SAFE FILLING OF ACETYLENE CYLINDERS, BUNDLES AND BATTERY VEHICLES

Doc 26/25

Revision of Doc 26/21

EUROPEAN INDUSTRIAL GASES ASSOCIATION AISBL

AVENUE DE L'ASTRONOMIE 30 • B – 1210 BRUSSELS

Tel: +32 2 217 70 98

E-mail: info@eiga.eu • Internet: www.eiga.eu

Doc 26/25

SAFE FILLING OF ACETYLENE CYLINDERS, BUNDLES AND BATTERY VEHICLES

Prepared by WG-12 Acetylene
Published in February 2025

EUROPEAN INDUSTRIAL GASES ASSOCIATION AISBL
Avenue de l'Astronomie 30 B 1210 Brussels Tel +32 2 217 70 98
E-mail: info@eiga.eu Internet: www.eiga.eu

Table of Contents

Amendments to Document 26/21

This document has been completely rewritten.
The latest version of this document from 2021 was titled ‘Permissible Charge / Filling Conditions for Acetylene Cylinders, Bundles, Battery Vehicles’. It was covering the theoretical aspects for filling. In this new version the scope has been extended to include operational aspects for filling.

Section	Change
4	‘Ownership and responsibility for safe filling’ has been added
5	‘Scales for acetylene packages’ has been added
6	‘Pre-fill inspection’ has been moved forward in the document
7	‘Solvent replenishment/Weigh-in’ has been moved forward in the document

1 Introduction

This document has been prepared by the European Industrial Gases Association (EIGA) to give guidance on the safe filling of acetylene cylinders, bundles and battery vehicles.

The previous publication of this document covered the theoretical aspects of permissible charge. In this new version the scope has been extended to include operational aspects for filling.

2 Scope and purpose

2.1 Scope

The scope covers single cylinders, bundles and battery vehicles containing different porous materials and different solvents.

As constant rate filling of cylinders is much more common than constant pressure filling the description of the filling process and requirements in this document is generally applicable to and intended for constant rate filling.

2.2 Purpose

This document provides guidance on safe filling practices.

3 Definitions and symbols

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May and Need not

Indicate that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 Acetylene bundle

Transportable unit consisting of two cylinders up to usually not more than 16 cylinders permanently manifolded together and contained within a rigid frame equipped with all necessary equipment for filling and use.

The following notes are directed to constructors of bundles and are required for safe filling:

- Cylinders need to have the same dimensions
- Cylinders need to have the same water capacity
- Cylinders need to contain the same porous material and the same porous material type approval for use in bundles
- Cylinders need to contain the same solvent
- Cylinders need to have the same working pressure.

3.2.2 Acetylene cylinder

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

3.2.3 Acetylene battery vehicle type A

Vehicle where cylinders or bundles are removed from the vehicle for the purpose of filling individually.

3.2.4 Acetylene battery vehicle type B

Vehicle where cylinders or bundles are filled and emptied at prescribed number of times without removal from the vehicle.

3.2.5 Constant pressure filling

(alternative names are Individual Scale Filling, Simpleo Filling, Fast Filling)

A single cylinder is placed on a filling scale and connected to a filling point. Acetylene is supplied to the filling point at a constant high pressure. This allows high fill rate initially. The filling rate slows down as the pressure in the cylinder increases. The weight of the cylinder is constantly monitored. Some systems monitor the gas mass-flow into the cylinder, rather than the cylinder weight. During this process, solvent may also be added to the cylinder at various stages of the cycle. When the cylinder contains the correct amount of gas, the acetylene supply is stopped.

Filling times can be as short as 40 minutes for a single cylinder.

3.2.6 Constant rate filling

(alternative names are Manifold Filling, Rack Filling, Conventional Filling, Parallel Filling)

A number of cylinders are connected to a common manifold (or rack) and filled at the same time from the same source. The filling rack is usually supplied with a constant flow of acetylene. Cylinders are filled by pressure allowing the gas to dissolve into the solvent over time. During the filling cycle, sample cylinders are removed from the manifold and weighed to check the mass of acetylene in the cylinders. When the correct weight is achieved, all the cylinders are disconnected from the rack, and individually checked for the weight of gas in each cylinder.

Filling times are typically between 4 hours and 20 hours for a rack of cylinders – restricted by the absorption rate of acetylene into the solvent slowing down as the solvent warms up during the fill.

3.2.7 Porous material

Single or multi component material introduced or formed in the cylinder shell filling the entire cylinder volume and that, due to its porosity, allows the absorption of the solvent/acetylene solution.

3.2.8 Saturation gas

The amount of acetylene required to saturate the solvent at atmospheric pressure and 15°C.

3.2.9 Solvent replenishment

Procedure for filling solvent into an acetylene cylinder up to the specified solvent content.

3.3 Symbols

3.3.1 a_1

Specific increase in volume of solvent due to dissolving acetylene in l/kg

3.3.2 a_2

Specific volume of the pure solvent in l/kg

3.3.3 L Solvent loss

The amount of solvent loss from an acetylene cylinder per filling and emptying cycle in kg/l

3.3.4 m_{A0} Maximum acetylene content

Maximum permissible mass of acetylene including saturation gas in the cylinder in kg

3.3.5 m_A Acetylene content

Actual mass of acetylene including saturation gas in the cylinder in kg

3.3.6 m'_A Acetylene filling ratio

Acetylene content per litre of cylinder water capacity in kg/l

3.3.7 m_{S0} Specified solvent content

Specified mass of solvent in the cylinder necessary for the specified maximum acetylene content in kg

3.3.8 m_S Solvent content

Actual mass of solvent in the cylinder in kg

3.3.9 m'_S Solvent filling ratio

Solvent content per litre of cylinder water capacity in kg/l

3.3.10 N Number of bundle or battery vehicle fillings

Maximum number of consecutive fillings of an acetylene cylinder bundle (battery vehicle type B) without disassembly

3.3.11 P Porosity

Porosity of the porous material in % determined according to EN ISO 3807, *Gas cylinders – Acetylene cylinders – Basic requirements and type testing* [1].

3.3.12 S_{min} Minimum solvent filling ratio

Minimum solvent filling ratio in an acetylene cylinder within a bundle in kg/l

3.3.13 S_{max} Maximum solvent filling ratio

Maximum solvent content in an acetylene cylinder within a bundle in kg/l

3.3.14 *t* Solvent safety margin

Solvent safety margin for bundle filling conditions in kg/l

3.3.15 V_a Available volume

Volume in the cylinder which is not occupied by porous material and can hold solvent and acetylene in l

3.3.16 V_A Volume increase

Increase of the volume of the solvent due to dissolving acetylene in l

3.3.17 V_F Free volume

Volume of free space in the cylinder in l

3.3.18 V_S Volume of the solvent

Volume of the solvent in the cylinder in l

3.3.19 V_w Water capacity

Water capacity of the empty cylinder shell in l

4 Ownership and responsibility for safe filling

Where the ownership of the cylinder is established the approval of the owner shall be obtained before filling. Cylinder owners may request that their authorization be obtained prior to their cylinders being filled. Hence, cylinder owners may refuse the permission to fill their cylinders.

The filler shall take responsibility for establishing the suitability of the cylinder before filling.

5 Scales for acetylene packages

Scales shall be selected with a range suitable for the type of cylinder to be replenished and to maintain safe filling conditions.

For example, a scale should not be the same for a small cylinder type (5 litres) as for a large one (50 litres).

Small Cylinder volume =< 6l	Medium Cylinder volume >6 and =<20l	Large Cylinder volume >20l	Bundles
Scale division 20g	Scale division 50g	Scale division 100g	Scale division 1kg

Scales shall be checked daily before use with standard calibration weights. This may be a cylinder whose weight is known. It is not mandatory, but good practice to record this daily check. Additionally, the scales should be calibrated annually by a person qualified to check for accuracy.

If the scale division is greater than above, then the filling ratio shall be reduced to compensate for the increase in scale division.

For battery vehicles type B an assessment of the required accuracy of the scale shall be completed to ensure the trailer will not be overfilled.

6 Pre-fill Inspection

Acetylene cylinders need pre-fill inspection to ensure they are:

- Physically in a condition that is safe for filling, and
- Comply with the legal requirements for filling

6.1 Pre-fill inspection for single acetylene cylinders

The cylinders are visually inspected according to EN ISO 11372, *Gas cylinders – Acetylene cylinders – Filling conditions and filling inspection* before they are considered for solvent replenishment or filling. [2]

Filling plant procedures shall include examples of cylinders that are not fit for service. These cylinders shall be quarantined for further investigation.

The following are examples of cylinders that shall not be directly replenished with solvent or filled with acetylene.

- Cylinders which cannot be clearly identified as being dissolved acetylene cylinders;
- Cylinders with evidence of the cylinder having been immersed in a liquid, e.g. water, oil;
- Cylinders having accumulated material in the cylinder base or foot-ring that may affect the cylinder weight (concrete, bitumen, mud, epoxy etc.);
- Cylinders with a loss of solvent of more than 10% of the nominal solvent quantity. See also 7.1.3.

