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Cylinders for acetylene — Basic requirements —

Part 2: Cylinders with fusible plugs

Bouteilles pour acétylène — Exigences de base —

Partie 2: Bouteilles avec bouchons fusibles

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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 3.

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 part of ISO 3807 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 3807-2 was prepared by Technical Committee ISO/TC 58, *Gas cylinders*.

This first edition, together with ISO 3807-1, cancels and replaces ISO 3807:1977, which has been technically revised.

ISO 3807 consists of the following parts, under the general title *Cylinders for acetylene — Basic requirements*:

— *Part 1: Cylinders without fusible plugs*

— *Part 2: Cylinders with fusible plugs*

Annexes A to F form a normative part of this part of ISO 3807.

Introduction

There are 2 types of acetylene cylinders working safely in certain parts of the world:

- acetylene cylinders designed with a test pressure of at least 60 bar gauge and without fusible plugs or any other safety devices;
- acetylene cylinders designed to a test pressure of at least 52 bar gauge, fitted with fusible plugs or other safety devices which release the gas and hence reduce the pressure if the cylinder temperature increases unintentionally.

It was decided to split International Standard ISO 3807 into 2 parts and specify the basic requirements of both systems separately; the differences are found mainly in the testing requirements.

Cylinders for acetylene — Basic requirements —

Part 2: Cylinders with fusible plugs

1 Scope

This part of ISO 3807 specifies the basic requirements for acetylene cylinders with shells made from steel and equipped with fusible plugs with a maximum nominal water capacity of 150 l. It includes the procedures for type testing, production batch testing and the methods for determining the maximum permissible settled pressure in acetylene cylinders and the porosity of the porous mass. It also contains requirements for filling conditions of acetylene cylinders and bundles.

This part of ISO 3807 does not cover acetylene cylinders with safety devices other than fusible plugs.

It does not include details of design for the cylinder shell; these are specified e.g. in ISO 4705, ISO 4706, ISO 9809-1 or ISO 9809-3.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this part of ISO 3807. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 3807 are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 13769:—[1], *Gas cylinders — Stamp marking.*

3 Terms and definitions

For the purposes of this part of ISO 3807, the following terms and definitions apply.

3.1
acetylene cylinder
pressure vessel, manufactured and suitable for transport of acetylene, containing a porous mass and solvent for acetylene (or solvent-free where applicable) with valve and other accessories fixed to the cylinder

NOTE 1 For solvent-free acetylene cylinders, see clause 6.

NOTE 2 When there is no risk of ambiguity, the word "cylinder" is used.

1) To be published.

3.2
cylinder shell
pressure vessel, manufactured and suitable for receiving and containing a porous mass and to be fitted as an acetylene cylinder

3.3
porous mass (porous substance)
single or multi-component material introduced or formed in the cylinder shell in order to fill it and that, due to its porosity, allows the absorption of the solvent/acetylene gas solution

NOTE The porous mass may be monolithic or non-monolithic:

— monolithic porous mass, consisting of a solid product typically obtained by reacting materials or by bonding materials together with a binder;

— non-monolithic porous mass, consisting typically of granular, fibrous or similar materials without addition of a binder.

3.4
solvent
liquid which is absorbed by the porous mass and is capable of dissolving and releasing the acetylene

NOTE The following abbreviations are used:

— "A" for acetone;

— "DMF" for dimethylformamide.

3.5
fusible plug
non-reclosing pressure relief device designed to function by the yielding or melting of a plug of fusible material at a predetermined temperature

3.6
acetylene bundle
transportable unit consisting of two or more cylinders manifolded together within a rigid frame, equipped with all necessary equipment for filling and emptying in the assembled state

3.7
tare weight
reference mass, in kilograms, of the acetylene cylinder with the specified amount of solvent, further specified in accordance with 3.7.1, 3.7.2 or 3.7.3

NOTE For cylinders with solvent, the tare weight is expressed by indicating either one or both of the masses corresponding to TARE A and TARE S. For solvent-free acetylene cylinders, the tare weight is expressed by indicating a TARE F. For the tare weight used for cylinders in bundles, see 7.5.3.

3.7.1
TARE A
sum of empty mass of the cylinder shell, the mass of the porous substance (see 3.3), the specified mass of solvent, the valve and the mass of all other parts which are permanently attached (e.g. by clamping or nut-and-bolt fixing) to the cylinder when it is going to be filled

3.7.2
TARE S
TARE A plus the acetylene mass required to saturate the solvent at normal atmospheric pressure (1,013 bar) and at a temperature of 15 °C (saturation gas)

3.7.3
TARE F
TARE A minus the specified mass of solvent

3.8
maximum acetylene content
specified maximum mass of acetylene the cylinder is designed to contain, in kilograms "KG" [see 4.6.2 e)]

NOTE When a solvent is used, it includes the saturation gas.

3.9
total weight
total mass, in kilograms "KG" equal to TARE A (or TARE F for solvent-free cylinders) plus the maximum acetylene content [see 4.6.2 e)]

3.10
water capacity (cylinder shell volume)
actual capacity of the cylinder shell, in litres, measured by filling the shell with water

NOTE The cylinder shell is defined as being empty of any porous mass, see 3.2.

3.11
porosity
ratio, expressed as a percentage, of the total volume (water capacity) of the cylinder shell minus the volume of the solid material of the porous mass, to the water capacity of the cylinder shell, and determined in accordance with annex A or annex B

3.12
acetylene/solvent ratio
ratio of the maximum acetylene content to the specified solvent content

3.13
maximum permissible settled pressure
maximum permissible pressure, in bar gauge, at a uniform temperature of 15 °C, in a cylinder containing the maximum acetylene content and the specified solvent content

3.14
manufacturer
company responsible for filling the cylinder shell with porous mass and which generally prepares it for the first charge of acetylene

4 Basic requirements

4.1 Cylinder shell

4.1.1 The cylinder shell shall conform to the requirements of the relevant International Standard or the national requirements of the country(ies) of use.

4.1.2 The minimum test pressure for acetylene cylinders equipped with fusible plugs shall be 52 bar gauge.

4.2 Porous mass

4.2.1 The porous mass in each cylinder shall be of such quality that it enables each completed cylinder to pass all the tests included in annex C.

For safety reasons, the porous mass shall be able to prevent the propagation of decomposition of the acetylene.

4.2.2 There shall be no hazardous reaction between the porous mass, the cylinder shell, the acetylene, the solvent and any parts in contact with them during preparation and use.

4.3 Solvent content

The specified mass of solvent for an acetylene cylinder shall be such that the cylinder will meet the requirements of all tests specified in annex C. Specific requirements for solvent content in acetylene cylinders and bundles are given in annex D.

4.4 Maximum acetylene charge

The total mass of acetylene in a cylinder shall not exceed the amount specified by the manufacturer. For specific requirements for individual cylinders and bundles, see annex D.

4.5 Settled pressure

When the cylinder has been charged with the specified solvent content and the maximum acetylene content, and the pressure has reached equilibrium at a uniform temperature of 15 °C, the gauge pressure in the cylinder shall not exceed the maximum permissible settled pressure for the type of cylinder — calculated using the formula in annex E.

