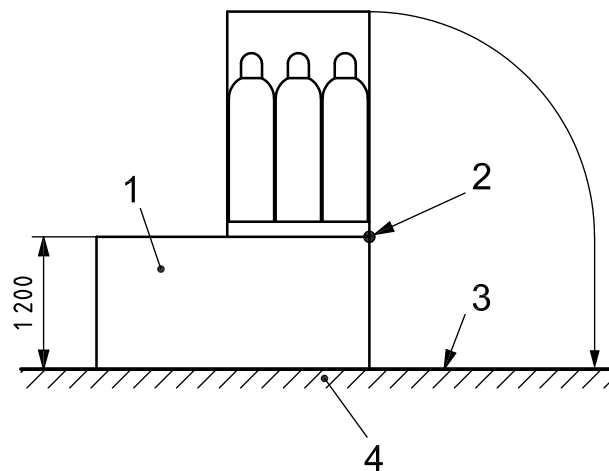


- the cylinders and manifolds shall remain constrained in the frame, though deformation of components and slight separation of the cylinders are acceptable;
- the bundle shall not leak.

For the rotating drop test, the bundle shall be placed on a platform with a minimum height of 1 200 mm in a position which is usually used during transport on a truck, and shall be dropped from the platform, rotating around point 2 in Figure 2, 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.

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 (concrete of sufficient thickness to withstand impact of bundle without breaking up)

**Figure 2 — Bundle drop test arrangement**

### 7.3 Test 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 as follows:

- lifting eyes shall be tested for crack defects in accordance with standards recognized in the country of manufacture, e.g. EN 1290, EN 1291 or ASTM standards (see Bibliography), prior to coating of the frame;
- all primary structural welded joints shall be subjected to crack detection in accordance with standards recognized in the country of manufacture, e.g. EN 1290, EN 1291 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, where applicable.

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

### 7.3.2 Manifold

Each manifold shall be proof pressure tested as described in 4.6.3.

All manifolds that fail this test shall be either scrapped or repaired and then tested again.

For acetylene, see Annex B.

### 7.3.3 Bundle

#### 7.3.3.1 General

Leak testing shall be performed using gases (or gas mixtures) containing not less than 2 % of helium or between 2 % and 4 % of hydrogen or compressed air at the working pressure of the bundle.

#### 7.3.3.2 Assembly leak test

Under the responsibility of the bundle manufacturer, the completed bundle shall be leak tested at a minimum of 25 % of the filling pressure to check the integrity of all joints and gas connections.

NOTE Depending on the gas type, higher pressure might be suitable.

#### 7.3.3.3 Final leak test

The completed bundle shall be tested for leaks at the filling pressure, using appropriate methods and acceptance criteria as defined by the user. This operation can be performed under the responsibility of the bundle manufacturer or in a filling centre during the first fill after assembly as a part of the “inspection at time of filling”.

NOTE Depending on the gas type, more sophisticated leak test methods might be suitable.

For acetylene, see 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 International Standard;
- the unique serial number of the bundle;
- the unique serial number of the frame;
- the model of the master outlet valve(s);
- the gas type(s) for which the bundle is intended;
- the bundle test pressure (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;
- 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 such that 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 components exist.

## **Annex A** (normative)

### **Special requirements for design, manufacture and testing of bundles disassembled 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;
- easy and safe disassembly and reassembly of the individual cylinders;
- removal of the cylinders from the side of the bundle.

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

Individual cylinders shall be marked, labelled and valved in conformity with the regulations applicable for a single cylinder.

Cylinders shall be provided with the means to attach valve protection (e.g. threaded neck ring, cylinder cap).

For additional requirements for acetylene, see Annex B.

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## Annex B (normative)

### Specific requirements for acetylene cylinder bundles

#### B.1 General

In addition to the design requirements specified in the main body of this International Standard, acetylene cylinder bundles shall meet the design requirements specified in Clause B.3. The design of the acetylene manifold shall conform to B.3.4.

In addition to the identification requirements specified in the main body of this International Standard, acetylene cylinder bundles shall meet the identification requirements specified in Clause B.4.

The testing requirements specified in the main body of this International Standard are applicable to acetylene cylinder bundles unless otherwise specified in this annex.

#### B.2 Additional descriptions concerning acetylene bundles

##### B.2.1 Acetylene cylinder bundles

An acetylene cylinder bundle contains not less than 2 and usually not more than 16 cylinders. It is intended for only a prescribed number of re-fillings before it is disassembled, and each cylinder is filled individually (including replenishment of solvent for UN 1001 acetylene, dissolved).

##### B.2.2 Bundle tare weights

For acetylene cylinder bundles that contain acetone as solvent, the maximum quantity of acetylene and of solvent shall be identified on each individual cylinder of the bundle.

For bundles with acetylene cylinders containing solvent, the following two tare weights are used:

- 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;
- 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.

NOTE Saturation gas is the acetylene required to saturate the solvent at atmospheric pressure and a temperature of 15 °C.

#### B.3 Design

##### B.3.1 Frame

The frames of acetylene cylinder bundles shall not impair the distribution of water to the tops of the cylinders for cooling purposes.