  NOTE Site operations may find that it is easier for operators to understand this rule (10%) if it is expressed as follows:

  a) a maximum kg of solvent by cylinder type.

  b) a maximum kg of solvent per litre volume of the cylinder.

- Cylinders with a sign of decomposition (soot in the valve outlet, paint damage by heat, …)
- Cylinders returned from customers with open valves or without residual pressure; In this case, see 7.1
- Withdrawn cylinders (where filling is no longer authorised)
- Unknown design types, not familiar to the plant personnel
- Cylinders suspected of base corrosion. Refer to EIGA Safety Information SI42, *Acetylene Cylinder Base Corrosion* [3]

More detail on cylinder defects can be found in Doc 26.1, Acetylene Cylinder Pre-fill Checks. [4]

6.2 Pre-fill Inspection of acetylene bundles

Prefill inspection shall be done according to EN ISO 13088, *Gas cylinders - Acetylene Cylinder Bundles – Filling conditions and filling inspection*. [5]

Bundles with defects shall be quarantined for maintenance.

6.2.1 Documentation at time of pre-fill

Some countries have local requirements for bundle documentation. Where required, plants shall follow their local requirements.

Records (also known as "bundle file", "bundle pass", "filling list", etc.) shall be retained for every bundle. The records shall include details of the complete design and filling data. The records shall be retained by the owner or at the filling plant. The records may be held electronically on a database.

The following data shall be available for the bundle:

- The number of consecutive fillings since the last replenishment of solvent.
- The serial numbers of all cylinders manifolded in the bundle.

If the bundle file is not available or incomplete, the bundle shall not be filled until the bundle file or the missing data is obtained.

6.2.2 Check marking with documentation

In addition to the information on single cylinders in accordance with the relevant marking regulations of the countries of use (see ISO 13769, *Gas cylinders — Stamp marking*), the relevant manufacturing, operational and certification data for bundles shall be clearly identified on a corrosion-resistant plate permanently fixed on the outside of the bundle [6]. For information see EN ISO 10961, *Gas cylinders - Cylinder bundles - Design, manufacture, testing and inspection. [7]*

The identification data on the bundle identification plate and in the bundle file shall match.

NOTE If there are any changes on a bundle during its lifetime (e.g. use of different valves with different weight, exchanging cylinders of the bundle cylinder set with different tare weights), the bundle identification plate needs to be replaced with the modified data. It needs to be stamped by the competent authority. The bundle records need to be updated.

6.3 Pre-fill Inspection of acetylene battery vehicles

The requirements for pre-fill inspection for battery vehicles can be found in EN 13720, *Transportable gas cylinders – Filling conditions for acetylene battery vehicles* [8]

7 Solvent Replenishment / Weigh-In

During use, an acetylene cylinder will lose some of its solvent for the following reasons:

- *The solvent's volatility*. Some solvent loss is normal. For acetone, in a country with a temperate climate, the average loss rate is approximately 60 g/kg of acetylene used. In the warm climate, the loss rate can increase to 100 g/kg of acetylene used.

  The volatility of acetone is greater than that of Dimethylformamide (DMF). Acetone is generally used for single cylinders and DMF is used for cylinders in bundles and battery-vehicles.

  However, in some cases, single cylinders may also use DMF for certain applications and acetone may be used for bundles (either for specific applications or where National Regulations forbid the use of DMF).

- *The so-called "spitting" phenomena.* Spitting occurs when solvent is expelled in liquid form when gas is withdrawn from the cylinder during use. Solvent spitting is not a normal phenomenon. It can be caused by an excessive withdrawal rate during use, defects in the porous material or excess solvent in the cylinder. If spitting occurs the solvent loss may be significantly greater than 100g/kg of acetylene used.

All acetylene cylinders are designed and approved for a specified charge of acetylene; the quantity of gas is determined in relation to a nominal quantity of solvent. Complying with the approved ratio for the quantity of gas/nominal quantity of solvent is one of the conditions for the safe operation of the cylinder.

Excess solvent can result in a hydraulically full cylinder that, when subjected to a temperature increase, can develop extremely high internal pressures. An insufficient quantity of solvent will result in the cylinder becoming less resistant against decomposition due to flashback.

Solvent replenishing of acetylene cylinders is essential. This operation shall therefore be systematically carried out with care, before refilling cylinders with gas.

Each type of cylinder has a stamped tare weight (refer to 3 for tare weight definitions).

Prior to filling cylinders with acetylene, checks shall be made to ensure that the amount of solvent is within specified parameters, by comparing the weight of the cylinder returned by the customer with the tare weight marked on the cylinder (see 6.1)

Exceeding the gas or solvent tolerances can pose a safety risk to fillers and/or users of the cylinders

- Extra solvent, and/or extra gas raises the risk of a cylinder hydraulic rupture if the cylinder warms up significantly. The worst-case scenario is where there are both extra solvent, and extra gas in the cylinder.

- Too little solvent with the correct amount of gas increases the gas/solvent ratio, increases filling pressures, and reduces the cylinder resistance to a flashback or decomposition. This also results in the cylinder settled pressure being higher than normal.

- Less solvent with the weight shortage made up with acetylene significantly raises the gas/solvent ratio.

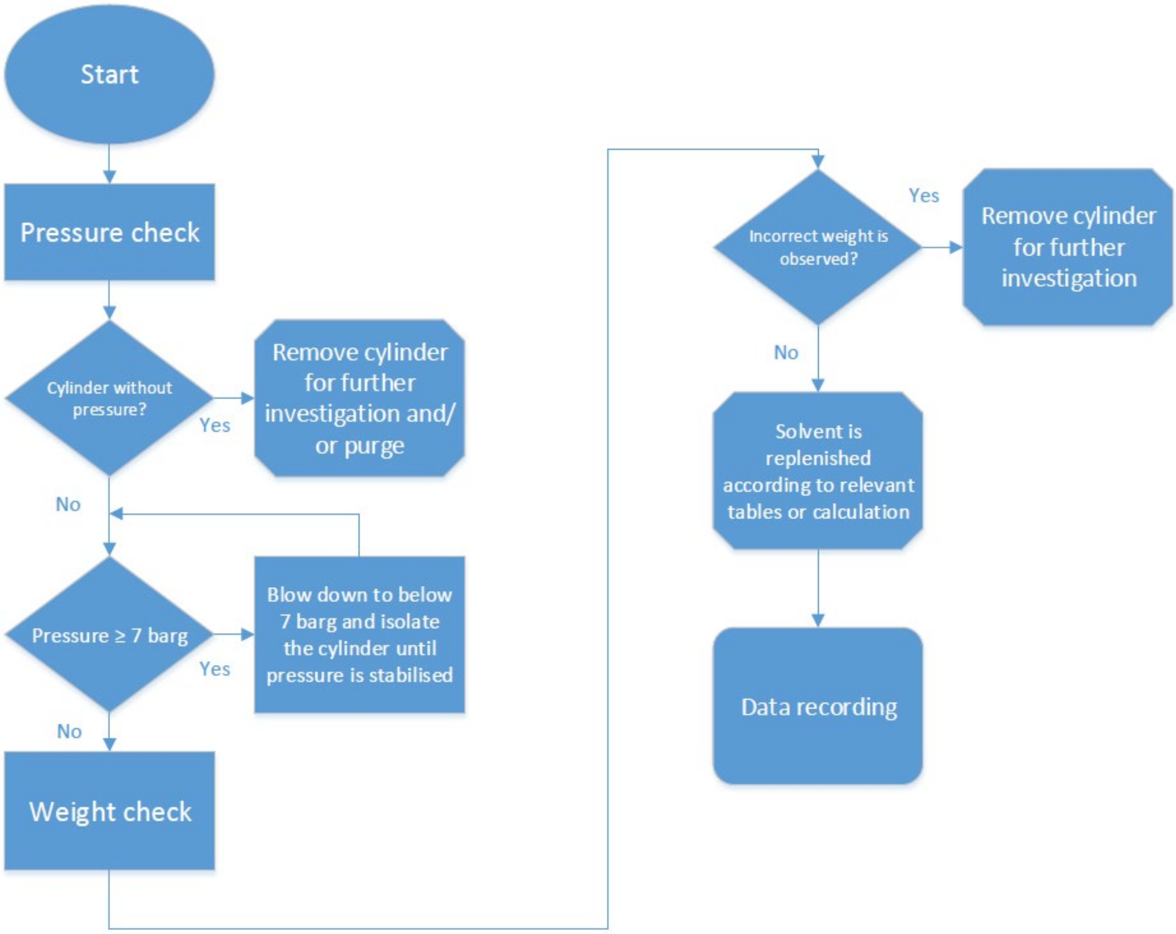
- Excess solvent can result in solvent spitting from the cylinder during use, potentially creating dangerous conditions for the user.

7.1 Replenishment Principles

Before filling an acetylene cylinder, the weight of the solvent and acetylene present in the cylinder shall be determined with weight, pressure and temperature checks. This information can be presented in several forms for each cylinder size and type such as tables, diagrams or computer programmes.

