PERMISSIBLE CHARGE/FILLING CONDITIONS FOR ACETYLENE CYLINDERS, BUNDLES, & BATTERY VEHICLES

AIGA 037/16

(Revision of AIGA 037/06)

Asia Industrial Gases Association

3 HarbourFront Place, #09-04 HarbourFront Tower 2, Singapore 099254
Tel : +65 6276 0160 • Fax : +65 6274 9379
Internet : http://www.asiaiga.org

AIGA 037/16

PERMISSIBLE CHARGE/FILLING CONDITIONS FOR ACETYLENE CYLINDERS, BUNDLES, & BATTERY VEHICLES

ASIA INDUSTRIAL GASES ASSOCIATION
3 HarbourFront Place, #09-04 HarbourFront Tower 2, Singapore 099254
Tel: +65 62760160 Fax: +65 62749379
Internet: http://www.asiaiga.org

Acknowledgement

This document is adopted from the European Industrial Gases Association document IGC 26/13 ‘Permissible charge/filling conditions for acetylene cylinders’. Acknowledgement and thanks are hereby given to EIGA for permission granted for the use of their document.

Table of Contents

Amendments to 037/06

Section	Change
	Extensive rewrite to improve clarity and addition of new chapters.

Note: Technical changes from the previous edition are underlined

1 Scope

This document is intended to give the requirements for filling individual cylinders, bundles and battery vehicles containing different porous materials and different solvents.
Furthermore this document is intended to supplement the existing standards by clarification of their safety philosophy and the method of implementation. As well it demonstrates the effects of the essential parameters, such as maximum acetylene content, necessary solvent content, acetylene/solvent ratio, acetylene filling tolerance, solvent filling tolerance, free volume in the cylinder, porosity of filler material.

2 Introduction

The permissible charge for acetylene cylinders was specified in different ways by various national regulations although in the course of generating an International standard, experts have agreed upon a simple and appropriate safety concept. This safety concept supersedes the arbitrary free space and/or maximum pressure requirements in some older national regulations.
Cylinders for dissolved acetylene contain a porous material, solvent and acetylene. Therefore the acetylene cylinder is a complex system with interdependent parameters.
For the safe operation of individual acetylene cylinders containing a certain porous material, two basic criteria are internationally acknowledged:

a) The acetylene content and the solvent content of individual dissolved acetylene cylinders have to be selected in such a way that for a cylinder with the specified solvent content and with 105 % of the maximum approved acetylene content:[1]

   - hydraulic over pressurisation does not occur at a uniform temperature of 65°C and that
   - the porous material is able to prevent the spread of an acetylene decomposition in the cylinder.

b) Tests shall be carried out to confirm that the above requirements have been met.

3 Definitions and symbols

3.1 Definitions

3.1.1 Acetylene cylinder

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

3.1.2 Acetylene battery vehicle type A

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

3.1.3 Acetylene battery vehicle type B

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

3.1.4 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

[1] *The maximum approved acetylene content is the maximum acetylene content specified by the approving authority or cylinder porous material manufacturer. It may be equal to or less than the maximum acetylene content.*

3.1.5 Saturation gas

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

3.1.6 Solvent replenishment

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

3.2 Symbols

3.2.1 a_1

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

3.2.2 a_2

Specific volume of the pure solvent in l/kg

3.2.3 *L* Solvent loss

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

3.2.4 m_{A0} Maximum acetylene content

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

3.2.5 m_A Acetylene content

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

3.2.6 m'_A Acetylene filling ratio

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

3.2.7 m_{S0} Specified solvent content

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

3.2.8 m_S Solvent content

Actual mass of solvent in the cylinder in kg

3.2.9 m'_S Solvent filling ratio

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

3.2.10 N Number of bundle or battery vehicle fillings

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

3.2.11 P Porosity

Porosity of the porous material determined according to EN 1800 [1] or ISO 3807-1 [2] in %