4.6 Cylinder identification

4.6.1 The identification of acetylene cylinders shall comply with relevant national requirements and standards for identification (e.g. stamp marking, labelling and colour-coding) in the country(ies) of use.

4.6.2 Irrespective of the requirements of 4.6.1, each acetylene cylinder shall be stamp-marked with at least the following information:

a) the number of this part of ISO 3807, i.e. 3807-2;

b) cylinder serial number;

c) gas identification, in the format of the chemical symbol "C_2H_2";

d) identification of the porous mass, enabling the mass, the country and factory of origin to be clearly identified;

e) tare weight as defined in 3.7.1 or 3.7.2. If this tare weight includes fixed parts other than the valve (normally fixed cap or valve guard), the total mass of those parts shall be indicated by a stamp marking in front of the letters "TARE" (e.g. 2.3 TARE 75.1/75.6 KG, see ISO 13769). For solvent-free acetylene cylinders, see 6 d);

f) total weight of the acetylene cylinder as defined in 3.9;

g) identification of the solvent including the specified mass of solvent, in kilograms (e.g. A 12.4 KG or DMF 16.0 KG). For solvent-free acetylene cylinders, see 6 d);

h) test pressure of the cylinder shell, in bar gauge;

i) maximum permissible settled pressure, in bar gauge, as defined in 3.13;

j) actual water capacity of the cylinder shell, in litres "L".

4.7 Fusible plugs

4.7.1 Each acetylene cylinder shall be equipped with one or more pressure relief devices of the fusible plug type, sized and selected as to location and quantity so that the pressure relief device(s) are capable of preventing rupture of the normally charged cylinder when subjected to a fire test in accordance with C.4.

4.7.2 The fusible plug shall utilize a fusible alloy having a yield temperature of no more than 107 °C and no less than 98 °C. The nominal yield temperature shall be 100 °C. The yield temperature is the temperature at which the fusible alloy becomes sufficiently soft to extrude from its holder to permit discharge of acetylene.

4.7.3 The fusible alloy may be installed in a threaded steel or brass plug or in the cylinder valve. The threaded plug shall be fitted into a boss or pad on the cylinder top or bottom. Bottom plugs are not permitted for cylinders used in bundles.

4.7.4 The fusible plugs shall be sample tested for yield temperature, and for resistance to extrusion and leakage as a quality control procedure during manufacture prior to installation into the cylinder. Detailed test procedures are given in annex F.

5 Type approval

5.1 General requirements

Representative cylinders, selected according to 5.3 by, or on behalf of, the approving authority, shall successfully withstand the type tests as required in 5.4 prior to type approval being granted to the manufacturer of the porous mass (see 5.2).

The massing factory and the process of filling of the porous mass into the cylinder shell shall be audited by, or on behalf of, the approving organization.

5.2 Approval requirements

5.2.1 Range of a single approval

A request for approval of acetylene cylinders may cover a range of different cylinder sizes provided that:

a) the cylinders contain the same porous mass from the same factory and the same solvent;

b) the maximum acetylene content per litre water capacity of the cylinder shell is the same;

c) the acetylene/solvent ratios are the same;

d) the nominal outside diameter of the cylinder falls within the range of either:

   1) $\leqslant$ 270 mm or

   2) > 270 mm;

e) the construction is similar (welded or seamless).

NOTE The maximum acetylene content per litre water capacity (b) and the maximum acetylene/solvent ratio (c) may be lower than the values approved, provided they are within the safe operating area of the safe operating diagram in Figure D.1.

5.2.2 Information to be supplied

Each request for approval shall include the following information:

a) A schedule of the different types, as defined in 5.3.2, of acetylene cylinders which form the subject of the request for approval and which includes, for each size of cylinder, the following information:

   1) nominal water capacity in litres;

   2) solvent to be used;

3) specified solvent content in kilograms;

4) maximum acetylene content in kilograms;

5) test pressure of the cylinder shell in bar gauge;

6) maximum settled pressure at 15 °C;

7) name of manufacturer and place of production of porous mass;

8) identification (trade name) of porous mass to be stamped on to the cylinder;

9) rejection criteria (maximum top clearance between mass and shell);

10) number and location of fusible plugs.

b) A description of the porous mass as it exists in the cylinder, which gives sufficient information concerning production process and quality control procedures (see annex B). The description shall include the following:

1) maximum top clearance as manufactured, which shall be consistent with periodic inspection criteria;

2) core hole size and packing material where applicable.

c) A report on the porosity determinations carried out by, or on behalf of, the manufacturer according to the method given in annex A and a statement of the maximum and minimum limits of porosity within which the porous mass will be manufactured.

5.2.3 Declaration of the manufacturer

The request for approval shall be accompanied by a declaration from the manufacturer stating that, provided type approval is granted, the production of the porous mass will be in accordance with the information given in the request for approval in 5.2.2.

5.3 Test cylinders

5.3.1 Submission of test cylinders

The manufacturer shall submit an adequate number of cylinders representative of production of that cylinder type (e.g. with regard to top clearance, etc.), including spare cylinders. These cylinders shall be complete with porous mass and all fittings, but without solvent and acetylene, unless otherwise specified by the approving organization.

5.3.2 Selection of test cylinders

Cylinders for tests shall be selected as follows:

a) for cylinders with a nominal water capacity > 60 l and $\leqslant$ 150 l, test cylinders with a capacity considered to be representative of the size under consideration shall be selected;

b) for cylinders with a nominal water capacity $\leqslant$ 60 l, tests shall be carried out on the smallest and the largest cylinders of every range proposed by the manufacturer;

c) for cylinders with a nominal water capacity < 20 l, no tests need to be carried out on cylinders having a maximum acetylene content of not more than 90 % of the equivalent proportional content used in approved cylinders of water capacity $\geqslant$ 20 l. However, in such a case the maximum acetylene content per volume (water capacity) shall not exceed 0,180 kg/l. For cylinders having a higher acetylene content, tests shall be carried out on cylinders with a nominal water capacity representative of the size under consideration.

5.4 Type approval tests

5.4.1 Approval requirements

All tested cylinders shall successfully withstand the following type tests:

a) the elevated temperature test in accordance with C.1;

b) the backfire test in accordance with C.2;

c) the impact stability test in accordance with C.3;

d) the fire test in accordance with C.4.

In case of failure in the backfire test, it shall be repeated under certain circumstances, see C.2.2.3 e) and C.2.2.4.

5.4.2 Prototype approval tests

Cylinders shall be tested as follows:

a) for a single cylinder size:

- three cylinders shall be subjected to the elevated temperature test (see C.1);
- three cylinders shall be subjected to the backfire test (see C.2);
- one cylinder shall be subjected to the impact stability test (see C.3);
- three cylinders shall be subjected to the fire test (see C.4).

b) for a range of cylinder sizes as defined in 5.2.1:

- three cylinders of the largest size shall be subjected to the elevated temperature test (see C.1);
- three cylinders of the largest and smallest size shall be subjected to the backfire test (see C.2);
- one cylinder of the largest standard production size shall be subjected to the impact stability test (see C.3);
- three cylinders with the highest acetylene/solvent ratio of each nominal diameter shall be subjected to the fire test (see C.4).

