PURIFICATION, COMPRESSION AND DRYING OF ACETYLENE

Doc 241/23

Revision of Doc 241/12

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Prepared by WG-12 Acetylene

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Table of Contents

Amendments to 241/22

Section	Change
3.2.2	Correction of table
12	Addition of sentence

1 Introduction

This document has been prepared by the European Industrial Gases Association (EIGA) to give guidance for the purification, compression and drying of acetylene.

2 Scope

This publication is intended to provide general guidelines for the purification, compression and drying of acetylene. This publication includes recommendations for operational and maintenance safe practices to mitigate potential acetylene decomposition and other hazards related to the purification, compression and drying of acetylene.

The equipment named is typical for carbide acetylene plants. In petrochemical plants similar compression and drying equipment can be used, but normally there is no purification system as this production method is not creating non-metal hydride (e.g PH3) impurities as in carbide acetylene plants.

This publication covers equipment from the exit of the generator to the entry of the fill manifold.

The scope of this document may be seen in diagram 1 below in the blue circles.

- Purification
    - Dry or wet acidic purification (followed by caustic soda or water neutralisation)
- Compression
- Drying
    - Low pressure drier
    - High pressure drier

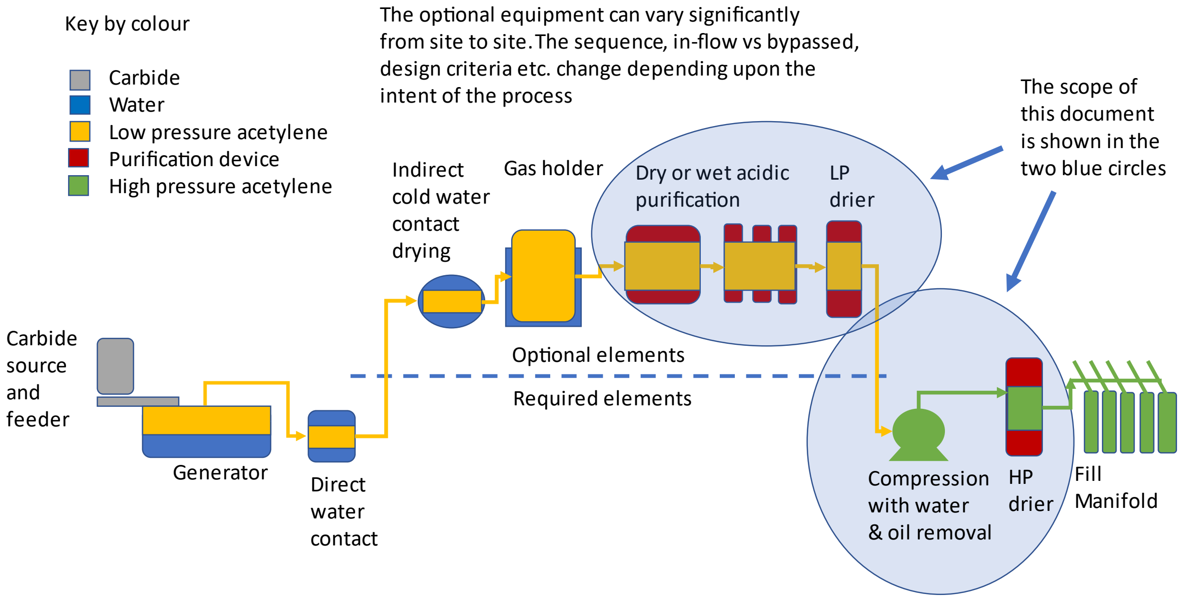

Figure 1 Overview of production process for acetylene (generated from calcium carbide)

3 Definitions

For the purpose of this publication, the following definitions apply.

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

Indicates 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 Hydration of acetylene

The combination of the acetylene with the moisture in the gas when the moisture is greater than saturation and the pressure/temperature of the acetylene is within a defined zone. Can lead to flow restrictions which in turn lead to increased pressure drop and hence greater (unwanted) cooling.

