INTERNATIONAL STANDARD

ISO 11372

Third edition
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Gas cylinders — Acetylene cylinders — Filling conditions and filling inspection

Bouteilles à gaz — Bouteilles d'acétylène — Conditions de remplissage et de contrôle au remplissage

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Foreword

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

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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 11372 was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 4, *Operational requirements for gas cylinders*.

This third edition cancels and replaces the second edition (ISO 11372:2005), with the following main technical revisions:

a) ISO 11372:2005 was revised taking into account EN 12754 and EN 1801.

b) The clauses concerning filling inspection were restructured in order to better reflect the actual proceeding of the filling inspection.

c) A new subclause 3.3 with requirements and information regarding the solvent content was added.

d) A new Clause 4 concerning the specific filling inspection of solvent-free acetylene cylinders was added.

e) A new informative Annex A introducing the Safe operating diagram was added in order to improve the understanding of the importance of correct filling conditions for acetylene cylinders.

f) A new normative Annex B outlining the calculations necessary for determination of the solvent content was added.

Introduction

This International Standard aims at the harmonization of the different operating and filling conditions of individual acetylene cylinders and covers requirements that reflect current practice and experience regarding the inspection at the time of filling.

ISO 11372 is intended to be used under a variety of national regulatory regimes but has been written so that it is suitable for the application of the UN Model Regulations[1].

Where there is any conflict between this International Standard and any applicable regulation, the regulation always takes precedence.

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”, but this practice is deprecated (see ISO 80000-4).

In this International Standard the unit bar is used, due to its universal use in the field of technical gases. It should, however, be noted that bar is not an SI unit, and that the corresponding SI unit for pressure is pascals (Pa).

Pressure values given in this International Standard are given as gauge pressure (pressure exceeding atmospheric pressure) unless noted otherwise.

Gas cylinders — Acetylene cylinders — Filling conditions and filling inspection

1 Scope

This International Standard specifies minimum requirements for the filling conditions and filling inspection of acetylene cylinders.

This International Standard is not applicable to an assembly of cylinders connected by a manifold, e.g. bundles (see ISO 13088).

2 Terms and definitions

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

2.1
acetylene cylinder
cylinder manufactured and suitable for the transport of acetylene, containing a porous material and solvent (where applicable) for acetylene, with a valve and other accessories affixed to the cylinder

NOTE 1 For solvent-free acetylene cylinders, see Clause 4.

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

2.2
cylinder shell
⟨acetylene cylinders⟩ empty cylinder manufactured and suitable for receiving and containing a porous material for use as part of an acetylene cylinder

2.3
filler
⟨gas cylinders⟩ trained person responsible for inspection prior to, during and immediately after filling

2.4
maximum acetylene content
⟨acetylene cylinders⟩ specified maximum weight of acetylene including saturation acetylene in the cylinder

2.5
maximum acetylene charge
⟨acetylene cylinders⟩ maximum acetylene content minus the saturation gas

2.6
porous material
⟨acetylene cylinders⟩ single- or multiple-component material introduced to or formed in the cylinder shell that, due to its porosity, allows the absorption of a solvent/acetylene solution

NOTE The porous material may be either:

— monolithic, consisting of a solid product obtained by reacting materials or by materials connected together with a binder, or

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

2.7
residual gas
⟨acetylene cylinders⟩ weight of acetylene including the saturation acetylene, contained in a cylinder returned for filling

2.8
saturation gas
⟨acetylene cylinders⟩ acetylene that remains dissolved in the solvent in the cylinder at atmospheric pressure (1,013 bar) and at a temperature of 15 °C

2.9
solvent
⟨acetylene cylinders⟩ liquid that is absorbed by the porous material and is capable of dissolving and releasing acetylene

NOTE The following abbreviations are used:

— "A" for acetone;

— "DMF" for dimethylformamide.

2.10
specified solvent content
⟨acetylene cylinders⟩ weight of solvent that the acetylene cylinder shall contain in accordance with the type approval

2.11
tare
⟨acetylene cylinders⟩ reference weight of the acetylene cylinder including the specified solvent content

NOTE 1 The tare is further specified in accordance with definitions 2.11.1 to 2.11.3.