The formulae in EN ISO 11372 (cylinders) and EN ISO 13088 (bundles) may be used to determine residual gas content in relation to temperature and pressure [2,5].

An alternative to undertaking a calculation of residual acetylene content is to vent the cylinder till atmospheric pressure and then replenish the solvent and fill with acetylene.



7.1.1 Cylinders with high residual pressure

Vent the cylinders below the pressure required for calculating residual acetylene

For more information on venting, see EIGA Doc 257, *Safe Blow-down of Acetylene Cylinders and Bundles*. [9]

NOTE A cylinder returned by a customer with a residual gas pressure greater than 7 barg AND at least 80% of its maximum acetylene content by weight may be filled directly (in this case it is assumed that the cylinder is not defective and that no solvent was lost).
In some countries or companies the product specification defines that cylinders are being filled under their maximum acetylene content. In this case the 80% applies to the defined filled acetylene content by weight.

7.1.2 Cylinders without residual gas

A cylinder returned by a customer without residual gas shall be treated with care. These cylinders may contain air, which shall be removed before final acetylene filling.

The cylinder shall not be replenished immediately if:

- It is returned to the plant with its valve open or without residual pressure

In this case, cylinders shall undergo:

- A visual check for leaks (for base corrosion refer to SI42 [3])
- Pre-fill with acetylene to a pressure between 4 and 5 barg.

- Vent to the atmosphere to remove possible contaminants. Keep a minimum positive pressure in the cylinders (typically below 1 barg). Cylinders that will be emptied to atmosphere shall be connected to a specific manifold venting to a safe area.
- Pre-fill check including solvent replenishment and then filling with acetylene on normal fill process.

7.1.3 Special case – abnormal solvent loss

The cylinder shall not be replenished immediately if:

- There is a loss of solvent of more than 10% of the nominal solvent quantity.

In this case, cylinders shall undergo:

- A visual check for leaks (for base corrosion refer to SI42 [3])
- Pre-fill check including solvent replenishment and then filling with acetylene on normal fill process.

7.1.4 Special case – excess weight

If there is an apparent excess of solvent in the cylinder, it shall not be filled with acetylene. This can be determined if the excess tare is more than the division of the scale – see par 5 for scale requirements.

This excess weight indicates either excess solvent in the cylinder, and/or the presence of another liquid (for example water, oil or another solvent such as DMF). This will require the reason for the excess weight of the cylinder to be investigated.

If the cause of the excess weight cannot be corrected in a controlled manner, dispose of the cylinder (see EIGA Doc 05, *Guidelines for the Management of Waste Acetylene Cylinders* [10]).

7.2 Replenishment Procedure

7.2.1 Single acetylene cylinders

After performing the pre-fill inspection, prior to replenishing with solvent and segregating cylinders that shall not be directly replenished, the following procedure should be observed:

- It is normally assumed that the cylinder's temperature is the same as the ambient temperature. However, if cylinders have been stored at high or very low temperatures, it is recommended that they be kept in the area where they will be replenished for sufficient time for the temperature of the cylinder and ambient area to equalise.

- Determine the amount of residual gas remaining in the cylinder considering the pressure and temperature of the gas. (see EN ISO 11372 [52]).

- Subtract the weight of acetylene remaining in the cylinder from the measured total weight of the cylinder.

- The result shall be subtracted from the stamped tare weight and the difference will be either:

    - Zero: the cylinder contains the correct amount of solvent

    - Positive (tare weight greater than result): it lacks solvent.

    - Negative (tare weight less than result): this means that there is either excess solvent, or there is another liquid in the cylinder.

NOTE The cylinder design assumes a specific amount of solvent within the cylinder. This is to ensure that the cylinder is neither at risk of rupture, nor does it exceed the gas/solvent ratio. Acetylene cylinders with either a shortage or an excess of solvent outside the cylinder design parameters shall not be filled.

Generally, cylinders are less tolerant of excessive solvent than solvent shortage; excess solvent in a cylinder can result in the bulging or rupture of an acetylene cylinder on the plant, while being transported or used.

- Add solvent, if necessary. If the manufacturer of the porous material has determined a maximum replenishing pressure, this shall be followed.

NOTE If the amount of solvent to be added is abnormally high then a period of time for homogenisation should be allowed.
NOTE Care should be taken when adding the solvent to not damage the porous material.

- Weigh the cylinder again to check that the tare was correctly re-established.

NOTE For cylinders equipped with a fixed valve protection device, e.g. guard or shroud, this shall not be removed before replenishing if it is considered part of the tare weight.
NOTE When single cylinders are placed into bundles the weights of guards and caps needs to be factored into the calculation of the bundles stamped weights. Different countries and regions have different approaches to the inclusion or exclusion of removable items like guards so special care must be taken when bundles are assembled using cylinders from other regions

NOTE Acetylene cylinders manufactured to

- U.S. Department of Transportation (DOT) Specifications 8 and 8AL found in Title 49 of the *U.S. Code of Federal Regulations (49 CFR)* 178.59 and 178.60 and used per 49 CFR 173.303 as well as older specifications cylinders ICC-8, ICC-8AL, DOT E-6517, DOT E-7542, or DOT E-10320 [11];
  or
- Specifications TC 8WM and 8WAM found in Canadian Standards Association (CSA) B339, C*ylinders, spheres, tubes for the Transportation of Dangerous Goods*, and used in accordance with *Transportation of Dangerous Goods Regulation*s of Transport Canada (TC) found in CSA B340, *Selection and use of Cylinders, Spheres, Tubes, and Other Containers for the Transportation of Dangerous Goods, Class 2*, as well as older specifications cylinders CTC-8, CTC-8AL, or CTC-8WC [12, 13]

shall be replenished according to CGA G-1.9 Recommended Practices for Maintaining the proper Solvent Level in Acetylene Cylinders [14]

7.2.2 Acetylene bundles

Individual cylinder valves of the bundle cylinders shall be checked to confirm if they are in open position.

Using the identification data/bundle file, the number of cycles the bundle has been filled since the last solvent replenishment should be verified.

When the calculated solvent content is out of the range [Smin,Smax] of the specified solvent content, the bundle shall not be refilled with acetylene until it has been dismantled and each single acetylene cylinder has been replenished with solvent.

The fill cycle that a bundle with acetone as solvent may be filled is generally maximum six consecutive fillings and will depend on the operating conditions. The number of fillings may be less, but in all cases the specified solvent content shall be in the range [Smin/Smax].

In a bundle with DMF as solvent, the need to dismantle the bundle to replenish the solvent will usually coincide with the periodic inspection of the cylinders for this bundle. The number of maximum consecutive fillings before the bundle is dismantled shall be in line with the requirements of the type approval.

Before filling a bundle, the solvent content shall be determined by calculating the residual gas from:

- Pressure
- Temperature
- Weight, and
- Using the appropriate documentation

Calculation to determine if solvent replenishment is required:

Inbound Weight - Residual Gas Weight = Weight Without Gas

If Weight Without Gas < TARE BAmin (or TARE BSmin if applicable) => Not Fillable

If Weight Without Gas > TARE BAmin and < TARE BAmax (or TARE BSmin and TARE BSmax if applicable) => Fillable

When the maximum number of consecutive fillings has been reached, or the weight of the acetylene bundle after deduction of residual gas is below TARE BAmin or TARE BSmin (which is stamped on the bundle identification plate) the bundle shall not be refilled with acetylene until the solvent has been replenished.

The replenishing of cylinders mounted in bundles requires a procedure different to that described for single cylinders. It is not possible to ensure the correct replenishment of the solvent for each cylinder; therefore, the bundles shall not be collectively replenished but shall be dismantled prior to replenishing the single cylinders with solvent. To avoid too frequent dismantling, a solvent tolerance is applied by reducing the acetylene charge. Further information is given in EN ISO 13088.[5]

Calibrated weighing scales, pressure gauges and other instruments which have a working range and measuring accuracy applicable to the bundle being filled shall be used.

NOTE Acetylene cylinders need time to reach temperature equilibrium.

7.2.3 Acetylene battery vehicles

The requirements for solvent replenishment of battery vehicles can be found in EN 13720. [8]

8 Safe Filling Requirements / Parameters

8.1 Available acetylene cylinder volume

The internal space of acetylene cylinders is completely filled with a porous material (normally except for a core hole under the cylinder valve). The function of the porous material is to distribute the solvent evenly within the cylinder and to stop the propagation of an acetylene decomposition which can enter the cylinder. Modern monolithic porous materials have a porosity of about 90 %. This means that the solid substance of the porous material excluding the pores takes up about 10 % of the water capacity V_w of the cylinder shell.