3.2.12 S_{min} Minimum solvent filling ratio

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

3.2.13 S_{max} Maximum solvent filling ratio

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

3.2.14 *t* Solvent safety margin

Solvent safety margin for bundle filling conditions in kg/l

3.2.15 V_a Available volume

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

3.2.16 V_A Volume increase

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

3.2.17 V_F Free volume

Volume of free space in the cylinder in l

3.2.18 V_S Volume of the solvent

Volume of the solvent in the cylinder in l

3.2.19 V_w Water capacity

Water capacity of the empty cylinder shell in l

4 Basic considerations

4.1 Available 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:

$$V_a = V_w \cdot P / 100 \quad (1)$$

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

$$V_a = V_S + V_A + V_F \quad (2)$$

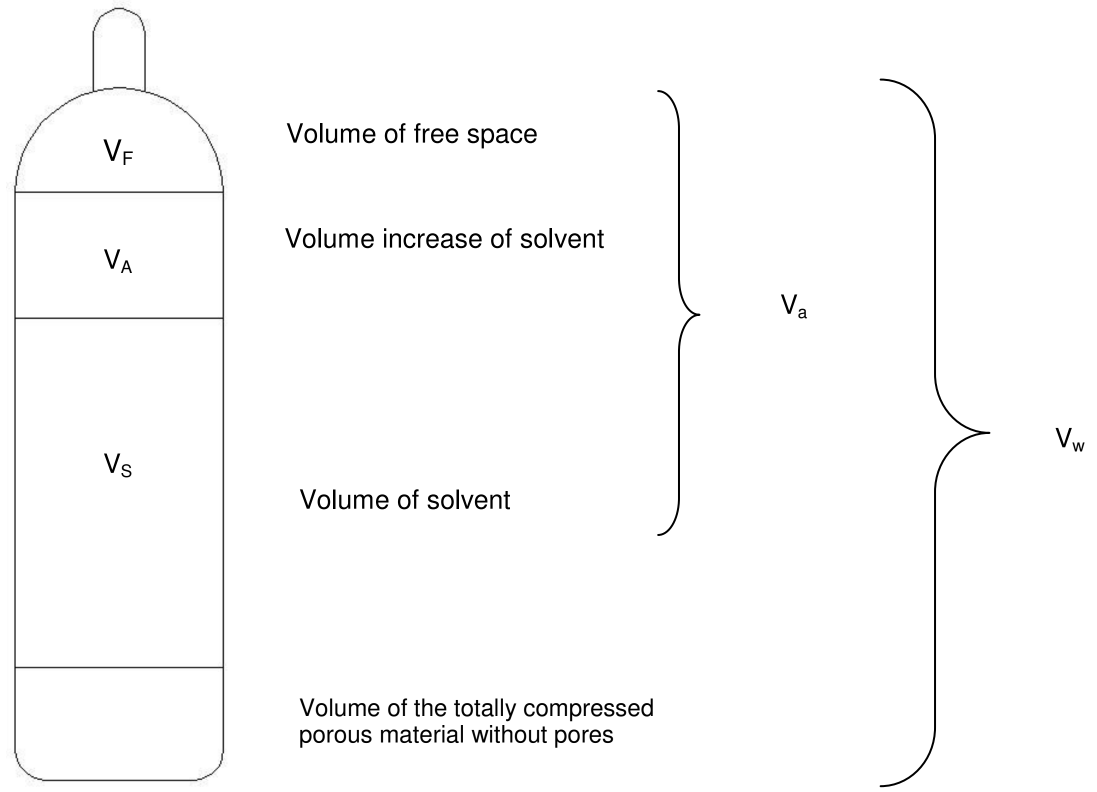

Figure 1: Schematic description of the available volume of an acetylene cylinder

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 an acetylene/solvent solution can be considered as the sum of the volume of the solvent (V_S) and its increase due to the diluted acetylene (V_A) . This sum shall not exceed the available volume Va.

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:

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

where

Vs – 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 ISO 11372 [3]).

	a_1 in l/kg	a_2 in 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.

4.2 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 $(m_S)_{2,min}$.