5.4.3 Extended approval tests

For cylinders containing the same porous mass and solvent for which prototype approval (see 5.4.1 and 5.4.2) has been granted, a reduced test programme may be performed:

a) For cylinders of the same size (or range of sizes) but different construction [see 5.2.1 e)] and otherwise complying with 5.2.1:

- the elevated temperature test (C.1) need not be carried out;
- three cylinders shall be subjected to the drop treatment (C.2.1), sectioned longitudinally and inspected for damage to the porous mass (e.g. for specified top clearance and cracks or disintegration). Before longitudinal sectioning, the cylinders shall be inspected for excessive top clearance.

If these inspections after the drop treatment do not show any faults, no further tests in accordance with C.2 are required. Otherwise a complete backfire treatment (C.2) on three further cylinders shall be carried out.

b) For cylinders outside the approved sizes (or range of sizes), but provided the acetylene/solvent ratio is not increased:

   — the elevated temperature test (C.1) need not be carried out;

   — three cylinders shall be subjected to the backfire test (see C.2).

In case of failure in the backfire test, it shall be repeated under certain circumstances, see C.2.2.3 e) and C.2.2.4.

The impact stability test (C.3) and the fire test (C.4) need to be carried out only if a size larger than that tested for prototype approval (5.4.2) is subjected to the extended approval tests.

6 Solvent-free acetylene cylinders

Acetylene cylinders intended for use as solvent-free acetylene cylinders shall:

a) have passed the type test procedures with acetone as solvent as described in annex C;

b) not have been previously filled with solvent;

c) comply with 4.5 for the maximum permissible settled pressure, when inserting the specified amount of acetone as determined in 6 a) and with the constants given in Table E.1 for acetone;

d) be stamped with TARE F as defined in 3.7.3 and the letters FS instead of the specified mass of solvent;

e) bear the words “solvent free” painted in a clear and visible manner.

The total weight shall be calculated from the density of acetylene at the maximum permissible settled pressure and the free volume (water capacity of the cylinder shell multiplied by the porosity) in the cylinder at 15 °C.

7 Acetylene cylinders used in bundles

7.1 General requirements

Acetylene cylinders that have been approved in accordance with the requirements of this part of ISO 3807 may be used in bundles, if authorized in the country of use, without further approval. They may be filled simultaneously provided the conditions specified in 7.2 to 7.5 are fulfilled.

7.2 Filling conditions

The bundle shall only be filled without dismantling if the total residual solvent content of the cylinders has been checked (e.g. by weighing the bundle and checking the pressure). It shall lie within the permitted safe solvent operating range, S_{so} (see annex D, Figure D.1).

The maximum number of times the bundle may be filled, before it is dismantled and the cylinders individually checked and replenished with solvent, is a function of the acetylene content and solvent operating range. It shall be determined as defined in annex D. In case of a “DMF bundle” the number of fills before the bundle is dismantled shall not exceed 100.

The maximum acetylene content per cylinder shall be reduced to approximately 90 % of the amount approved for the individual cylinder.

In practice the number of times an "acetone bundle" may be filled will generally not exceed six and will depend on the operating conditions. The number of fillings may be more or less, but in all cases the permitted solvent operating range shall not be exceeded.

NOTE In the case of a "DMF bundle", the need to dismantle the bundle to replenish the solvent will usually coincide with the periodic statutory re-inspection.

7.3 Maximum acetylene content

The maximum permissible acetylene content of the bundle, G_{bund}, is a function of the selected acetylene/solvent ratio and shall be determined as defined in annex D.

7.4 Acetylene/solvent ratio

The procedure for determining the acetylene/solvent ratio is explained in annex D. It is based on the approved data for the quantities of acetylene and solvent in an individual cylinder.

NOTE The range of acetylene and solvent content may be increased if further testing (backfire, etc.) is carried out. The results from these additional tests require the consent of the relevant authority.

7.5 Construction details

7.5.1 The bundle manifold and its support structure shall be designed in accordance with a recognized code of practice.

7.5.2 All cylinders comprising the bundle shall have the same water capacity and shape and contain the same porous mass of the same designation and the same solvent.

7.5.3 Cylinders used in bundles may have an additional quantity of solvent, which will increase the tare weight. This revised tare weight shall be shown on the cylinder by the addition of a plastic or metal ring or other suitable means. This tare weight will include any changes to the individual tare weight which might have resulted from the removal or addition of the various fixed components (caps or guards, etc.).

The original stamp marking of the tare weight (as defined in 3.7) shall not be changed.

7.5.4 Each of the cylinders within the bundle shall be fitted with a valve. These valves shall be left open during storage and shipping.

7.5.5 Fusible plugs shall not be placed in the bottom part of cylinders used in bundles.

Annex A
(normative)

Determination of porosity of the porous mass for type approval testing

A.1 Procedure

a) A cylinder filled only with the porous mass is fitted with a valve and weighed. It is subjected to the action of vacuum so that after standing for 12 h, with the valve closed, the pressure is less than 27 mbar absolute. It is then filled with acetone under a pressure not exceeding 18 bar gauge. When the solvent no longer penetrates, the valve is closed and the cylinder is weighed.

b) The cylinder is again subjected to a vacuum for at least 15 min and further acetone is added. This cycle of operations is repeated until all air is expelled from the cylinder and a constant mass obtained.

c) The cylinder is then placed in a room where the temperature is constant, the valve being left open and connected to a vessel containing acetone under a small liquid head, for at least 24 h.

d) The valve is then closed, the acetone container disconnected and the cylinder weighed.

e) The difference between the final mass of the cylinder and that of the cylinder before the introduction of the acetone represents the mass of acetone introduced.

A.2 Calculation

The porosity, P, of the porous mass is given as a percentage by the following formula:

$$P = \frac{m}{V \times \rho} \times 100$$

where

m is the mass of acetone in kilograms;

V is the actual water capacity, in litres, of the cylinder shell without porous mass;

ρ is the density of acetone, in kilograms per litre, at the temperature in A.1 c).

NOTE Alternative methods for determination of the porosity of the porous mass during batch testing are given in B.1 h).

Annex B
(normative)

Production batch test procedures for the manufacture of porous mass for acetylene cylinders

General requirements for production batch tests are given in B.1 and additional requirements for non-monolithic masses in B.2.

B.1 General requirements

The manufacturer shall establish quality control procedures, including test frequencies, for the manufacture of the porous mass, which shall include at least:

a) specifications for the raw material used;

b) procedures for the goods inwards inspection of raw materials;

c) (for monolithic masses only) procedures for testing every batch of porous mass in the condition in which it will be introduced into the cylinders;

d) (for monolithic masses only) means for recording temperature/time curves for any heat treatment (curing, drying, etc.) performed on the batch;

e) procedures for measuring and recording the top clearance between the porous mass and cylinder;

f) means for checking and/or recording all necessary masses and volumes stamp-marked on the cylinders;

g) any additional quality-relevant requirements necessary for the type of porous mass manufactured;

h) means for determination of the porosity of the porous mass by checking it either by a test described in annex A or by one of the following two batch methods:

   1) by calculation:

$$P = \frac{\rho_t - \rho_a}{\rho_t} \times 100$$

   where

   P is the porosity of the mass in %;

   ρ_t is the true density (material density) determined by taking dry mass samples from the cylinder after final preparation and measuring with a porosimeter;

   ρ_a is the apparent density determined by weighing a cylinder before and after preparation, taking into account the actual water capacity;

   or

   2) for monolithic masses only where the precision of weighing shall be better than $\pm$ 0,1 kg:

      i) select a control cylinder, making certain that the cylinder is empty and dry;

ii) weigh the empty control cylinder shell;

iii) fill the control cylinder with water, weigh and subtract the shell mass; this yields the volume of the wet mix in the control cylinder;

iv) empty the control cylinder of water making sure that the cylinder is dry;

v) fill the control cylinder with wet mix, weigh and deduct the mass of the empty shell; this is the mass of the wet mix in the control cylinder;

vi) process the control cylinder through autoclaving and drying operations together with the production cylinders;

vii) weigh the dried control cylinder, making sure that no filler is adhering to the outside surface;

viii) subtract the dry control cylinder mass (step vii) from the wet control cylinder mass (step v); this is the amount of water removed from the control cylinder;

ix) divide the volume of water removed from the control cylinder (step viii) by the volume of the control cylinder (step iii); this is the porosity of the porous mass in the control cylinder.