NOTE 2 For cylinders with solvent, the tare is expressed by indicating either tare S or both, tare A and tare S. For solvent-free acetylene cylinders, the tare is expressed by indicating tare F. For the tare used for cylinders in bundles, see ISO 13088.

2.11.1
tare A
⟨acetylene cylinders⟩ sum of the weights of the empty cylinder shell, the porous material, the specified solvent content, the valve, the coating, where applicable, and all other parts which are permanently attached (e.g. by clamping or bolting) to the cylinder when it is presented to be filled

2.11.2
tare S
⟨acetylene cylinders⟩ tare A plus the weight of the saturation gas

2.11.3
tare F
⟨acetylene cylinders⟩ tare A minus the specified solvent content

2.12
total weight
⟨acetylene cylinders⟩ tare A plus the maximum acetylene content or tare S plus the maximum acetylene charge, respectively

NOTE 1 For solvent-free cylinders, the total weight is tare F plus the maximum acetylene content.

NOTE 2 The stamped value can be less than the approved value.

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NOTE 1 For solvent-free cylinders, the total weight is tare F plus the maximum acetylene content.

NOTE 2 The stamped value can be less than the approved value.

3.2.2 Verification of serviceable condition

It shall be established that each cylinder is in a serviceable condition before filling. It shall therefore be established that the cylinder is clean and free from foreign material, so that the cylinder can be assessed for mechanical damage that would otherwise prevent it from being filled safely, that it does not exhibit any abnormalities that could impair the safety, including arc burns, severe corrosion, heat/fire damage, or have any other significant mechanical damage.

Any fusible plug, if fitted, shall be inspected to ensure that it is in a satisfactory condition.

Cylinders that have been found to be unserviceable shall be clearly identified and segregated in accordance with the written procedures of the filling organization, and shall not be filled.

3.2.3 Verification of integrity of permanent attachments

Before filling a cylinder, it shall be established that the neck ring/threaded boss is fit for its intended use and that the neck ring, if one exists, is not loose. If there is a permanent valve guard, it shall be checked to ensure that it is in good condition and properly attached. Similarly, the integrity of the foot ring, if fitted, shall be checked for its intended use.

NOTE If a permanent valve guard is exchanged, this might affect the tare of the cylinder.

3.2.4 Verification of valve integrity and suitability

Before filling a cylinder, it shall be established that the installed valve is suitable for acetylene and is in a satisfactory condition. As a minimum, it shall be established that:

a) the valve outlet is suitable for the intended use;

b) the valve is easy to operate;

c) the valve is free from contaminants;

d) the valve operating mechanism is operable (handwheel or key operated); if the valve is suspected to be blocked, isolate and identify the acetylene cylinder and rectify the blockage in accordance with an appropriate procedure, e.g. as described in ISO 25760;

e) the fusible plug, where present, is undamaged;

f) the outlet thread and body are undamaged;

g) the filling connector attaches securely to the valve.

3.3 Solvent content

3.3.1 Determination of solvent content

Before filling an acetylene cylinder with acetylene, its actual solvent content shall be determined by measuring the pressure, temperature and weight of the cylinder in conjunction with the appropriate documentation. Calibrated weighing scales, manometers and other instruments which have a working range and measuring accuracy appropriate for the cylinder size to be filled shall be used.

Acetylene cylinders take time to reach temperature equilibrium. Special care should be taken if the temperature of the cylinder is very low and/or the pressure is very high or if the cylinder has been exposed to a significant environmental temperature change in the preceding 3 h.

Since the determination of the solvent content is not accurate for acetylene cylinders that contain high amounts of residual gas, cylinders should be emptied until a low amount of residual gas has been reached.

Typically, this would amount to a pressure of less than 7 bar for cylinders with a working pressure of 17 bar or higher and to less than 4 bar for cylinders with a working pressure below 17 bar.

Emptying of the cylinder should be carried out slowly; a typical rate would be 1/8 of the maximum acetylene content per hour. The determination of the solvent content should not be done immediately afterwards as the cylinder will cool down considerably during emptying and will need time to reach temperature equilibrium again.