The remaining volume can contain solvent and acetylene and is commonly known as the available volume V_a consisting of the sum of all pores and can be expressed as:

$$V_a = V_w \cdot P / 100 \tag{1}$$

where

V_a - volume available

V_w – nominal water capacity of the cylinder

P – porosity (in %)

The available volume V_a (see schematic depiction in figure 1) is the sum of

- the volume of the solvent V_S
- the volume increase V_A of the solvent due to dissolving acetylene
- the volume of free space V_F

$$V_a = V_S + V_A + V_F \tag{2}$$

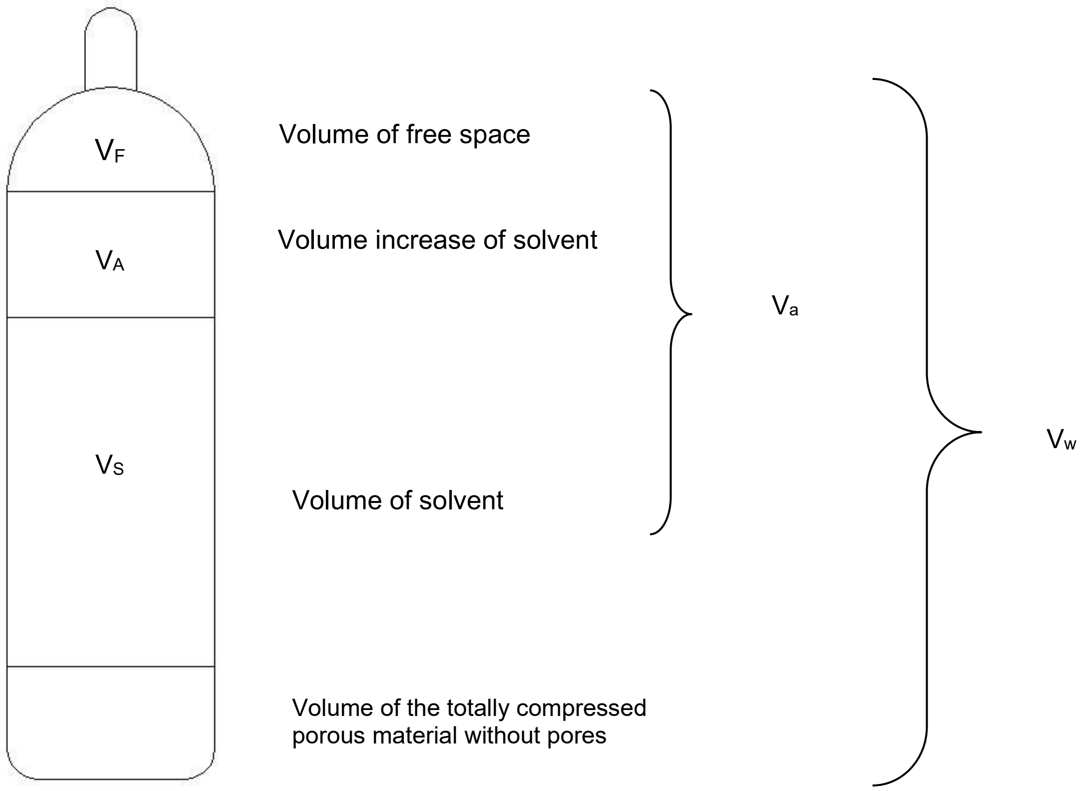


Figure 1: Schematic description of the available volume of an acetylene cylinder

When filling acetylene cylinders, two basic considerations shall be taken into account:

- the volume of the acetylene/solvent solution $V_A + V_S$ shall not exceed the available volume V_a, that is the "hydraulic filling" conditions shall never be reached.
- the acetylene/solvent solution shall resist propagation of a decomposition in the cylinder, in the event of a backfire.

Hydraulic filling

The volume of the solvent V_S can be expressed by the term $a_2 * m_S$, a_2 therefore is the reciprocal value of the density of the solvent.

The volume increase (V_A) of the before mentioned volume (V_S) due to dissolving acetylene can be expressed by the term $a_1 * m_A$.

The volume of an acetylene/solvent solution $V_A + V_S$ is therefore given by:

$$V_A + V_S = V = a_1 \cdot m_A + a_2 \cdot m_S \qquad (3)$$

where

V_s – volume of the solvent

V_A – volume increase of the solvent due to dissolving acetylene

a_1 - specific increase in volume of solvent due to dissolving acetylene in l/kg

a_2- specific volume of the pure solvent in l/kg

m_A - actual mass of acetylene including saturation gas in the cylinder in kg

m_S- actual mass of solvent in the cylinder in kg

The values of a_1 were experimentally determined for acetone and dimethylformamide (DMF) and their values are given in Table 1 (values are taken from EN ISO 11372 [2]).

	a_1 (l/kg)	a_2 (l/kg)
Acetone	1.91	1.25
DMF	1.75	1.05

Table 1 : Values for a1 and a2 at 15 °C

Hydraulic filling of acetylene cylinders results from all pairs of mass of acetylene m_A and mass of solvent m_S which take up the entire available volume V_a of the cylinder without leaving any free space.

At a uniform temperature of 65 °C this line is called the f_{65} = 0 line (see figure 2). The f_{65} = 0 line is different for each solvent but the same for all cylinders containing the same solvent.

All acetylene/solvent ratios to the right and above of the f_{65} = 0 line are not permitted because hydraulic filling can occur at temperatures below 65°C.

Since it is the objective to accommodate as much acetylene as possible under safe conditions in a cylinder, the best safe filling conditions are those as close as possible to the upper left side of the f_{65} = 0 line and thus at highest possible values for m_A. This means that the solvent content decreases as the acetylene content increases, since there is only a given available volume in the cylinder.

8.2 Resistance against propagation of an acetylene decomposition

The other criterion to be considered when filling acetylene cylinders is the resistance of acetylene cylinders against the propagation of an acetylene decomposition.

The resistance of acetylene cylinders against the propagation of an acetylene decomposition (often called backfire resistance) decreases with increasing acetylene content and decreasing solvent content.

The limit of the resistance against the propagation of an acetylene decomposition of a cylinder can be determined by a series of backfire tests as shown in figure 2.

A test series 1 is carried out with a certain acetylene content $(m_A)_1$ and varying solvent contents. The solvent content $(m_S)_{1,min.}$ is the minimum solvent content necessary to pass the backfire test with the acetylene content $(m_A)_1$.

For a test series 2 the procedure is repeated by selecting an acetylene content $(m_A)_2$ and conducting tests with varying solvent contents as described above to establish $(m_S)_{2,min}$.

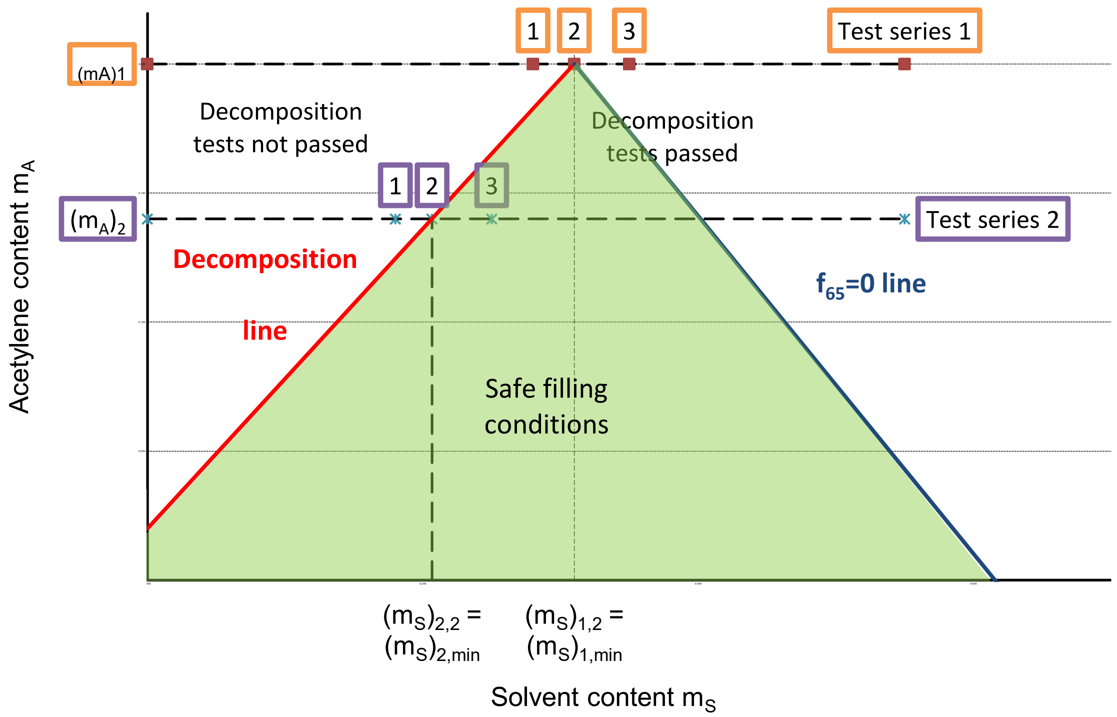


Figure 2: Determination of the safe filling conditions

All acetylene/solvent ratios to the left and above the line connecting $(m_S)_{2,min}$ and $(m_S)_{1,min}$ are not permitted because they are not backfire resistant.

8.3 Safe filling conditions

Safe filling conditions are reflected by all filling conditions on and below the resistance against decomposition line and the hydraulic filling line as shown in Figure 2., highlighted by the green colour.