B.2 Non-monolithic masses

The manufacturer shall establish quality control procedures, including test frequencies, for the manufacture of the porous mass, which shall include at least means for checking excessive settlement of the mass (e.g. by the drop test described in C.2.1).

Annex C
(normative)

Procedure for type testing of acetylene cylinders

C.1 Elevated temperature test

This test shall be carried out on cylinders which have been filled with the specified mass of solvent and charged with acetylene to the maximum content as prescribed by the manufacturer, plus an overcharge of 5 % acetylene.

Each cylinder shall be placed in a heated water bath, the mean temperature of which is maintained at 65 °C ± 2 °C, until the pressure in the cylinder becomes constant or the pressure curve shows that hydraulic pressure has developed. If hydraulic pressure develops, it is evident that the test shall be interrupted.

If during this test the pressure curve indicates that hydraulic pressure has developed in the cylinder, or if the maximum pressure in the cylinder exceeds the cylinder test pressure, the cylinder has failed.

C.2 Backfire test

The backfire test comprises two steps, a drop treatment C.2.1 followed by the backfire procedure C.2.2.

C.2.1 Drop treatment

Each cylinder shall be filled with the mass of solvent specified by the manufacturer. It shall then be dropped ten times from a height of 0,70 m on to a concrete block covered with a protective plate in an apparatus similar to that shown in Figure C.1. It shall be confirmed that the friction between the cylinder and any guides is negligible.

The clearance between the top of the mass and the cylinder shall be measured both before and after the drop treatment and prior to the backfire procedure and included in the test report.

Each cylinder shall be fitted with a device that will prevent loss of cylinder contents during the drop treatment.

Any subsidence or other defect of the porous mass which has taken place during the drop treatment shall not be corrected before submitting the cylinders to the backfire procedure.

C.2.2 Backfire procedure

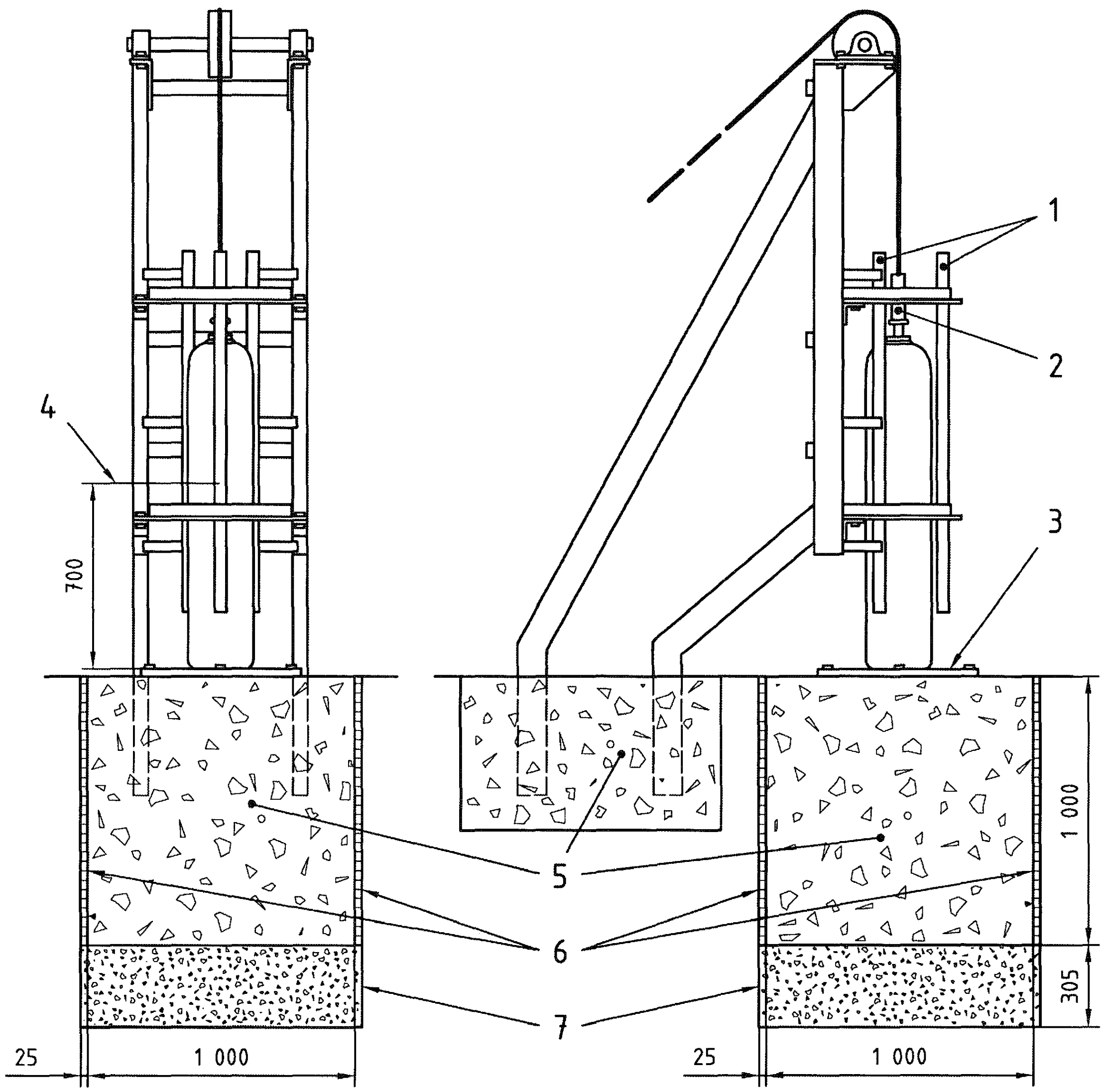
C.2.2.1 Explosion tube

For the purpose of this procedure the cylinder, after having undergone the drop treatment in C.2.1, shall be fitted with an explosion tube directly connected to the cylinder similar to that shown in Figure C.2. The capacity of the explosion tube shall be 75 ml with an internal diameter of 30 mm, terminating in a passage 4 mm in diameter and with a length of 70 mm connecting directly to the interior of the cylinder. The explosion tube shall be provided with a means of ignition, incorporating a suitable wire such as a tungsten wire 0,2 mm in diameter and 15 mm in length.