Calculation of the actual solvent content in cylinders shall be in accordance with Annex B.

NOTE The result of these calculations normally is made available to the filler, e.g. in the form of a table or a chart indicating the residual acetylene content.

If the weight of the acetylene cylinder after deduction of the residual gas is below the appropriate tare stamped on the cylinder, the solvent loss shall be replenished. The type of solvent shall not be changed for a given acetylene cylinder.

The uncertainty of the method for determining the solvent loss is influenced by several factors including the accuracy of the balance and the accuracy of temperature measurement, etc. These factors should be taken into account for solvent replenishment.

If the weight of the acetylene cylinder after deduction of the residual gas exceeds the appropriate tare stamped on the cylinder, the cylinder shall be examined and the reason for the excess weight shall be determined before further handling.

3.3.2 Solvent replenishment

For solvent replenishment, it shall be checked that:

a) the valve is not blocked/obstructed and that the operation is progressing satisfactorily;

b) the valve does not leak when in the open position; if leakage is suspected, a leak check shall be performed, including around the valve gland nut. The filling process of the cylinder shall be stopped and only recommenced after the leak has been rectified.

During replenishment of solvent, it shall be ensured that the porous material is not damaged by the pressure with which the solvent is pumped into the cylinder. If no reliable information is available, it is recommended to limit the pressure to a pressure a few bar above the pressure to which cylinders are supposed to be emptied, in accordance with 3.3.1.

3.4 Inspection during filling

3.4.1 General

During the filling cycle of an acetylene cylinder, which includes the solvent-replenishment stage, the filler shall verify that:

a) the valve is not blocked/obstructed by checking that the cylinder is filled normally (e.g. by checking its surface temperature);

b) the valve and fusible plugs, where fitted, do not leak (external leak tightness). If leakage is suspected, a leak check, including around the valve gland nut, shall be performed. The filling process of the cylinder shall be stopped and only recommenced after the leak has been rectified in a safe manner.

3.4.2 Simultaneous filling of acetylene cylinders

Acetylene cylinders which are to be filled simultaneously shall have the same type of solvent if the backflow of solvent cannot be prevented by an appropriate technical device.

Special care shall be taken with cylinders having different types of porous material or high amounts of residual gas because they might have different filling properties.

3.5 Post-fill inspection

3.5.1 Verification of tightness

After filling a cylinder, the filler shall ensure that there are no leaks. Leak tests shall be carried out by using an appropriate leak-detection fluid. Checks shall be made

a) for seat leakage at the valve outlet (internal tightness),

b) at the interface between the valve and the cylinder, and

c) at the fusible plugs (if fitted) including the interface between the fusible plug and the cylinder or valve.

3.5.2 Weight and pressure checks

After the cylinder has been filled it shall be verified by weighing that the maximum acetylene content or maximum acetylene charge, respectively, is not exceeded. For example, this can be achieved, by checking that the actual measured weight does not exceed the total weight. Calibrated weighing scales that have a working range and measurement accuracy appropriate to the respective cylinder size shall be used.

NOTE There is no need to check that the pressure corresponds to the stamped working pressure for every cylinder under the following conditions:

— the total weight of the cylinder is not exceeded;

— the solvent content has been verified as being correct in accordance with 3.3.

The reason is that the acetylene-to-solvent ratio has been established during the type approval of the single cylinder. However, there might be reasons to carry out a pressure check (e.g. because the cylinder is difficult to fill). If the pressure is too high at ambient temperature and the total weight is not exceeded, it is indicative of the following possible conditions:

— deficiency of solvent;

— the solvent has become contaminated, e.g. by water;

— high concentration of other gases in the acetylene which are not soluble in the solvent used.

Conversely, too low a pressure at ambient temperature is indicative of an excessive solvent content.

3.5.3 Valve protection

It has to be checked that the valve is protected appropriately, where applicable.

NOTE Appropriate protection can be achieved by a valve protection cap or a valve guard (see ISO 11117). Alternatively, a valve can be designed to resist impacts (see ISO 10297).