8.4 Filling conditions for single acetylene cylinders

When determining safe filling conditions, the above criteria shall be considered.

Based on its experience and on tests as described in 8.1 and 8.2, the manufacturer specifies the intended solvent content and the intended maximum acetylene content for single cylinders.

To verify that hydraulic filling and decomposition resistance criteria are satisfied, the acetylene cylinders are filled with the specified solvent content and 105% of the intended maximum acetylene content. These cylinders are then subjected to

- elevated temperature tests to prove that hydraulic over pressure does not occur at a uniform temperature of 65 °C and
- backfire tests to prove that the porous material is able to stop the propagation of an acetylene decomposition within the cylinder.

If the tests are passed the specified filling conditions reflect the permissible filling conditions for single acetylene cylinders (see figure 3).

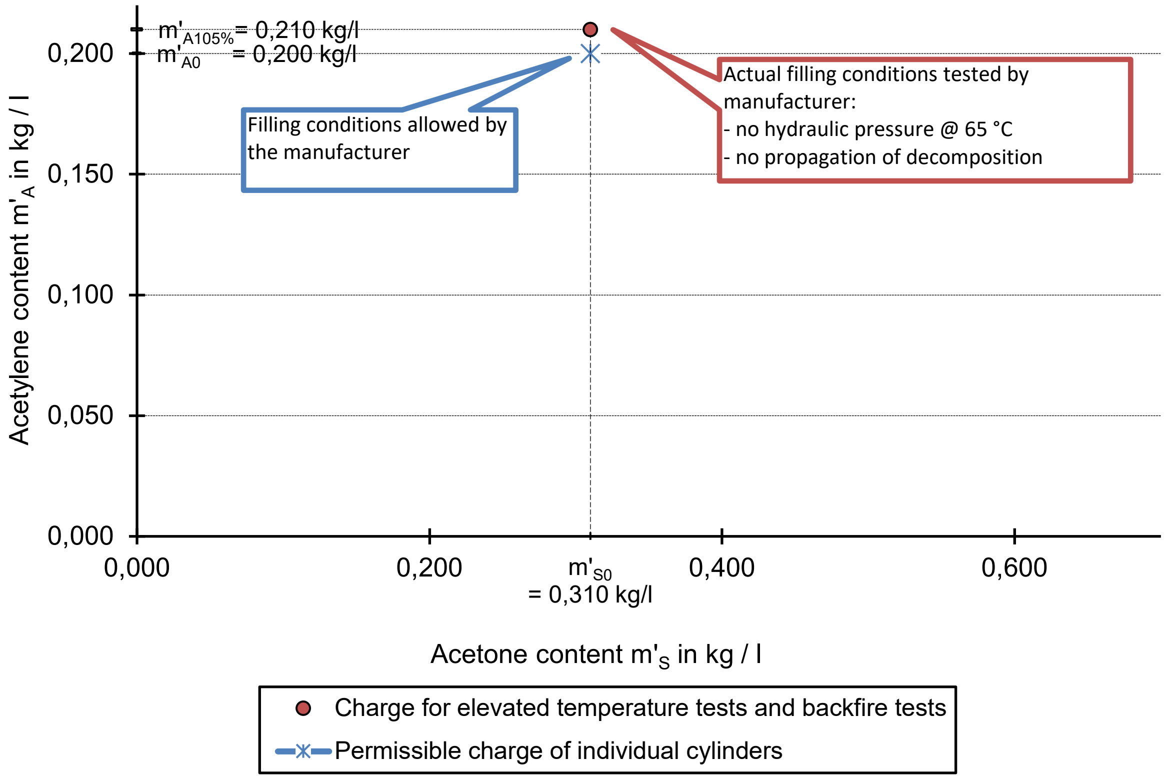


Figure 3: Permissible filling conditions for single acetylene cylinders as determined by elevated temperature tests and backfire tests

Example with a maximum acetylene filling ratio of 0,200 kg/l and a specified acetone filling ratio of 0,310 kg/l

8.5 Filling conditions for acetylene bundles

Cylinders in bundles should be filled and emptied together for a certain number of times during which the solvent is not intended to be replenished. Therefore, the filling conditions have to be selected in such a way that they allow for a tolerance of the solvent content. These filling conditions are derived from the permissible filling conditions for single cylinders based on some considerations with regard to safe filling conditions.

Starting from the filling conditions of the single cylinder, two lines are derived:

- constant volume line

- backfire line

8.6 Constant volume line

The volume of an acetylene/solvent solution at a given temperature is (see also chapter 8.1):

$$V = a_1 \cdot m_A + a_2 \cdot m_S \qquad (3)$$

Where:

V – volume of the acetylene and solvent solution

a_1 - specific increase in volume of solvent due to dissolving acetylene in l/kg

a_2- specific volume of the pure solvent in l/kg

m_A - actual mass of acetylene including saturation gas in the cylinder in kg

m_S- actual mass of solvent in the cylinder in kg

For a single acetylene cylinder, the volume V_0 as given by the permissible filling conditions is known to be safe as it passes the elevated temperature test. V_0 is:

$$V_0 = a_1 \cdot m_{A0} + a_2 \cdot m_{S0} \qquad (4)$$

Where:

V_0 – volume of the acetylene and solvent solution for permissible filling conditions

a_1 - specific increase in volume of solvent due to dissolving acetylene in l/kg

a_2- specific volume of the pure solvent in l/kg

m_{a0} – mass of acetylene for permissible filling conditions

m_{s0} – mass of solvent for permissible filling conditions

The volume V of an acetylene/solvent solution shall not exceed V_0.

Filling conditions with the same volume but a lower acetylene/solvent ratio are given by a line for constant volume through the permissible filling conditions. This line is obtained by equating of equation (3) and (4) and then solving for m_A leads to:

$$m_A = \frac{a_1 \cdot m_{A0} + a_2 \cdot m_{S0} - a_2 \cdot m_S}{a_1}$$

$$m_A = m_{A0} + \frac{a_2}{a_1} \cdot m_{S0} - \frac{a_2}{a_1} \cdot m_S \qquad (5)$$

$$m_A = m_{A0} + \frac{a_2}{a_1} \cdot (m_{S0} - m_S)$$

Equation (5) is called the constant volume line. Filling conditions on this line have the same volume but a lower acetylene/solvent ratio than the permissible filling conditions for single cylinders (see figure 4). Therefore the filling conditions on and below this line shall be considered safe as well.

Using the constant volume line instead of the f_{65} = 0 line has the advantage that no additional tests have to be carried out once the permissible filling conditions for single acetylene cylinders were determined.

8.7 Backfire line

The acetylene/solvent ratio m_{A0} / m_{S0} as given by the permissible filling conditions for single cylinders is known to be safe as it passes the backfire test. Filling conditions with the same acetylene/solvent ratio are given by the line connecting the permissible filling conditions for single acetylene cylinders and the zero point (see Figure 4). Therefore, the filling conditions on and below this line shall be considered safe as well. This gradient is called the backfire line and is described by:

$$m_A = \frac{m_{A0}}{m_{S0}} \cdot m_S \qquad (6)$$

The backfire line is slightly different from the line of resistance against decomposition as described in chapter 8.3, but using the backfire line as well has the advantage that no additional tests have to be carried out once the permissible filling conditions for single acetylene cylinders were determined.

8.8 Tolerance for solvent content

In order to keep acetylene cylinders within the "triangle" of safe filling conditions as given in figure 4 and to allow for a tolerance of the solvent content, the acetylene content shall be lower than the maximum permissible acetylene content.

According to EN ISO 13088 the acetylene content should be decreased to 90 % of the maximum permissible acetylene content m_{A0}.[5] This allows for a tolerance of the solvent content until reaching either the backfire line or the constant volume line.