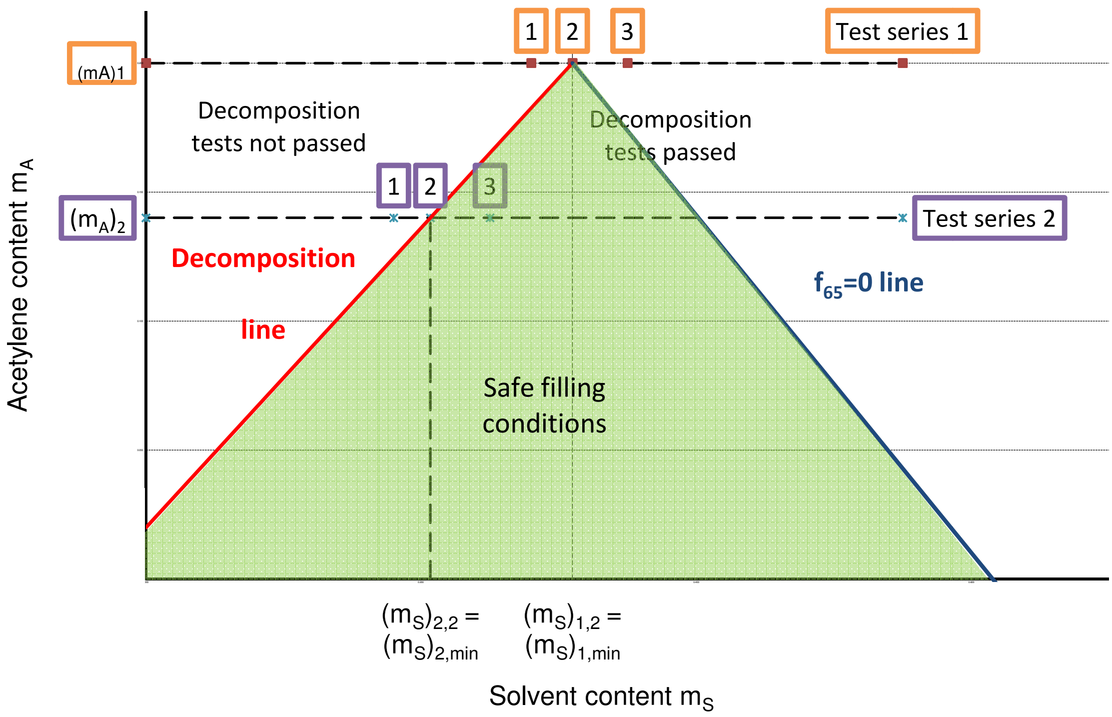

Figure 2: Determination of the safe filling conditions

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.

4.3 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.

5 Filling conditions for individual acetylene cylinders

When determining safe filling conditions, the above criteria shall be considered.
Based on its experience and on tests as described in 4.1 and 4.2, the manufacturer specifies the intended solvent content and the intended maximum acetylene content for individual 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 in order to prove that hydraulic over pressure does not occur at a uniform temperature of 65 °C and
- backfire tests in order 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 individual acetylene cylinders (see figure 3).