4 Specific filling inspection of solvent-free acetylene cylinders

4.1 Pre-fill inspection

A cylinder intended to be used as a solvent-free acetylene cylinder shall be evacuated prior to the first filling with acetylene.

A solvent-free cylinder shall not be filled with acetylene, unless it meets the following requirements:

— it is clearly identified with the words “solvent free”, stamped with the value of tare F, in kilograms, and the letters “SF” (see ISO 13769);

— it is checked by weight that it was not previously filled with solvent;

— the appropriate requirements of Clause 3 are fulfilled;

— the working pressure is identified.

Solvent-free acetylene cylinders shall not be filled simultaneously with acetylene cylinders containing solvent.

4.2 Post-fill inspection

After filling a solvent-free acetylene cylinder, a post-fill inspection shall be carried out in accordance with 3.5.

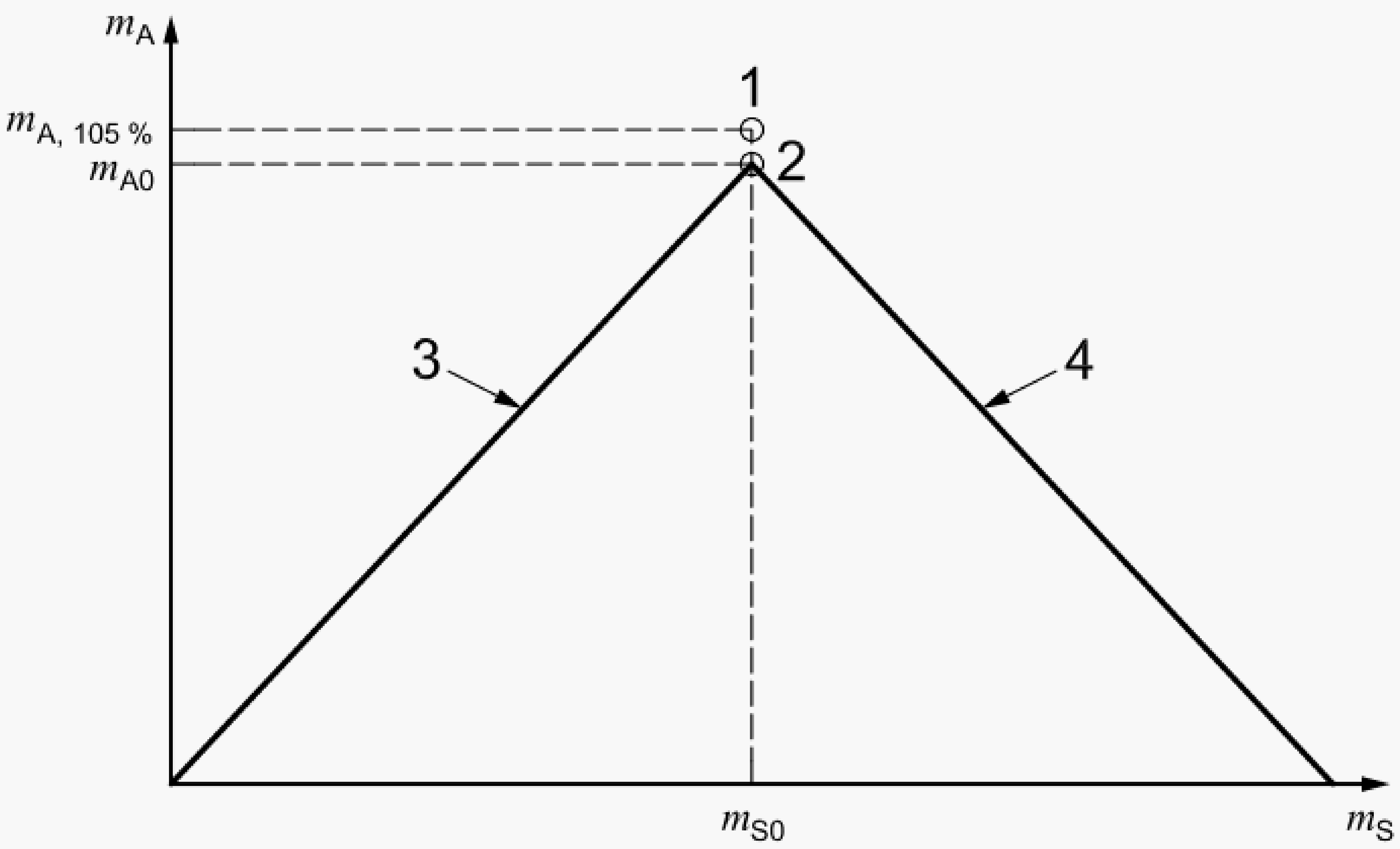
In addition, the settled pressure shall be checked after filling and shall not exceed the working pressure stamped on the cylinder.