In addition, the different filling behaviour of the single acetylene cylinders within the bundle has to be considered. Therefore, the solvent tolerance also has to take into account an additional safety margin *t* to the backfire line and the constant volume line. This safety margin is given by EN ISO 13088 [5] and amounts to:

	t = 0,010 kg / l	for acetone
and	t = 0,025 kg / l	for DMF

Using these safety margins the minimum solvent content $S_{\min}$ and the maximum solvent content $S_{\max}$ can be calculated for a given acetylene content as follows:

$$S_{\min} = m_{A90\%} \cdot \frac{m_{S0}}{m_{A0}} + t \qquad (7)$$

$$S_{\max} = \left(m_{A0} - m_{A90\%} + \frac{a_2}{a_1} \cdot m_{S0} \right) \cdot \frac{a_1}{a_2} - t \qquad (8)$$

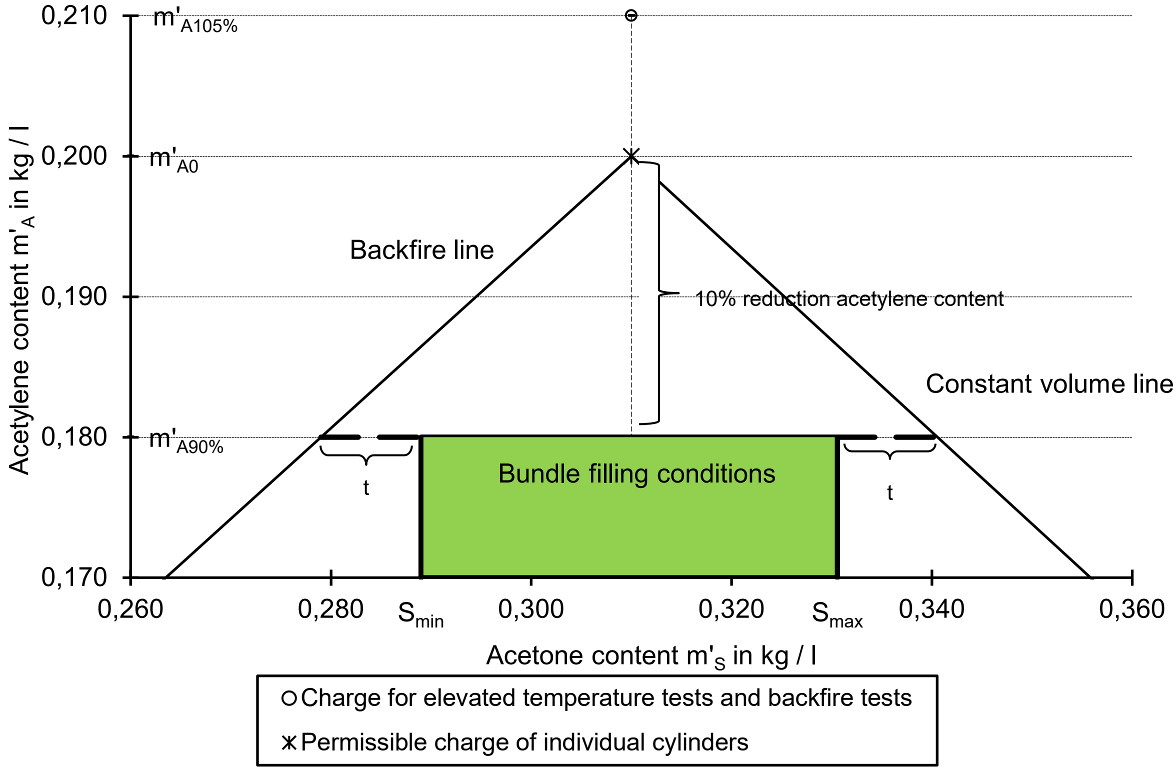


Figure 4: Example for filling conditions for acetylene bundles according to EN ISO 13088 [5]

Single cylinders:		
Maximum acetylene filling ratio:	*0,200 kg / l*	
Specified acetone filling ratio:	*0,310 kg / l*	
Cylinders in bundles:		
Maximum acetylene filling ratio:	*0,180 kg / l*	
Minimum acetone filling ratio:	*0,289 kg / l*	
Maximum acetone filling ratio:	*0,331 kg / l*	*(rounded up from 0.33056 kg / l)*
Maximum number of consecutive fillings:	*6*	

8.9 Number of consecutive fillings

The loss of solvent during a number of consecutive fillings before disassembly of a bundle for solvent replenishment shall not exceed the solvent tolerance. The average loss of solvent per cycle is given by EN ISO 13088 [5] and amounts to:

L = 0,00750 kg / l for acetone

and L = 0,00025 kg / l for DMF

The maximum number of consecutive fillings N is determined by dividing the solvent tolerance by the average loss of solvent per cycle:

$$N \leq \frac{S_{max} - S_{min}}{L} + 1 \qquad (9)$$

8.10 Filling conditions for acetylene bundles according to EN ISO 13088

Filling conditions for acetylene bundles determined as described earlier are in accordance with EN ISO 13088 if the single cylinders are approved according to EN ISO 3807 [5, 1]. An example is shown in Figure 4.

Information on approved porous materials for acetylene cylinders and their filling conditions can be found e.g. in CEN/TR 14473, *Transportable gas cylinders - Porous materials for acetylene cylinders* [15].

These lists are not exhaustive; different porous materials can be approved and not appear in the previous documents.

8.11 Filling conditions for acetylene battery vehicles

Cylinders or bundles in battery vehicles can be filled either together (Type “B” battery vehicle) or individually (Type “A” battery vehicle). In this second case, cylinders or bundles shall be disassembled from the battery vehicle, filled, and re-assembled in the battery vehicle.

The safe filling conditions are then determined accordingly to chapter 8.4 for type “A” battery vehicles and to chapter 8.6 for type “B” battery vehicles. Additional information can be found in EN 13720 [8].

9 Filling of acetylene packages

A cylinder, bundle or battery vehicle shall be filled only if it has successfully passed the pre-fill inspection and solvent replenishment.

The following provides a brief summary of the factors affecting cylinder filling. This list is not comprehensive.

Factor	Details
Compressor Capacity	Increasing compressor capacity decreases the filling time, provided the cylinders can be kept cool.
Cylinder Capacity	Connecting large cylinders to a filling manifold and compressor take longer to fill than the same number of small cylinders on the same rack and compressor. The cylinder capacity connected to the filling rack must be matched to the compressor capacity; typical filling times for a rack of cylinders is 6 to 8 hours.
Cylinder Size/Shape	Small diameter cylinders cool better than large diameter cylinders, generally lowering filling pressures when compared to similar capacity large diameter cylinders. Tall thin cylinders can generally be filled faster than short fat cylinders.
Returned Gas	Cylinders with high returned gas levels require a shorter filling time than cylinders that are completely empty. Filling pressures are generally also lower as high return gas cylinders do not warm up as much during filling.
Solvent Shortage	Cylinders with a solvent shortage require higher filling pressures to become full.
Solvent Excess	Cylinders with solvent excess may require less pressure to achieve the gas capacity but can become dangerous if slightly overfilled.
Cooling Water	Cylinders that are not completely wetted by the cooling fluid fill to a lower gas level because they warm up more and resist absorbing acetylene. Other cylinders that are properly wetted tend to be overfilled.
Filling Pressure	If the filling pressure rises too quickly, the compressor discharge pressure can rise above the maximum allowable pressure without the cylinders being full. The filling process may have to be stopped to allow the cylinders to rest and cool down before further filling.
Valve Opening	If the cylinder and rack valves are not opened properly, cylinders can take longer to fill. If valves are opened by different amounts for different cylinders, there will be a high number of over- and under-filled cylinders.
Blocked Filling Hose, Connectors, Filters or Valves	Single cylinders connected to blocked filling points or hoses will underfill. Cylinders connected to filling points that are not blocked tend to overfill.
Blocked Main Flashback Arrestor	Compressor pressure is high, but rack pressures low, resulting in slow filling or underfilling.
Water Contamination of Solvent.	Water in solvent reduces its capacity to absorb acetylene and reduces the amount of solvent in the cylinder. The cylinder requires a higher filling pressure to reach its gas capacity or may not become full.
Blocked Cylinder Core Packings	Has the same effect as a blocked filling hose. Cylinder underfills.

Insoluble Gases in Acetylene or Cylinder.	Insoluble gases (nitrogen, air, carbon dioxide) do not dissolve in solvent. This results in high filling pressures, and even a failure to get the cylinder filled. Maximum filling pressures may be exceeded. Insoluble gases may be a danger in the filling process. Air in the cylinder or acetylene is hazardous.
Porous Material Condition	A contaminated/blocked/damaged/deteriorated porous material may cause the cylinder to underfill or exhibit high filling pressures.
Packages that are filled slower than normal	Some packages may not accept a full charge of acetylene because of a defect in the cylinder. NOTE Where packages fail to fill to the correct level after two top-up attempts, these cylinders shall be sent for investigation in the cylinder exam / maintenance shop.

9.1 Single acetylene cylinder filling

9.1.1 Prepare acetylene cylinders for filling

After pre-fill inspection and solvent replenishment has been passed successfully, cylinders are connected to a filling manifold. Cylinders are commonly grouped for filling to form sections that will fill at a similar rate. This is done by:

- Cylinder capacity
- Porous material
- Solvent
- Diameter (tall and thin vs short and fat)
- Residual content (especially if being topped up having been found underfilled)
- Other factors including manufacturer, cylinder age, valve etc.

Cylinders returned from test shop and / or new cylinders ready for filling are often kept separate from the rest of the population for their first fill.

When placing acetylene cylinders on the filling manifold, precautions are required to avoid cross contamination of DMF and acetone. Contamination can occur if cylinders containing different types of solvent are filled on the same manifold. Consequently, it is recommended to fill cylinders containing different types of solvents on separate manifolds or at different times.

9.1.2 Nominal filling time

On a constant flow process the cylinder will absorb up to approximately 1/8th of its contents per hour, but this will start easily and become increasingly harder as the solvent warms. The rate of filling may need to be reduced towards the end of the fill.

9.1.3 Filling Manifold Checks before filling

Acetylene filling manifolds contain different equipment that is exposed to severe working conditions (i.e. with cooling water continuously sprayed on cylinders) and should be included in the local maintenance and mechanical integrity program.