3.2.2 Moisture

Moisture is expressed in a number of different units. Below is a table expressing moisture in acetylene in a number of the more commonly used units.

Dew Point temp @ 1bara [°C]	moisture content by volume [ppmV]	moisture content by weight [ppmW]	Absolute Humidity [g/m3]	Dew point temp @ 26bara [°C]
-60	11	7,4	0,008	-32,9
-50	39	27,0	0,030	-20,1
-40	127	88,0	0,100	-7,1
-30	375	260,0	0,300	6,8
-20	1.019	706,0	0,800	22,3
-10	2.565	1.776,0	2,000	38,4
0	6.032	4.176,0	4,600	55,2
10	12.100	8.377,0	9,200	70,3
20	>23.000	15.938,0	17,500	85,8

3.2.3 Pressure

In this document bar shall indicate gauge pressure unless otherwise noted –i.e., (bar, abs) for absolute pressure and (bar, dif) for differential pressure.

3.2.4 Pressure Swing Adsorption (PSA)

PSA is a technology used for removing an undesired (contaminant) gas present in a gas stream. The process is made under pressure and the contaminant is retained by an adsorbent material. The adsorbent is regenerated by reducing the pressure and using a carrying gas.

3.2.5 Dry purifying media

A typical composition is:

35%	Diatomaceous Earth (DE Diatomite) a naturally occurring, soft, siliceous sedimentary rock that is easily crumbled into a fine white to off-white powder
63%	Ferrous chloride (as a 35% solution in water) Containing impurities of ferric chloride, copper and acid
1.1%	Copper sulphate
0.3%	Manganese Dioxide
0.2%	Mercury Bichloride

NOTE Trade names for this include Monkey Dust, Catalysol or Heratol

3.2.6 Temperature Swing Adsorption (TSA)

TSA is a technology used for removing an undesired (contaminant) gas present in a gas stream. The process uses thermal energy. The adsorbent is regenerated by raising the temperature of the adsorbent which acts in favour of increasing the gas desorption process.

3.2.7 ppmv

parts per million by volume

3.2.8 ppmw

parts per million by weight

4 Overview of the process

Acetylene exiting a wet calcium carbide generator is at low (< 0,2 bar) or medium pressure (< 1,5 bar) and at an elevated temperature 50°C to 90°C. The acetylene is saturated with water vapour (100 to 120 g/m3), and there are impurities – ammonia, hydrogen sulphide, phosphine (and lesser extent arsine). The purpose of the post generation equipment (low and high pressure) is to clean the gas so that it:

1. is at least 98% pure;
2. is free of impurities which would be corrosive to the materials of build of the plant, e.g acidic sulphuric compounds;
3. is free of water that would cause absorption problems for the porous material inside the cylinders;
4. has reduced phosphine and arsine impurities (for cutting and welding applications these impurities are irrelevant).

Typical values in raw acetylene from the wet generation process are:

	ppmv unless stated
Moisture	100 to 120 g/m3
Nitrogen	3600
Oxygen	750
Argon	50
Hydrogen	350
Methane	350
NH3	200 to 400
Hydrogen sulphide	50 to 300
PH3	400 to 500
AsH3	3

For the product specification see EIGA Doc 240, *Commodity Specification Acetylene* [1]

For use as a flame the quantities of phosphine, arsine and hydrogen sulphide are generally unimportant to the user but for other uses such as carbon black deposition these impurities may be impactful.