Annex A
(informative)

Safe operating diagram

A.1 General

In the “Safe operating diagram”, the specified solvent content and the maximum acetylene content (specified by the manufacturer) are shown. A typical diagram is shown in Figure A.1.



Key

1 filling conditions for type testing of an individual cylinder

2 filling conditions of an individual cylinder

3 backfire line

4 constant-volume line

m_S solvent content (x-axis) in kg

m_A acetylene content (y-axis) in kg

$m_{A,105\ \%}$ acetylene content in the cylinder for type testing in kg

m_{A0} maximum acetylene content of individual cylinder in kg

m_{S0} specified solvent content of individual cylinder in kg

Figure A.1 — Example of Safe operating diagram

A.2 Backfire line

The “backfire line” in Figure A.1 is assumed to be straight (constant acetylene-to-solvent ratio) and starts at the origin (no acetylene and no solvent) and extends to the filling conditions of an individual cylinder which has been established to be safe by means of the elevated temperature test and the backfire test and is also approved by the relevant authority.

NOTE For the elevated temperature test and the backfire test, the test cylinders contain 5 % more acetylene.

The backfire line is given by:

$$m_A = \frac{m_{A0}}{m_{S0}} \cdot m_S \qquad \text{(A.1)}$$

Filling conditions with the same acetylene-to-solvent ratio as approved for the individual cylinder are represented by the backfire line. Therefore, the filling conditions on and below this line must also be considered as safe.

A.3 Constant-volume line

The "constant-volume line" in Figure A.1 represents the points where, at a specified temperature, the volume of the acetylene/solvent solution is a constant.

The volume V (in litres) of an acetylene/solvent solution at a given temperature is given by:

$$V = a_4 \cdot m_A + a_5 \cdot m_S \qquad \text{(A.2)}$$

where a_4 and a_5 are constants with values as given in Table A.1

The volume V_0, in litres, as given by the filling conditions for the individual cylinder, is known to be safe as it passes the elevated temperature test. It is given by:

$$V_0 = a_4 \cdot m_{A0} + a_5 \cdot m_{S0} \qquad \text{(A.3)}$$

The volume V of an acetylene/solvent solution in an acetylene cylinder shall not exceed V_0. Filling conditions with the same volume but a lower acetylene-to-solvent ratio are given by the constant-volume line. This line is obtained by equating Equations (A.2) and (A.3) above and then solving for m_A:

$$m_A = \frac{a_4 \cdot m_{A0} + a_5 \cdot m_{S0} - a_5 \cdot m_S}{a_4} \qquad \text{(A.4)}$$

$$= m_{A0} + \frac{a_5}{a_4} \cdot m_{S0} - \frac{a_5}{a_4} \cdot m_S \qquad \text{(A.5)}$$

$$= m_{A0} + \frac{a_5}{a_4} \cdot (m_{S0} - m_S) \qquad \text{(A.6)}$$

Filling conditions on the constant-volume line have the same volume but a lower acetylene-to-solvent ratio than the permissible filling conditions for individual cylinders. Therefore, the filling conditions on and below this line must also be considered as safe.

The constants a_4 and a_5 have been determined experimentally for a temperature of 15 °C and the values given in Table A.1 shall be used.