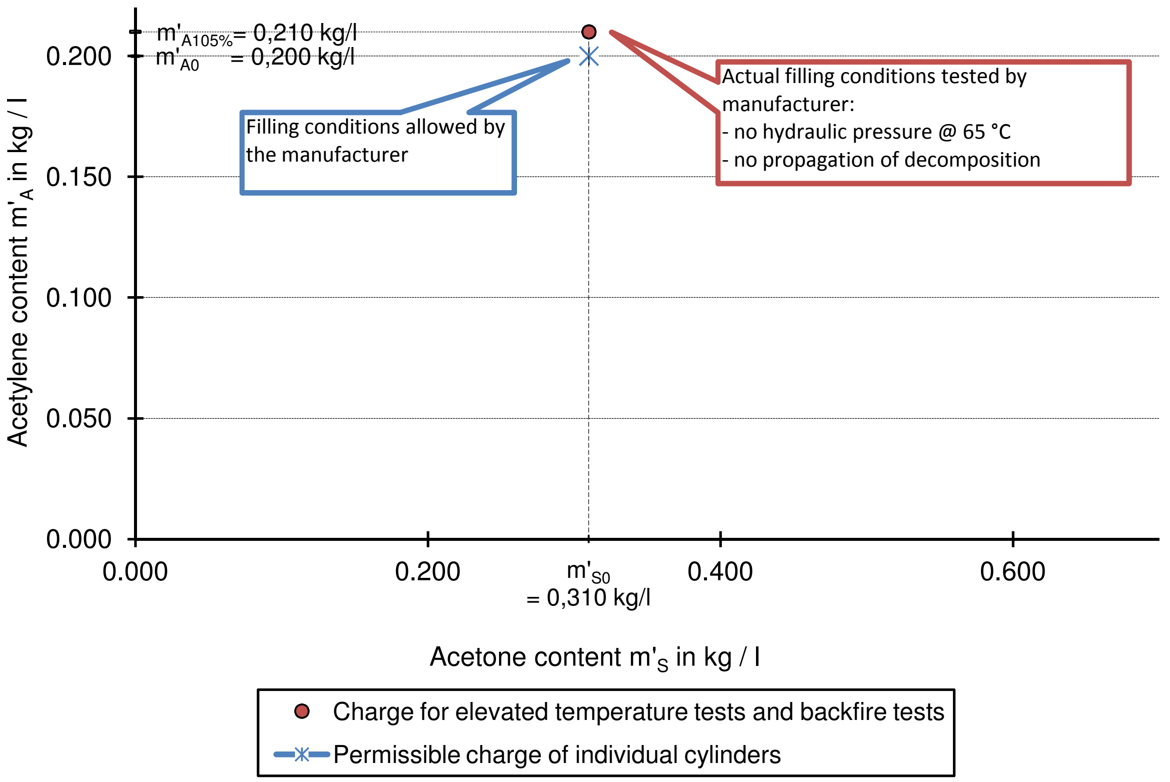

Figure 3: Permissible filling conditions for individual acetylene cylinders as determined by elevated temperature tests and backfire tests.

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

6 Filling conditions for acetylene cylinder 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 individual 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

6.1 Constant volume line

The volume of an acetylene/solvent solution at a given temperature is (see also chapter 4.1):

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

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 – mass of acetylene
m_s – mass of solvent
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 individual cylinders (see figure 6). 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 individual acetylene cylinders were determined.

6.2 Backfire line

The acetylene/solvent ratio m_{A0} / m_{S0} as given by the permissible filling conditions for individual 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 individual 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 4.3, 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 individual acetylene cylinders were determined.

6.3 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 12755 the acetylene content should be decreased to 90 % of the maximum permissible acetylene content m_{A0}. 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 individual 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 12755 [4] 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:

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

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

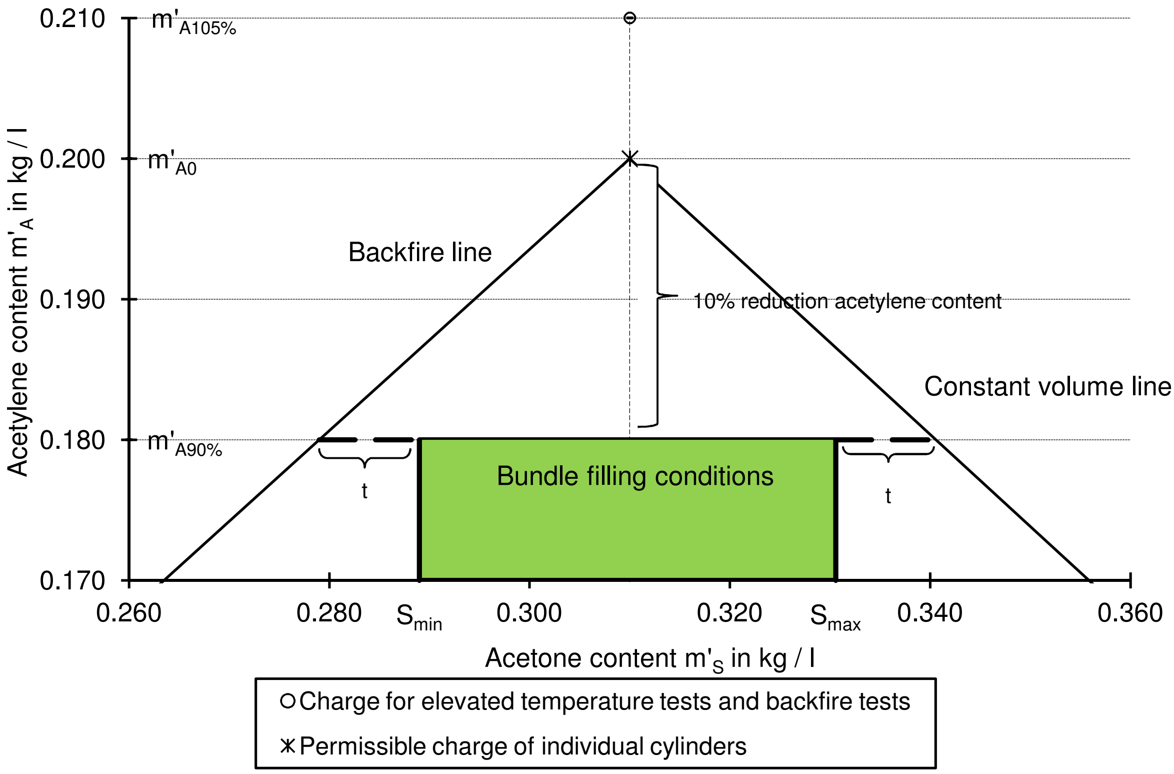

Figure 4: Example for filling conditions for acetylene cylinder bundles according to EN 12755:

Individual 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*	

6.4 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 12755 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:

$$N \leq \frac{S_{\max} - S_{\min}}{L} + 1 \tag{9}$$

6.5 Filling conditions for bundles according to EN 12755

Filling conditions for acetylene cylinder bundles determined as described earlier are in accordance with EN 12755 if the individual cylinders are approved according to EN 1800. An example is shown in Figure 4.
Information on approved porous materials for acetylene cylinders and their filling conditions can be found in

- PD CR 14473 [5]
- List of porous materials pdf- file can be downloaded from the BAM Server from the section: Home>Expertise>Chemical Safety Engineering>Gases, Gas Plants.

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

7 Filling conditions for acetylene battery vehicle

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 5 for type "A" battery vehicles and to chapter 6 for type "B" battery vehicles. Additional information can be found in EN 13720 [6].

8 Pre-fill, fill and post fill checks procedures

8.1 General

Each cylinder, bundle or battery vehicle shall be submitted to an inspection prior to, during and immediately after filling.
Cylinders not fulfilling the requirements stated below shall be identified for further treatment according to the written procedures of the filling station.

8.2 Pre-fill inspection

8.2.1 Verification of stamp marking and necessary documentation

The information required in the following list shall be made available to the filler.
Before filling an acetylene cylinder, bundle, or battery vehicle it shall be identified that:

a) the cylinder/bundle/battery vehicle is permitted for filling in the country of the filling station;

b) the cylinders have not exceeded due date for periodic inspection;

c) the cylinder/bundle/battery vehicle does not have a current history of problems;

d) the stamp marking and labelling are appropriate to acetylene;

e) the colour coding is appropriate to acetylene;

f) in case of bundles or battery vehicles, the number of consecutive fillings without replenishment is not overdue.

Before filling an acetylene cylinder, the following information shall be made available:

a) identification of the porous material;

b) type of solvent;

c) specified solvent content;

d) tare (with information whether tare A or tare S is used);

e) total weight and/or its maximum acetylene content (if tare A is used) or its maximum acetylene charge (if tare S is used)

8.2.2 Verification of serviceable condition

It shall be established that each cylinder, bundle and battery vehicle is in a serviceable condition before filling.
It shall be established that:

a) the cylinder/bundle/battery vehicle is clean and free from foreign material, so that the cylinder/bundle/battery vehicle can be assessed for mechanical damage that would otherwise prevent it from being filled safely

b) the cylinder/bundle/battery vehicle does not exhibit any abnormalities that could impair the safety, including arc burns, severe corrosion, heat/fire damage, or have any other mechanical damage

c) fusible plugs, if required, are in place .

d) flexible hoses on bundles or battery vehicles shall be inspected to ensure that

   a. the date for periodic change, if established, is not overdue

   b. they do not show any leak or mechanical damage such as kinks, cracked end fittings or other damages that could impair the safety

e) cylinders/bundles/battery vehicles that have been found to be unserviceable shall be identified and segregated in accordance with the written procedures of the filling organization, and shall not be filled.