Regarding daily filling activity it’s recommended to do the following checks:

- Leaks in manifold components such as flexible hoses connections, flash back arrestors, manifold valves and pressure gauges. See EIGA Doc 78, *Leak Detection Fluids with Gas Cylinder Packages*. [16]
- Signs of deterioration of flexible hoses and its anti-whip wires (if applicable).
- Good condition of threads in the connectors or couplings.
- Availability in packs filling of anti-tow-away systems.

9.1.4 Filling Procedure for Acetylene Cylinders

Once the acetylene cylinders are connected to the filling manifold, all valves in acetylene service shall be operated gently, smoothly and steadily. It is potentially dangerous to operate acetylene valves quickly and carelessly as sudden high flows of acetylene, or shocks to high-pressure

acetylene, may cause a decomposition under certain circumstances. Ball valves in acetylene service should always be opened with particular care

After connecting the cylinder to the filling hose it is recommended to open the cylinder and the manifold valves in the sequence below. By applying this sequence - from the cylinder backwards (upstream) - adiabatic compression of acetylene will be avoided, and always allows any trapped acetylene pressure a larger volume to travel to:

- Cylinder valve;
- Valve at the end of the filling connector or yoke (if fitted);
- Rack valve or filling point valve at the manifold (if fitted);
- Manifold main valve and supply acetylene to the manifold.

After the filling is completed it is recommended to close the valves as below. This sequence, working from the manifold master main valve forwards (downstream), avoids compressing acetylene against a diminishing volume and allows some time for pressure equilibrium across the manifold:

- Manifold main valve
- Rack valve or filling point valve at the manifold (if fitted)
- Valve on the end of the filling connector or yoke (if fitted)
- Cylinder valve

Immediately after starting and during the filling process leak checks should be performed between the cylinder valve and filling connector to be sure the connection between both is gas tight. See EIGA Doc 78. [16]

9.1.5 Checks While Cylinders are Filled

The manifold is pressurised by the acetylene compressors, forcing gas into the cylinders which dissolves in the solvent. While acetylene cylinders are filling, the following is ongoing:

- System, piping and cylinder pressures are increasing
- Amount of gas dissolved in the cylinder solvent is increasing
- Heat is being generated inside the cylinder

Once the filling process is underway, the cylinders, manifold and components are periodically checked for leaks or other abnormal conditions. During filling, the pressure in the filling manifold, hoses, connections and cylinders rises. Leaks that are not obvious at the beginning of the filling cycle can become evident as filling pressures increase. See EIGA Doc 78. [16]

During the filling cycle of an acetylene cylinder 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. See EIGA Doc 78. [16]

During the filling cycle it is normal to remove a cylinder from the manifold to check the cylinder weight to determine how close the cylinders are to being correctly filled.

9.1.6 Weigh-Out of acetylene cylinders

The purpose of weighing-out cylinders is to ensure that each cylinder contains the correct amount of gas, both from a safety and a commercial point of view. Calibrated weighing scales, which have a working range and measurement accuracy appropriate to the cylinder size, shall be used.

9.1.6.1 Filling Tolerances

In terms of the quantities of acetylene and solvent safe for use means that the final cylinder must meet the requirements of the permissible charging / filling conditions which could be found in the type approval data for the porous materials (see CEN/TR 14473 or equivalent document that certifies safe filling conditions for an overview of typical porous materials and their characteristics [15])

When filling acetylene cylinders, each cylinder will absorb acetylene at slightly differing rates, leading to a distribution of amounts of acetylene in the cylinders e.g. some cylinders having more acetylene, some less.

To comply with the requirement that no cylinder is filled beyond its maximum safe limit, this distribution of filled values means that some cylinders will be filled to a lesser amount. Whether this lesser value is acceptable for sale depends upon what is permitted both by regulation and by the commercial terms applied. This range of acceptability is known as the filling tolerance.

Under-filled cylinders are sent for top-up by returning them to the filling rack and continuing the filling process.

Over-filled cylinders shall have excess gas safely removed from them. Refer to Doc 257, *Safe Blow-down of Acetylene Cylinders and Bundles* [9]

9.2 Acetylene bundle filling

9.2.1 Filing procedure for acetylene bundles

The maximum acetylene content for a cylinder in a bundle must be reduced to approximately 90% of the amount approved for the single acetylene cylinder. This means if single cylinders are migrated into a bundle, they need to be de-rated according to EN ISO 13088 [5].

The bundles may only be filled without dismantling if the total residual solvent content of the bundle has been checked and is still within the permitted solvent operating range.

Acetylene bundles which are to be filled simultaneously shall have the same solvent or be separately filled to prevent cross contamination of the solvents.

Calculation of gross weight (target weight):

Inbound Weight - Residual Gas Weight + Maximum Acetylene Content = Gross Weight

Before filling bundles, it is necessary to verify that *all* the cylinder valves are open.

9.2.2 Checks While Bundles are Filled

A during-fill check includes the following:

- Cylinder valves shall be checked to ensure they are in the open position so that the acetylene is distributed equally to all cylinders.
- If cylinders are cooled during filling, care shall be taken to ensure all bundle cylinders are cooled at approximately the same rate.
- All connections in the bundle manifold shall be checked for leaks during filling. See EIGA Doc 78 [16]

- Bundles should be checked for gross weight 1 hour before the filling process is expected to be stopped. A representative number of bundles (e.g. 50%) on a filling manifold should be checked.

9.2.3 Weigh-Out of acetylene bundles

After the filling process is complete, all bundles shall be weighed-out with a calibrated and suitable weigh scale.

Under-filled bundles shall be topped-up until the acetylene content is within the filling range.

Over-filled bundles shall be blown down until the acetylene content is within the filling range. Bundle blow down shall be performed slowly to avoid excessive solvent emissions.

9.3 Acetylene battery vehicles filling

Refer to EN 13720 [8]

9.4 Application of cooling water during filling

During the filling of acetylene cylinders, the heat of solution of the acetylene in the solvent warms the cylinder and the pressure rises until the maximum charging pressure is reached before the cylinder has taken its full acetylene charge. This phenomenon is more important during the warmer months of the year when cylinder initial temperatures are high enough to affect the charging rate.

To dissipate the heat of solution and cool the cylinders, each charging rack (single cylinders or bundles may be fitted with cooling sprays. For a uniform charge, it is important that the spray evenly covers the cylinders on the same manifold. Otherwise, the warmer cylinders not covered by water will not charge as fast as those cooler cylinders covered by the sprays.

There are several basic types of cylinder cooling water configurations:

- Fixed jet or nozzle system – water is sprayed on the whole or part of the cylinder shell.
- Neck ring or cooling water distribution rings – water is trickled over the neck of the cylinder and runs down the shell sides.
- Immersion systems – where the cylinder is placed in a bath of cooling water.

Due to the wide variety of cylinder filling cooling systems, each plant should establish and maintain a set of operating and maintenance procedures suitable for that plant and cooling system.

10 Post-fill inspection

All acetylene packages should not be placed in service until at least 12 hours after the end of filling; this is to ensure that the package is within the safe working limits of the safe operating diagram.

10.1 Post-fill Inspections for single acetylene cylinders

Post-fill checks are important in managing the safety risk of cylinders being released from the plant. They can be the last opportunity to prevent a defective cylinder being released. The post-fill inspection is about the physical condition of the cylinder and is commonly incorporated into the weigh-out process where the gas quantity of the cylinder is verified.

The most significant difference between pre- and post-fill cylinder inspections is that after filling, the pressure in the cylinder may reveal leaks that were not detectable when the pre-fill inspection was done. Post-fill inspection should concentrate on detecting any leaks on the cylinder, or other pressure related defects that may become evident. For inspection after filling, the requirements of EN ISO 11372 shall apply [2].

If a leak cannot be stopped immediately or if other faults are found on the cylinder, which could create a hazard, the cylinder shall be depressurised on an appropriate blow down system (See Valve Checks

It has to be checked that the valve is protected appropriately, where applicable. This can be achieved by a valve protection cap or a valve guard (see ISO 11117 *Gas cylinders - Valve protection caps and guards - Design, construction and tests* [17]). Alternatively, a valve can be designed to resist impacts (see ISO 10297 *Gas cylinders - Cylinder valves - Specification and type testing* [18]).

A visual cylinder valve inspection is done to ensure no damage has occurred during the filling or disconnection process, and that no defect has been missed in previous inspections:

Valve outlet: check for signs of soot and for worn or damaged threads.

- Valve handwheel or spindle on cylinders opened using a valve key: check bent or skew handwheel and twisted or bent valve spindle.

- Leaks: check leaks from neck thread, safety devices, valve outlet (internal leak; do not overtighten) and valve body (external leak). See EIGA Doc 78 [16].

If any of the above defects are noted, the cylinder shall be rejected.

10.1.1 Single acetylene cylinder checks

At least the following checks must be done:

- Checks for bulging or deformation.

- Leaks especially on the bottom and on the welds where they are present.

- Footring: where present check for corrosion, loosening or damage, cylinder stability and that the cylinder base not touching the ground

If any of the above defects are noted, the cylinder shall be rejected.