Table A.1 — Values for a_4 and a_5

	Acetone	DMF
a_4 in l/kg	1,91	1,75
a_5 in l/kg	1,25	1,05
a_4/a_5	1,53	1,67

A.4 Recommendations for filling acetylene cylinders

It follows that the filling conditions for acetylene cylinders with m_{A0} and m_{S0} are the optimum operating point and any filling ratio that lies beneath the backfire line and the constant-volume line is safe and may be used. When filling acetylene cylinders, the uncertainty of measuring the pressure, temperature and weight (before and after filling) of the cylinder should be taken into account so that the cylinder is not overfilled. (i.e. too much acetylene or incorrect acetylene-to-solvent filling ratio).

Annex B
(normative)

Determination of the solvent content in acetylene cylinders

The determination of the actual solvent content in acetylene cylinders returned for filling, containing either acetone or DMF as the solvent, is achieved by measuring the pressure, temperature and weight of the cylinder and carrying out a subsequent calculation as described below. The result of the calculation normally is made available to the filler, e.g. in the form of a table or a chart indicating the residual acetylene content.

Measurement of the weight of the acetylene cylinder alone will only give the sum of the weights of the solvent and acetylene in the cylinder but will not indicate the shortfall or excess of its solvent and acetylene content.

The actual acetylene-to-solvent ratio in the cylinder shall be determined using the following equation:

$$F = \frac{m_A}{m_S} = \frac{10^{f(p,T)}}{1 - 10^{f(p,T)}} \quad \text{(B.1)}$$

where

F is the actual acetylene-to-solvent ratio;

m_A is the residual acetylene content, in kilograms;

m_S is the actual solvent content, in kilograms;

$f(p,T)$ is a factor dependent upon pressure, temperature and solvent

Since the solubility of acetylene in acetone and DMF is different, there are two different equations for the calculation of $f(p,T)$.

For acetone, $f(p,T)$ is determined by the following equation:

$$f(p,T) = \frac{\log_{10}(p + 1{,}013) - 4{,}194\,5 + \dfrac{712{,}88}{T + 273{,}15}}{0{,}456\,9 + \dfrac{207{,}8}{T + 273{,}15}} \quad \text{(B.2)}$$

For DMF, $f(p,T)$ is determined by the following equation:

$$f(p,T) = \frac{\log_{10}(p + 1{,}013) - 3{,}630 + \dfrac{504{,}36}{T + 273{,}15}}{-0{,}982\,6 + \dfrac{695{,}8}{T + 273{,}15}} \quad \text{(B.3)}$$

where

p is the actual pressure in the cylinder, in bar;

T is the temperature of the cylinder, in degrees Celsius.

Based on the calculated actual acetylene-to-solvent ratio F in the cylinder [see Equation (B.1)], the solvent content actually contained in the acetylene cylinder is calculated as follows:

— Equation to be used for cylinders on which tare S is stamped:

$$m_{S} = \frac{m_{c} - \text{tare}_{S} + m_{S0} + m_{A,\text{saturation}}}{1 + F} \quad \text{(B.4)}$$

— Equation to be used for cylinders on which tare A is stamped:

$$m_{S} = \frac{m_{c} - \text{tare}_{A} + m_{S0}}{1 + F} \quad \text{(B.5)}$$

where

m_{c} is the actual weight of the cylinder, in kilograms;

tare_{A}, tare_{S} is the tare as stamped on the cylinder, in kilograms;

m_{S0} is the specified solvent content in the cylinder (according to the approval), in kilograms;

m_{S} is the actual solvent content in the cylinder, in kilograms;

m_{A} is the residual acetylene content in the cylinder, in kilograms;

$m_{A,\text{saturation}}$ is the saturation acetylene, in kilograms.

NOTE Equations (B.4) and (B.5) are derived as follows.

The actual weight of the cylinder, as measured before filling, can be expressed as follows (depending on whether tare S or tare A is used):

$$m_{c} = \text{tare}_{S} - m_{A,\text{saturation}} - m_{S0} + m_{S} + m_{A} \quad \text{(B.6)}$$

$$m_{c} = \text{tare}_{A} - m_{S0} + m_{S} + m_{A} \quad \text{(B.7)}$$

Considering the actual acetylene-to-solvent ratio F in the cylinder, as calculated according to Equation (B.1) and solving for m_{S}, leads to Equations (B.4) and (B.5) which are used for calculating the actual solvent content contained in the cylinder.

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