8.2.3 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 a serviceable condition and securely attached. Similarly, the foot ring, if fitted, shall be checked for corrosion and stability problems.
NOTE If a permanent valve guard is exchanged, this could affect the tare of the cylinder.

8.2.4 Verification of valve integrity and suitability

Before filling a cylinder/bundle/battery vehicle, 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/bundle/battery vehicle and rectify it in accordance with an appropriate procedure, e.g. as described in ISO 25760 [7];

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.

8.2.5 Scales

Scales shall be selected with a range suitable for the type of cylinder to be replenished (maximum load and accuracy) 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	Medium Cylinder	Large Cylinder
volume =< 6l	Volume >6=<20l	volume >20l
Scale tolerance ±20g	Scale tolerance ±50g	Scale tolerance ±100g

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 of the appropriate tolerance is not available, then the filling ratio shall be reduced to compensate for the increase in scale tolerance.

8.3 Solvent content

8.3.1 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 for the cylinder type.
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.
Measurement of the acetylene-cylinder weight 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:

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

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:

$$f(p,T) = \frac{\log_{10}(p + 1{,}013) - 4{,}1945 + \frac{712{,}88}{T + 273{,}15}}{0{,}4569 + \frac{207{,}8}{T + 273{,}15}}$$

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

$$f(p,T) = \frac{\log_{10}(p + 1{,}013) - 3{,}630 + \frac{504{,}36}{T + 273{,}15}}{-0{,}9826 + \frac{695{,}8}{T + 273{,}15}}$$

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, 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:

$$m_s = \frac{m_C - tare_S + m_{S0} + m_{A,S}}{1 + F}$$

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

$$m_s = \frac{m_C - tare_A + m_{S0}}{1 + F}$$

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;
- $m_{A,s}$ is the saturation acetylene, in kilograms.

The above formulas can be used only if the following are respected:

a) Calibrated weighing scales, manometers and other instruments which have a working range and measuring accuracy suitable for the cylinder size to be filled are used.
b) The cylinder has had sufficient time (approximately 3h) to equalize its temperature with the filling building/area temperature
c) Residual pressure of the cylinders is less than 7 bar for cylinders with a working pressure of 17 bar or higher and is less than 4 bar for cylinders with a working pressure below 17 bar.
   Should the residual pressure be above these values, the remaining gas should be vented until the values specified above have been reached.
   Venting of the cylinder should be carried out slowly; a typical rate would be 1/8-1/10 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 venting and will need time to reach temperature equilibrium again.

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 in the cylinder shall not be changed.
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.

8.3.2 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 it is 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 the solvent, it shall be ensured that the pressure does not exceed the maximum pressure specified by the porous material manufacturer.

8.4 Inspection during filling

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.

8.5 Post-fill inspection

8.5.1 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 approved leak detection fluid, see AIGA document 070[8]. 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.

8.5.2 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 has not been exceeded. For example, this can be achieved, by checking that the measured weight does not exceed the total weight. Calibrated weighing scales, which have a working range and measurement accuracy appropriate to the cylinder size, shall be used.

8.5.3 Valve protection

It shall be checked that the valve is protected (e.g. safety guards, caps), where required.

9 References

[1] EN 1800 Transportable gas cylinders – Acetylene cylinders – Basic requirements and definitions
[2] ISO 3807-1 Cylinders for acetylene – Basic requirements
[3] EN ISO 11372 Gas cylinders – Acetylene cylinders – Filling conditions and filling inspection
[4] EN 12755 Transportable gas cylinders – Filling conditions for acetylene bundles
[5] PD CR 14473: Transportable gas cylinders. Porous masses for acetylene cylinders
[6] EN 13720 Transportable gas cylinders – Filling conditions for acetylene battery vehicles
[7] ISO 25760 Gas cylinders. Operational procedures for the safe removal of valves from gas cylinders
[8] AIGA 070, Leak detection fluids gas cylinder packages

10 References not including in the text

The following are not included in the text but provide useful information
ISO 13088 Gas cylinders- Acetylene cylinder bundles – Filling conditions and filling inspection
CGA G-1.6 Standard for mobile acetylene trailer systems