C.2.2.2 Acetylene charging

The cylinders fitted with the appropriate equipment shall be charged with acetylene to the maximum acetylene content proposed by the manufacturer plus an overcharge of 5 %, taking all necessary steps to purge the cylinder of non-soluble gases as far as is practicable.

Dimensions in millimetres



Key

1 Guides

2 Quick release system

3 Protective plate [a]

4 Height of travel

5 Concrete [b]

6 Sound proofing (optional)

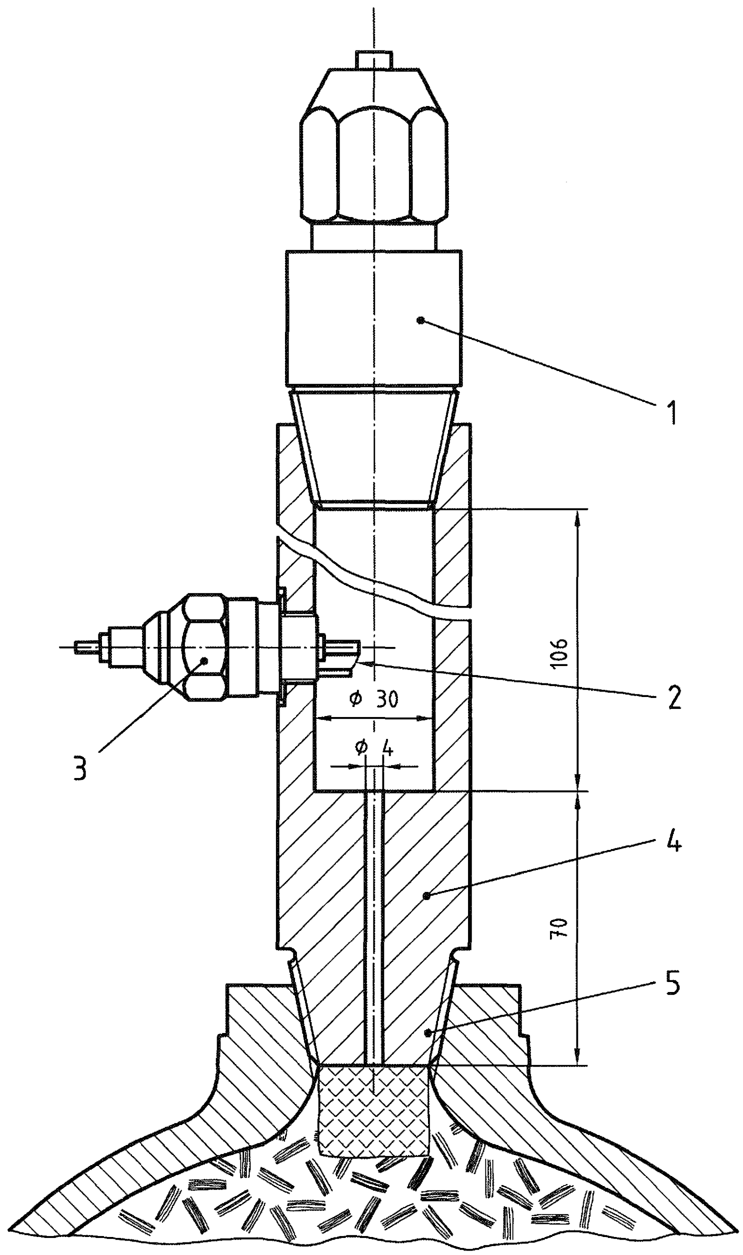
7 Sand

[a] The protective plate shall consist of 25 mm thick sheet made from material with a Brinell hardness of approx. 48 HB (10 mm ball, 300 kg load).

[b] Recommended concrete grade for the foundation is C25/30 in accordance with ISO 3893:1977. The concrete shall be cast in one piece. It is important that the surface on which the protective plate is placed be smooth and horizontal.

Figure C.1 — Typical apparatus for drop treatment

Dimensions in millimetres



Key

1 Valve enabling the test cylinder to be filled with acetylene
2 Ignition source
3 Firing device
4 Explosion tube
5 Taper part to suit valve threads in the cylinder

Figure C.2 — Typical explosion tube for backfire procedure

C.2.2.3 Test sequence

After filling, each cylinder shall be subjected to the following procedure:

a) stored horizontally for at least 3 d at a minimum temperature of 15 °C;

b) placed vertically in a water bath, maintained at a temperature of 35 °C, for at least 3 h except for cylinders $\leqslant$ 10 l nominal water capacity in which case the heating time shall be at least 1,5 h;

c) placed vertically in the firing test location before the pressure inside the cylinder has fallen to a value not more than 4 % below the maximum pressure attained in the cylinder during its heating, as described in b) above, then fired by igniting the firing device;

d) there shall be an adequate means of verifying that the required energy has been provided to initiate the acetylene decomposition in the explosion tube (e.g. by inspection of the wire after firing to ensure that it has fused);

e) if there is evidence of a fault in the test equipment or in the procedure, the test shall be repeated.

C.2.2.4 Failure criteria

The cylinder has failed the test if it bursts, if there is a significant deformation of the shell or if there is any release of gas within 24 h of the initiation of the backfire other than through the fusible plug.

If the pressure after 24 h in any one of the tested cylinders is higher than 30 bar gauge related to the temperature of 15 °C, another three cylinders shall be subjected to the complete backfire test. All three cylinders shall pass the test.

C.3 Impact stability test

C.3.1 General

This test is required only once for the initial approval of a given porous mass/solvent system for welded cylinders designed to a test pressure of at least 52 bar gauge.

One cylinder of the largest standard production size to be manufactured shall be tested.

The cylinder shall be charged with the specified solvent content and to the maximum acetylene content.

C.3.2 Test procedure

The cylinder shall be placed in a horizontal position and subjected to an impact sufficient to produce a dent (not a break) in the cylinder side wall. The depth of the dent shall be at least one fourth of the cylinder diameter. The dent shall be produced by the drop weight impact method as specified in C.3.3 or by any other suitable method that produces the same type of dent.

C.3.3 Impact by drop weight method

The cylinder to be tested shall be placed horizontally and braced to receive the impact. The weight shall be dropped from a sufficient height to impart the desired impact. The weight's impact surface shall be smooth and convex with a diameter of approximately one-third the diameter of the cylinder. The impact shall not be located in the vicinity of a weld.

At least 24 h after impact, the gas shall be released from the cylinder and the cylinder sectioned longitudinally through the dented area for examination.

C.3.4 Acceptance criteria

Measure the diameter and depth of the dent. If the depth is at least one fourth of the cylinder diameter, the test is acceptable, provided that:

— there is no progressive acetylene decomposition through the porous mass (however, evidence of decomposition immediately under the dent is acceptable);

— there is no visible crack in the shell, and the cylinder does not leak.

C.4 Fire test

C.4.1 General

Three cylinders of the largest rated capacity of each nominal diameter, but otherwise of identical design, shall be tested. The test procedure may be either the chimney fire test method (C.4.2) or the wood bonfire test method (C.4.3).