The steps of the process are:

1. Water soluble impurity removal
   Direct acetylene to water contact - ammonia scrubber
   Function: Removal of water dissolvable components e.g. ammonia and hydrogen sulphide
   Purpose: Prevention of internal corrosion of the pipes and vessels

2. Low pressure drying
   Indirect cooling of the acetylene – cooler condenser
   and / or
   Direct contact calcium chloride driers
   Function: Moisture reduction
   Purpose: Less water into downstream equipment

3. Low pressure phosphine and arsine removal
   Optional purification via contact with acidic compounds
   a. Direct gas contact with dry purification material
   b. Direct gas contact with strong sulphuric acid (afterwards neutralisation with caustic soda)

   Function: Removal of phosphine and arsine
   Purpose: High purity acetylene for customer processes

4. Compression
   Function: Increased pressure, and some further water removal
   Purpose: To be able to fill cylinders, bundles and trailers

5. High pressure driers
   Function: Final dryness of gas before entering cylinders
   Purpose: Removal of moisture to prevent damage to cylinders as moisture can:
   - mix with the solvent and reduce its ability to dissolve acetylene;
   - damage the porous material;
   - cause corrosion of the internal cylinder walls.

5 Impurities in Acetylene

See EIGA Doc 240 [1]

6 Impurity removal equipment

6.1 Direct contact with water - Ammonia scrubbers

Scrubbers are used on most medium and low-pressure acetylene generators to scrub and cool the exiting gas. They reduce the ammonia and hydrogen sulphide content of the gas. The scrubbers also prevent lime carryover. Some low-pressure generators have bubble-through water baths. The main purpose of these is to prevent back flow of acetylene from the gasholders or other generators but in addition they remove the lime and some of the ammonia and hydrogen sulphide. This method of scrubbing the gas is not as effective as scrubbers designed for the contact of the acetylene to the water and may not reduce the ammonia content of the gas to acceptable levels. Separate ammonia scrubbers may be used at low pressure generating plants.

6.2 Low pressure dryers

The acetylene leaves the generator saturated with moisture – its relative humidity is 100%. At approximately 1 bar and 60°C the saturation loading of acetylene is 130g of moisture per Nm3.

To be put into the cylinders the less moisture the better as overtime any moisture put into the porous material will cause damage (the cylinder becomes a “bad filler”). A good and achievable target is to dry the acetylene to below 0.1g/Nm3 (a dewpoint at atmospheric pressure of -40°C).

There are two options for drying acetylene

- Cooling the acetylene so that the relative humidity goes over 100% and water will form on surfaces and can be drained away

OR

- Passing the acetylene through a vessel containing an absorption material (e.g. calcium chloride, silica gel, molecular sieve).

6.2.1 Low pressure cooling and condensing to remove water from acetylene

It is possible to achieve some water removal without the cooling step of the cooler condensing regime. A vessel filled with a contact surface (“Raschig” rings or large diameter chain) will allow condensation at the current gas temperature. After the ammonia scrubber this will be less than it was in the generator, so some part of the humidity will condense.

This is not as effective as bringing the temperature of the gas down via a heat exchanger whilst at the same time condensing the moisture. A specially designed vessel with a water jacket surrounding vertical pipes called a cooler condenser achieves this function. The gas is cooled as it ascends the vessel, the moisture forming as liquid water inside the pipes drains downwards into an inlet header.

As acetylene is liable to liquify or form hydrate if it is cooled, the system design must ensure that this does not occur (see properties of acetylene in Doc 123, *Code of Practice Acetylene*, figure 2 hydrate formation) [2].

NOTE it is notable that in the low-pressure section of the wet production process the temperature of liquification and hydration is below -40°C, which can allow for control by use of the correct cooling media (water with glycol).

Another issue with cooling for water removal in the low-pressure part of the plant is the carryover of lime. For this reason, and the removal of ammonia, it is normal to have a wash system (direct water contact) before any cooling. It is also advisable to design the low-pressure cooler condenser in a manner to be resistant to lime build up and/or to allow cleaning.

As an example, if in the low-pressure part of the plant chilled water in a specially designed contact vessel / heat exchanger (cooler condenser) can drop the temperature of the acetylene from its discharge temperature of the generator from 60°C to 30°C, then this would remove 75% of the water from the acetylene i.e. to below 30g/m^3.

Without a technique involving cooling of the acetylene to remove of water then the first step of water removal will be either a low-pressure drier, absorption into purification material or the compressors.