Where new cylinders are filled for the first time, every cylinder shall be thoroughly leak tested before being released from the plant, including all welds (if any) and all safety devices.

10.1.2 Safety Device Checks

Some cylinder designs incorporate safety devices in the cylinder shell. These may be fusible plugs or bursting discs, or other pressure relief devices (or where replaced by blank or solid plugs).

Safety devices are visually checked for any obvious defect or leakage.

Check the safety devices for any of the following:

1. Indications of soot or blockage

2. Any signs of tampering

3. Extrusion of the fusible metal element from fusible plugs

If there is any suspected defect with a safety device, the cylinder shall be rejected.

10.2 Post-fill inspections for acetylene bundles

During and after filling, acetylene bundles shall be checked for leaks. The connections and the cylinder valves shall be reviewed, for example, by applying leak detection fluid, refer to EIGA doc 78. [16]

If a leak cannot be stopped immediately or if other faults are found on the bundle, which could create a hazard, the bundle shall be depressurised on an appropriate blow down system.

Post-fill inspections include checking of the following:

- Final evaluation of cylinder shells and bundle frame (corrosion, integrity including lifting eye, …)
- Leaks from the cylinder valves or cylinder shells
- Leaks from safety devices
- Leaks from bundle internal manifolds, hoses or connections
- Leaks from bundle main valve
- Cylinders need to be permanently fixed in the bundle frame

Note Where acetylene bundles are dismantled for filling as loose cylinders, each cylinder must undergo and pass a post-fill inspection as an single cylinder before being reassembled into the bundle. After assembly into the bundle, the bundle as a unit also requires an inspection as mentioned in previous paragraph.

10.3 Post-fill inspections of acetylene battery vehicles

Refer to ISO 13720 [8]

11 References

[1] EN ISO 3807, *Gas cylinders – Acetylene cylinders – Basic requirements and type testing*, www.iso.org

[2] EN ISO 11372, *Gas cylinders – Acetylene cylinders – Filling conditions and filling inspection*, www.iso.org

[3] EIGA Safety Information SI42, *Acetylene Cylinder Base Corrosion*, www.eiga.eu

[4] EIGA Doc 26.1, Acetylene Cylinder Pre-Fill Checks, www.eiga.eu

[5] EN ISO 13088, *Gas cylinders - Acetylene cylinder bundles – Filling conditions and filling inspection*, www.iso.org

[6] ISO 13769, *Gas cylinders - Stamp marking*, www.iso.org

[7] ISO 10961, *Gas cylinders - Cylinder bundles - Design, manufacture, testing and inspection*, www.iso.org

[8] EN 13720, *Transportable gas cylinders – Filling conditions for acetylene battery vehicles*, www.cen.eu

[9] EIGA Doc 257, *Safe Blow-down of Acetylene Cylinders and Bundles*, www.eiga.eu

[10] EIGA Doc 05, *Guidelines for the Management of Waste Acetylene Cylinders*, www.eiga.eu

[11] U.S. Code of Federal Regulations, *Title 49, Transportation*, www.govinfo.gov/app/collection/CFR

[12] Canadian Standards Association (CSA) B339, *Cylinders, spheres, tubes for the Transportation of Dangerous Goods*, https://tc.canada.ca/en/dangerous-goods

[13] Canadian Standards Association (CSA) B340, *Selection and use of Cylinders, Spheres, Tubes, and Other Containers for the Transportation of Dangerous Goods, Class 2*, https://tc.canada.ca/en/dangerous-goods

[14] CGA G-1.9 *Recommended Practices for Maintaining the proper Solvent Level in Acetylene Cylinders*, www.cganet.com

[15] CEN/TR 14473, *Transportable gas cylinders - Porous masses for acetylene cylinders*, www.cen.eu

[16] EIGA Doc 78, *Leak Detection Fluids Gas Cylinder Packages,* www.eiga.eu

[17] ISO 11117, *Gas cylinders - Valve protection caps and guards - Design, construction and tests,* www.iso.org

[18] ISO 10297, *Gas cylinders - Cylinder valves - Specification and type testing*, www.iso.org

12 Other references

EN 13807 *Transportable gas cylinders - Battery vehicles and multiple-element gas containers (MEGCs) - Design, manufacture, identification and testing,* www.cen.eu

EN ISO 25760, *Gas cylinders. Operational procedures for the safe removal of valves from gas cylinders,* www.iso.org

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

CGA G-1.6, *Standard for mobile acetylene trailer systems,* www.cganet.com

ANNEX A – Filling new single acetylene cylinders

New cylinders are those that have not been through a filling cycle before.

New cylinders are supplied by manufacturers in several different conditions:

- Supplied without solvent under vacuum
- Supplied without solvent with nitrogen or air in the shell
- Supplied with solvent without saturation gas
- Supplied with solvent including saturation gas

When new cylinders are received at the filling plant, it shall be identified what the condition of the cylinders is before any attempt is made to fill them.

New cylinders need the same pre-fill inspections as cylinders in use to ensure they are:

- Physically in a condition that is safe for filling, and
- Comply with the legal requirements for filling

If the new cylinders have been supplied with an acetylene valve mounted on the cylinder, a simple check shall be performed to check that the valves are obviously fixed on the cylinders correctly:

- Check if the valve can be loosened by hand easily.
- Check if 2 or 3 turns of the valve thread can be seen above the cylinder neck ring thread.

If there is any doubt check the torque.

<u>Where cylinders are supplied without solvent:</u>

- If the cylinder is supplied under vacuum, the correct weight of solvent is added without loosing the vacuum in the cylinder. Do not allow the cylinder valve to be opened to atmosphere, as this draws air into the cylinder.
- If the cylinder is supplied with air or nitrogen in the cylinder, draw a vacuum of at least 0,4 bara on the cylinder at least one hour before adding the correct weight of solvent.
- Connect the cylinder to the solvent replenishment system.
- For Tare A cylinders fill the cylinder with solvent until it reaches the Tare Weight marked on the cylinder. These cylinders will not have any saturation gas after the solvent is added and may still have a slight negative cylinder pressure.

  For Tare S cylinders fill the cylinder with solvent until it reaches the Tare Weight minus the saturation gas for that cylinder.

<u>Where cylinders are supplied without saturation gas:</u>

Cylinders with solvent, but without saturation gas are likely to have a slight negative pressure in the cylinder. When checked on a scale, they are slightly underweight by the amount of the saturation gas if the cylinders are marked with the Tare S. For Tare A type cylinders, the scale weight should equal the Tare A marking. Do not allow the cylinder valve to be opened to atmosphere, as this draws air into the cylinder.

<u>Where cylinders are supplied with saturation gas:</u>

Cylinders supplied with solvent and saturation gas should have a slight positive pressure if warm (>15ºC). If the cylinders are cold (<10ºC) they are likely to have a slight negative pressure. When checked on a scale, the cylinder actual weight is the same as TARE S or slightly heavier than TARE A.

1. First fill of new cylinders without saturation gas

Cylinders are connected to the filling rack without opening the cylinder valves.

Raise the filling rack pressure to approximately 2 barg, and open the filling point and cylinder valves slowly, cylinder by cylinder.

Constantly check the filling rack pressure to ensure that it does not drop below 0,5 barg. Re-pressurize the filling rack if the pressure drops too far.

When all the filling points and cylinder valves are open, the cylinders can be filled as described in chapter “First fill of new cylinders with saturation gas”.

2. First fill of new cylinders with saturation gas

It is recommended that on the first fill, cylinders are filled slowly, with the smallest available compressor. Ensure that the maximum number of cylinders is connected to the filling rack.

Do not fill "new" cylinders with cylinders already in circulation. Constantly monitor the filling rack pressure and immediately stop the filling process if the pressure appears to be rising too fast.

During-Fill inspections shall be performed, including leak checks at:

- Cylinder valve neck thread
- Cylinder valve outlet connection
- Fusible plugs on cylinder shoulder or neck
- Hose end connections and threaded joints on fittings.

It is recommended that the filling process is stopped half-way through the filling cycle (about 7barg) to allow the cylinders to rest for a few hours, and for the rack pressure to drop and stabilize. Isolate the filling rack from the compressor but leave the filling point and cylinder valves open. Some new cylinders require a slightly longer filling time to become full.

3. Sample checks after filling new cylinders

Allow the cylinders to rest for approximately 8 hours and check a sample of the cylinders for settled pressure. If the cylinders appear to have an abnormally high settled pressure, they may be contaminated with insoluble gases.

Conduct acetylene purity tests on a few of the cylinders to confirm that the gas quality is acceptable.

New cylinders can have lower settled pressure than cylinders in circulation because the solvent is fresh and uncontaminated.

If the cylinders have acceptable pressure, and the acetylene is of suitable purity, the cylinders can be released into general circulation when the weigh-out and post-fill inspections have been passed. Thereafter, the cylinders are filled as per normal filling practice.

If the cylinders do not show an acceptable pressure, or the acetylene is of poor purity, blow down these cylinders and fill them again according to this document starting with the weigh-in procedure.