After a design has been qualified, this test shall be conducted again if there is any significant design change which includes:

a) the number, size or design of pressure-relief devices;

b) relocation of pressure-relief devices 25,4 mm (1 inch) or more from a previously tested location;

c) change in spud (or flange) of 40 % in weight or more;

d) change in top or bottom shape, e.g. from convex to concave;

e) change in type of solvent;

f) increase in the maximum acetylene content of 5 % or more.

Each cylinder shall be charged with the maximum specified solvent content and to the maximum acetylene content.

Each cylinder shall be held at a temperature of at least 18 °C for at least 18 h before testing.

The pressure and shell temperature of the cylinder immediately prior to the test shall be recorded.

C.4.2 Chimney fire test method

C.4.2.1 Test set-up

The chimney fire test is designed to simulate a building fire and rate of temperature rise therein. The burner shall be capable of delivering a flue gas temperature of approximately 650 °C within 5 min of start-up and maintaining that same gas flow rate for 15 min. After 10 min the burner shall be shut off provided that the pressure is less than 3 bar gauge.

NOTE A recommended typical chimney fire test procedure is given in CGA Pamphlet C-12-1994.

Figure C.3 shows a view of a chimney fire apparatus assembly. Note that the cylinder stands upright on a non-combustible base within an enclosure and is not subject to direct flame impingement.

A record shall be kept of the design and performance characteristics of the fire test equipment. This record shall show construction details, details of the test procedure, e.g. temperature, time, pressure, and the results of the test.

C.4.2.2 Acceptance criteria

The following criteria shall be fulfilled for the cylinder to pass the test:

a) one or more fusible plugs shall release gas during the test;

b) the cylinder shall not rupture violently.

NOTE A small split due to localized overheating from an air/acetylene flame is acceptable and not cause for test failure.

C.4.3 Wood bonfire test method

C.4.3.1 Test set-up

The basic intent of the wood bonfire test method is to provide a means of exposing cylinders in a horizontal position to a fire environment.

NOTE A recommendation for a typical test procedure is given in CGA Pamphlet C-12-1994.

The cylinder to be tested shall be placed in such a way that its entire length is in direct flame impingement long enough to cause the fusible plugs to function.

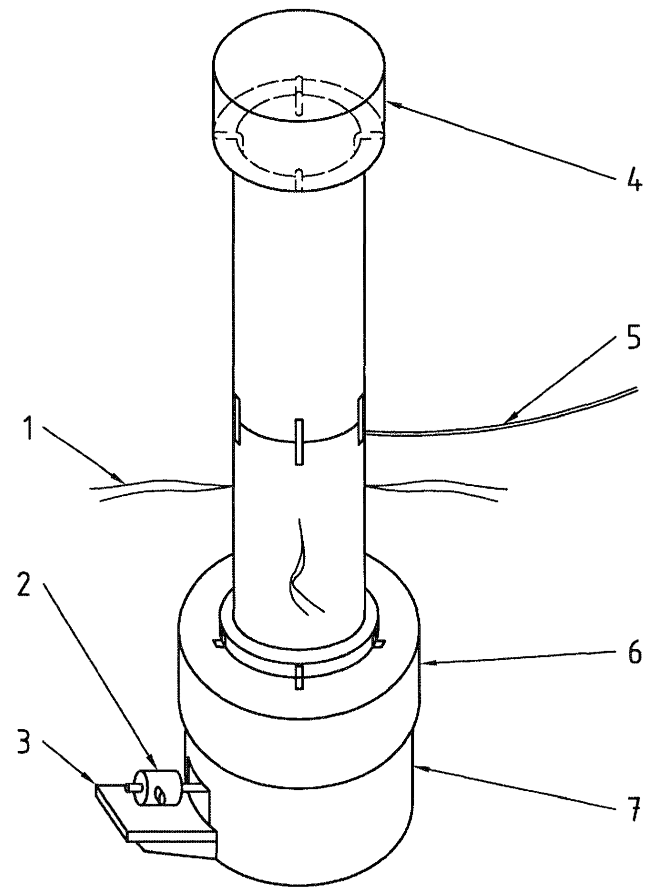
The elapsed time to completion of test and test result shall be recorded.

C.4.3.2 Acceptance criteria

For all three cylinders tested at least one fusible plug shall function within 10 min of start-up thus preventing rupture of the cylinder.

If the cylinder becomes dislodged from its test position in a manner so as to reduce its exposure to the fire, the test shall be aborted and a retest initiated with a new cylinder.

NOTE Secondary venting from locations other than the fusible plug(s) (such as plastic valve components) is not considered a failure, and retesting is not required. A localized split is not cause for test failure.



Key

1 Thermocouples
2 Burner
3 Burner support
4 Downdraught diverter
5 Pressure gauge tube
6 Draught control
7 Base

Figure C.3 — Isometric view of fire test apparatus assembly

Annex D
(normative)

Procedure for establishing permissible acetylene/solvent concentrations

D.1 Symbols

a_4, a_5 are constants for the constant volume line (see D.2);

G is the acetylene content per cylinder shell water capacity in kilograms per litre;

G_{bund} is the acetylene content per acetylene bundle water capacity in kilograms per litre;

G_{opt} is the optimum acetylene content per cylinder shell water capacity in kilograms per litre (point A in Figure D.1);

K is the reduction coefficient for acetylene content, $K = \frac{G_{opt} - G_{bund}}{G_{opt}}$;

m_{gas} is the mass of acetylene in kilograms;

m_{sol} is the mass of solvent in kilograms;

N is the number of cycles before dismantling the bundle for solvent replenishment (see D.3);

S is the solvent mass per cylinder shell water capacity in kilograms per litre;

S_{alw} is the solvent safety allowance per acetylene bundle water capacity in kilograms per litre (see D.3);

S_{cft} is the solvent cylinder filling tolerance in kilograms per litre (see D.3);

S_{loss} is the loss of solvent per cylinder shell water capacity and fill cycle in kilograms per litre (see D.3);

S_{max} is the maximum solvent content per acetylene bundle water capacity in kilograms per litre;

S_{min} is the minimum solvent content per acetylene bundle water capacity in kilograms per litre;