### B.3.2 Acetylene cylinders

The acetylene cylinders in a bundle shall all be of the same size and shell type, and 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 the relevant International Standards or national regulations.

### B.3.3 Cylinder valves/cylinder fittings

In an acetylene cylinder bundle, every cylinder shall be equipped with a cylinder valve meeting 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

In general, the inspection body can approve a method for the wall thickness calculation, such as ASME B31.3. Currently, the most commonly used method is that described below. This method calculates the wall thickness (e.g. of pipes and fittings) necessary for the whole system to withstand shock reflection occurring at any point.

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 where the shock wave can be reflected, such as sharp bends, valves and closed ends of pipes.

To calculate the necessary wall thickness of the pipes, the following equation is used:

$$t = \frac{P \times D}{20F + P} \quad (\text{B.1})$$

where

- $t$  is the necessary wall thickness, in mm;
- $P$  is the dimensioning pressure (gauge pressure), in bars<sup>1)</sup>;
- $D$  is the external diameter of pipe, in mm;
- $F$  is the allowable stress in the material, in N/mm<sup>2</sup>.

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 as follows:

$$P = f_1(P_f + 1) - 1 \quad (\text{B.2})$$

$$F = \frac{R_e}{1,1} \quad (\text{B.3})$$

where

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

$P_f$  is the maximum filling pressure (gauge pressure), in bars<sup>1</sup>);

$R_e$  is the stress at yield point of the material, in N/mm<sup>2</sup>;

$f_1$  is the safety factor (at least 35).

#### B.3.4.3 Design by means of an experimental method

In a part or a model of the manifold pipe to be manufactured, the acetylene shall be ignited at the maximum acetylene filling pressure [the highest pressure which is allowed in an acetylene cylinder bundle manifold during filling, equal to 25 bar (gauge)] by an ignition device. This method may only be used where the necessary facilities and experience with ignition tests exist. The test set-up used shall be designed to reproduce the conditions which can be expected to occur in the actual manifold pipe on ignition, i.e. same pipe diameter and sufficient length to allow deflagration/detonation to develop. The wall thickness of the pipe shall be demonstrated to be able to withstand the stresses occurring in the test without serious damage, e.g. bursting, cracking or release of acetylene.

#### B.3.4.4 Design of flexible hoses

The material for the hose connection shall be of such quality that the bursting pressure, depending on the inner diameter of the hose, meets the minimum requirement specified in Table B.1.

Table B.1 — Bursting pressure

Inner diameter mm	Minimum bursting pressure bar (gauge)
< 6	600
≥ 6 but ≤ 12	900

Three hoses shall be taken from the first production batch for use as test specimens for type approval testing under the responsibility of the hose manufacturer. Two of these samples shall be submitted to a detonative decomposition test in order to demonstrate that the hoses withstand the stresses occurring without serious damage. For this test, the starting pressure shall be at least 25 bar (gauge). The third test specimen shall undergo a hydraulic burst test. The value of the hydraulic burst pressure is taken as a reference value. For production hoses, the hose manufacturer shall guarantee a minimum burst pressure of not less than 90 % of the value thus derived.

Flexible hoses 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 the cylinder valves) and seals

The strength of the valve body shall be similar to the calculated strength of the pipe in which it is installed and shall comply with ISO 10297.

The design of the valve or the method of installation shall be such as to minimize the risk of ignition due to friction between valve components. Filters may be used to eliminate the possibility of dirt 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 use of both is recommended.

## B.4 Identification

### B.4.1 General

The tare weight 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 Bundle filling identification

The tare weight 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 bundle frame in accordance with the regulations of the country of use. The plate shall include, in a suitable order, the data listed below:

- 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 dimethylformamide);
- the previous test date (YY/MM) of that cylinder within the bundle which is first due for periodic inspection;
- the tare weight  $BS_{min}$ , 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 bars, preceded by the letters “PW” as stamped on the cylinders.

### B.4.3 Other information

The following identification data may be marked on the bundle in addition to the data given in 6.3:

- the serial numbers of the individual acetylene cylinders within the bundle (alternatively, these numbers may be recorded in a bundle file);
- instructions for the handling of the cylinder bundle (including the information that cylinder valves should be closed in special circumstances only);
- the tare weight  $BS_{max}$ , in kilograms, rounded down to the nearest whole number, followed by the letters “KG” (see the examples in B.4.2);
- the home station of the bundle.

## B.5 Testing

### B.5.1 Design qualification testing of a manifold

The manifold, with the exception of safety devices, shall be pressure tested to a minimum pressure of 300 bar (gauge). If flexible hoses are used, they shall be prototype tested and approved so that they conform to the requirements of B.3.4.4.



### **B.5.2 Design qualification — Drop testing of a bundle**

The two types of drop test specified in 7.2.2.3.4 shall be performed.

NOTE Because of the unstable nature of acetylene, drop testing with acetylene in the cylinders is not recommended.

### **B.5.3 Production testing of manifold**

Each manifold, with the exception of safety devices, shall be pressure tested to a minimum pressure of 300 bar (gauge).

Each flexible hose shall be hydraulically tested to a minimum pressure of 300 bar (gauge) before it is mounted on the manifold.

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