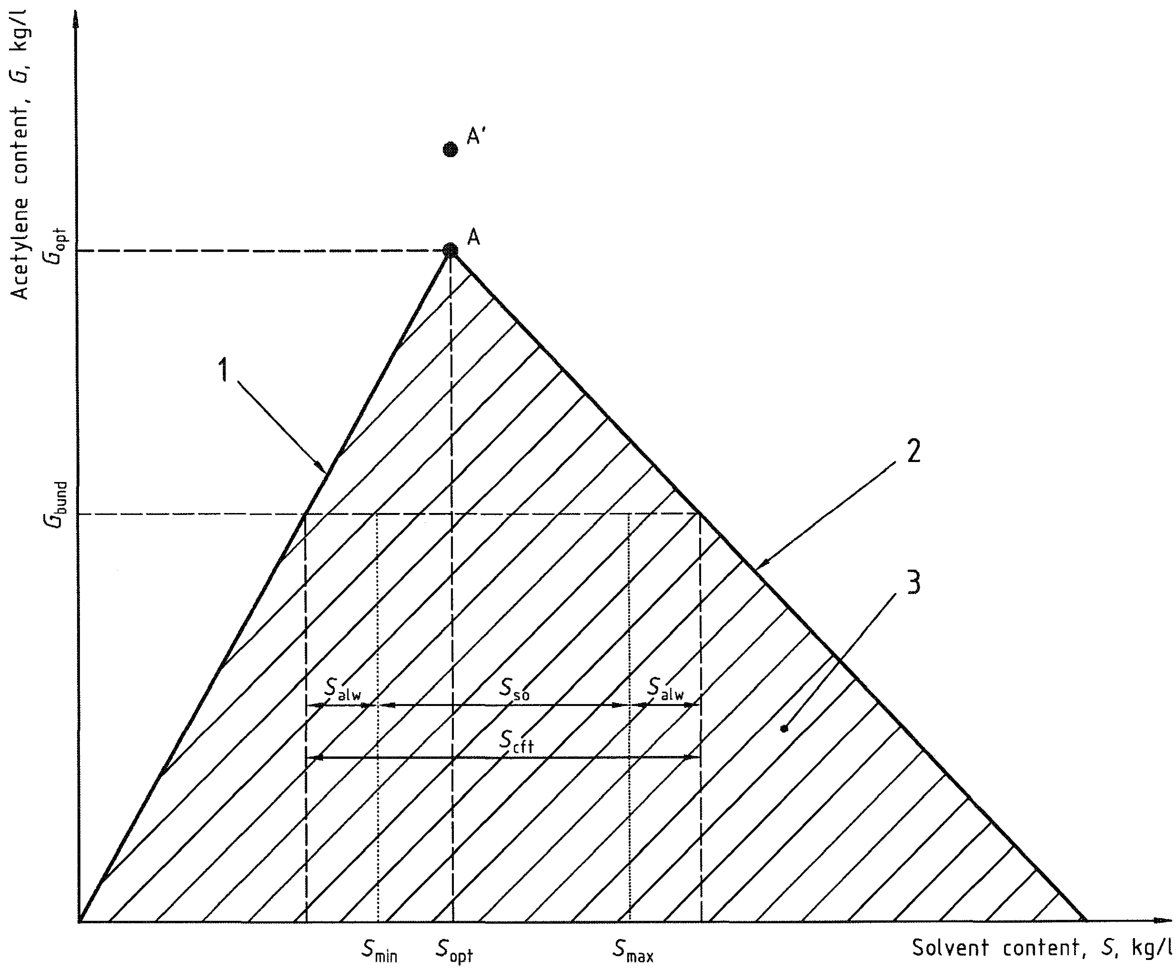
S_{opt} is the solvent content per cylinder shell water capacity in kilograms per litre at optimum acetylene content (point A in Figure D.1);

S_{so} is the solvent operating range in kilograms per litre;

V is the volume of the acetylene/solvent solution in litres;

V_A is the volume of the acetylene/solvent solution in litres at point A, see Figure D.1;

V_{wc} is the water capacity of the cylinder shell in litres.



Key

1 Backfire line — Line 1

2 Constant volume line — Line 2

3 Safe operating area (hatched)

Figure D.1 — Typical safe operating diagram for individual cylinders or bundles

D.2 The safe operating diagram

The safe operating diagram defines the maximum and minimum permissible quantities of solvent for a given quantity of acetylene. A typical diagram is shown in Figure D.1 and it is prepared from experimental data. The diagram shows the acetylene and solvent quantities divided by the cylinder shell water capacity, thus making it independent of the actual cylinder size.

Line 1 represents the backfire line. This line is assumed to be straight and to start at the origin (no acetylene and no solvent) and runs to point A, which has been established by backfire tests according to annex C and is approved by the relevant authority.

NOTE The actual test cylinders contained 5 % more acetylene — point A′ in Figure D.1.

Line 2, the constant volume line, represents points for which the volume of the acetylene/solvent solution is constant at any acetylene/solvent ratio, at a specified temperature. The line is drawn through point A, which has been established by elevated temperature tests as described above for Line 1. It represents a permissible volume of solution in the cylinder.

The volume, V, of an acetylene/solvent solution in the range of interest may be represented by a linear expression,

$$V = a_4 \times m_{\text{gas}} + a_5 \times m_{\text{sol}} \tag{D.1}$$

where a_4 and a_5 are constants, which have been determined experimentally (results vary between laboratories). The values given in Table D.1 shall be used for the diagram in Figure D.1.

Table D.1 — Volume formula constants

Constant	Solvent	
	Acetone l/kg	DMF [a] l/kg
a_4	1,91	1,75
a_5	1,25	1,05
a_4/a_5	1,53	1,67

[a] Dimethylformamide.

There is no common consensus about the values for the constants in Table D.1 and they shall not be used uncritically for any other purpose. They are considered to give a conservative value for the quotient a_4/a_5.

The equation for Line 2 is derived as follows:

Let the volume of the acetylene/solvent solution at point A be V_A and divide formula D.1 by the cylinder shell water capacity, V_{wc}. Insert expressions for the specific quantities of acetylene and solvent (mass per cylinder shell water capacity).

$$\frac{V_A}{V_{wc}} = a_4 \times G + a_5 \times S \tag{D.2}$$

in which

$$G = \frac{m_{\text{gas}}}{V_{wc}};\ S = \frac{m_{\text{sol}}}{V_{wc}} \tag{D.3}$$

Solving for G yields,

$$G = -\frac{a_5}{a_4} S + \frac{V_A}{a_4 \times V_{wc}} \tag{D.4}$$

where the last term contains constants only. As can be seen from the equation, the slope of Line 2 is – (a_5/a_4).

It follows that although point A is the optimum operating point, any complementary ratio which lies beneath Line 1 and Line 2 is safe and may be used. It is this principle which permits any cylinder to be safely filled with less than the rated amount of solvent provided that the acetylene charge is correspondingly less.

D.3 Acetylene and solvent limitations within a bundle

D.3.1 Safety considerations

When cylinders are used in bundles, the quantity of acetylene in each cylinder shall be reduced to permit the bundle to be filled without need of solvent replenishment every time. It is necessary to find the relation between the maximum quantity of acetylene permitted and the number of times a bundle may be filled and emptied (number of cycles) before it has to be dismantled and the individual cylinders checked and replenished. There are two reasons for this. First, to allow for the loss of solvent each time the cylinder is emptied, the maximum acetylene content for the individual cylinder is reduced and a solvent cylinder filling tolerance, S_{cft}, thus established. Second, there are inevitable differences between the cylinders, which may lead, over time, to uneven distribution of the solvent. An allowance, S_{alw}, shall thus be made at both ends of the solvent cylinder filling tolerance, establishing a solvent operating range, S_{so}. The equations for determining the relation between the permissible number of cycles, N, and the corresponding reduced permissible quantity of acetylene for the bundle, G_{bund}, are given in D.4.

D.3.2 Solvent loss

Each time a cylinder is emptied a small amount of gaseous solvent in equilibrium with the acetylene is lost. In general the amounts may be taken as:

acetone loss per cylinder shell water capacity and fill cycle: $S_{\text{loss}} = 7{,}50 \times 10^{-3}$ kg/l

DMF loss per cylinder shell water capacity and fill cycle: $S_{\text{loss}} = 0{,}25 \times 10^{-3}$ kg/l

D.3.3 Solvent safety allowance

An allowance shall be made for the different operating characteristics of each cylinder with regard to temperature, adsorption rate, flow distribution of the gas in the bundle and manifold, etc. This is known as solvent safety allowance, S_{alw}, and shall be included to allow for uneven solvent distribution. The values may be taken as:

for acetone per cylinder shell water capacity: $S_{\text{alw}} = 0{,}010$ kg/l

for DMF per cylinder shell water capacity: $S_{\text{alw}} = 0{,}025$ kg/l

D.4 Calculation of acetylene content of bundle and equivalent number of fill cycles

D.4.1 Relation between acetylene content reduction and number of fill cycles

To calculate the number of fill cycles for the bundle before dismantling and solvent replenishment, N, with G_{bund} given or vice versa, the following equations apply:

From Figure D.1, expressions for S_{min} and S_{max} are derived. N is then calculated, taking into account that a last cycle, bringing the bundle below S_{min}, is permitted, since the solvent loss occurs at the end of the emptying period,

$$S_{\text{min}} = S_{\text{opt}} \times \frac{G_{\text{bund}}}{G_{\text{opt}}} + S_{\text{alw}} \tag{D.5}$$

$$S_{\text{max}} = S_{\text{opt}} + \frac{a_4}{a_5}\left(G_{\text{opt}} - G_{\text{bund}}\right) - S_{\text{alw}} \tag{D.6}$$

$$N = \frac{S_{\text{max}} - S_{\text{min}}}{S_{\text{loss}}} + 1 \tag{D.7}$$

With the reduction coefficient K given, G_{bund} is easily calculated and inserted in the expressions above,

$$G_{\text{bund}} = G_{\text{opt}}\left(1 - K\right) \tag{D.8}$$

With N given, the following expression is derived from equations D.5 to D.7,

$$G_{\text{bund}} = \frac{S_{\text{opt}} + \dfrac{a_4}{a_5} G_{\text{opt}} - 2S_{\text{alw}} - S_{\text{loss}}(N-1)}{\left(\dfrac{a_4}{a_5} + \dfrac{S_{\text{opt}}}{G_{\text{opt}}}\right)} \tag{D.9}$$

Annex E
(normative)

Maximum permissible settled pressure

The settled pressure at a uniform temperature of 15 °C in a cylinder containing the maximum acetylene content and the corresponding mass of solvent shall be calculated by the following formula (rounded up to the nearest bar).

$$P_m = a_1 \times \frac{m_A / m_S + a_2}{m_A / m_S + a_3} + 1{,}7$$

where

P_m is the maximum settled pressure in bar gauge;

m_A is the maximum acetylene content in kilograms;

m_S is the specified solvent content in kilograms;

a_1, a_2, a_3 are constants with values as given in Table E.1.

Table E.1 — Pressure formula constants [a]

Constant	Solvent type	
	Acetone	DMF [b]
a_1	59,853	– 50,671
a_2	– 0,020 2	0,095 8
a_3	1,524 7	– 2,525 3

[a] The constants are taken from Miller[10].

[b] Dimethylformamide.

For other solvents the maximum permissible settled pressure has to be determined experimentally by the manufacturer.

Annex F
(normative)

Test procedures for fusible plugs used in acetylene cylinders

F.1 Measurement of yield temperature of fusible alloy

To determine the yield temperature, the following test on the alloy shall be conducted:

F.1.1 Select at random two samples of the fusible alloy from each batch (heat) in the manufactured form; ingot, wire, etc.

F.1.2 For a fusible alloy supplied in ingot form, two specimens, each 50 mm long by approximately 6 mm in diameter, shall be taken from each ingot for test purposes.

For a fusible alloy supplied in wire form, two specimens shall be taken from each coil, each between 38 mm and 50 mm in length.

F.1.3 Each test specimen shall be positioned horizontally on two knife-edges spaced apart so that the ends of the specimen overhang the knife-edges by 12 mm. The supported specimens shall be immersed in a glycerine bath positioned not closer than 6 mm to the bottom of the container.

F.1.4 Two specimens from a given ingot or coil of wire shall be tested at the same time. The bath temperature may be raised at a maximum rate of 3 °C per min up to 5 °C below the minimum yield temperature of the alloy. After the temperature has stabilized at this level, the bath temperature shall be raised at a much slower rate, not exceeding 0,6 °C per min. Temperatures shall be measured using a suitable measuring device inserted in the bath between and closely adjacent to the specimens so that the sensor will be immersed at the same level as the specimens.

F.1.5 The yield temperature shall be taken as that temperature at which the second of the four ends of the specimens loses its rigidity and droops, and/or drooping of the sections of the two specimens between knife edges occurs. After the temperature of the bath and fusible metal have stabilized, yielding must occur before the maximum allowable yield temperature (107 °C) has been exceeded.

F.2 Tests of fusible plugs

F.2.1 Sample size

Two representative samples shall be selected at random from each lot and subjected to the tests prescribed in F.2.2 and F.2.3. If both samples fail to meet the requirements of F.2.2 and F.2.3, the lot shall be rejected. If one sample fails to meet the requirements of F.2.2 and F.2.3, four additional samples may be selected for these tests. If any of these four additional samples fails to meet the requirements of F.2.2 and F.2.3, the lot shall be rejected.

A lot shall constitute not more than 3 000 units of new, or 3 000 units of reconditioned fusible plugs manufactured during one day.

F.2.2 Resistance to extrusion

Fusible plugs used for acetylene cylinders shall be tested to confirm the fusible alloy's resistance to extrusion and leaks as follows.

F.2.2.1 The fusible plugs shall be subjected to a controlled temperature of not less than 82 °C for 24 h and an air or gas gauge pressure not less than 70 % of the test pressure of the cylinder with which the device will be used. The pressure shall be applied to the end exposed to the contents of the cylinder.

F.2.2.2 To pass this test, no leakage or visible extrusion of the material shall be evident upon examination of the end exposed to atmospheric pressure.

F.2.3 Yield temperature determination

A test for determining the yield temperature of a fusible plug shall be carried out as follows.

F.2.3.1 Subject the plugs to an air or gas pressure of 0,2 bar gauge applied to the end normally exposed to the contents of the cylinder.

F.2.3.2 While subjected to this pressure, the plugs shall be immersed in a water bath or glycerine bath heated to a temperature of 95 °C maximum (3 °C below the specified minimum yield temperature) and held at that temperature for a period of at least 10 min.

F.2.3.3 The bath temperature shall then be raised at a rate not exceeding 0,6 °C per min during which the pressure may be increased to up to 35 bar gauge. When the metal weakens sufficiently to produce leakage of air or gas, the temperature of the bath shall be recorded as the yield temperature of the plugs. Yielding must occur within 10 min of the maximum allowable yield temperature of 107 °C being reached and stabilized. Yielding shall occur between 98 °C and 107 °C.

F.2.3.4 As an alternative method, after passing the portion of the test given in F.2.3.2 at a temperature of not more than 95 °C, the plugs shall at once be immersed in another bath held at the maximum yield temperature of 107 °C. If air or gas leakage occurs within 10 min at that temperature, the requirements have been met.

F.2.3.5 Variation in temperature within the liquid bath in which the plug is immersed shall be kept to a minimum by stirring while making the tests in F.2.3.2, F.2.3.3 and F.2.3.4.

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