6.2.2 Low pressure drying with direct contact to absorption material

The acetylene is passed through a vessel containing a solid drying material.

The typical low pressure drying material is calcium chloride.

The drying achieved depends upon contact time with the calcium chloride so as the pressure is low the vessel size is correspondingly large.

Given sufficient contact time the acetylene may be dried completely this way, but it will consume calcium chloride. See section 8 for good practices for high-pressure calcium chloride driers. Note that the formation of a void in a vessel of low/medium pressure is a much-reduced risk in comparison to that of a high-pressure vessel.

6.3 Purifiers

Acetylene is purified mainly to remove phosphine and hydrogen sulphide. The need for purification is based on the calcium carbide quality, the process and required acetylene specification. Two purifying methods are in use, dry purification and wet purification. Both require careful design as the residence time of the gas and the contact efficiency to the reactive material determine the effectiveness of the purification.

6.3.1 Wet purification

In the wet purification process acetylene is passed through a tower filled with a packing material such as “Raschig” rings. Concentrated sulphuric acid is pumped into the top of the tower and flows downwards against the acetylene flow. Phosphine and hydrogen sulphide are removed by contact of sulphuric acid with acetylene. Any acidic substances carried over with the acetylene are neutralised in a subsequent alkaline scrubbing tower. It is important that the system is kept cool as the reaction is exothermic.

Polymerisation of acetylene in wet purification is a safety issue as it forms a tar like substance that can cause blockages through the process. Polymerisation of acetylene in the wet purification process is associated to:

1. Excessively strong acid concentration >98%

   Purification requires above 80% but beyond 98% the potential for polymerisation increases.

2. Increased temperature

   A nominal temperature of operation should not exceed 25°C.

   If the system becomes warm (>40°C) this will facilitate polymerisation.

3. Presence of impurities

   Iron and Mercury impurities in the acid will catalyse promote polymerisation.

   Iron impurities are not atypical as the generator and low-pressure plant are made of steel

   Other impurities can be found in the fresh acid depending upon the source and grade/quality.

The maintenance of the correct acid concentration is important otherwise phosphine could be dissolved in the acid in the scrubber sump and possibly be released and ignite spontaneously on contact with air.

To avoid the rapid decrease in concentration of the acid due to moisture in the acetylene sometimes the weak acid that has been exhausted in the purification tower is put in a similar tower upstream – providing a water removal process before the purification tower.

After direct contact with sulphuric acid the gas stream is acidic and highly corrosive. Before contacting piping and vessels made of steel it must be neutralised. For this purpose, a third similar tower is placed after the strong acid tower but with a weak alkaline wash flow (NaOH at 4% to 10%)

At the end of its life, the weak acid (60% concentration) will need disposal. One option is use of the lime treatment facilities. Care needs to be taken when adding any acid to alkali as the reaction will often be violent. Also even with small quantities unpleasant odours can be generated.

6.3.2 Dry purification

Dry purification is no longer the preferred method of purification due to environmental reasons when disposing of the purification medium. In the dry purification method acetylene is passed through a vessel containing several layers of purifying compound, which removes the acetylene impurities. All purifying compounds are acidic and have a corrosive effect on human tissue. When the raw acetylene passes through the purifier material, the phosphine and the remaining traces of hydrogen sulphide and ammonia are oxidized or absorbed and removed from the gas stream. The purifier material becomes less efficient after a finite lifetime and must be regenerated or re-oxidized by exposure to air. Then it may be reused. It is normal to humidify the air used to regenerate the material. The material can be regenerated several times before it has to be discarded. Some of these dry purification compounds contain mercuric chloride which could result in the release of free mercury which can accumulate in dangerous quantities. It is necessary to monitor the purifier's performance and change the compound when it starts to deteriorate in performance.

7 Compression

Acetylene generated via the wet calcium carbide process is at low pressure (<1,5 bar). To be filled into cylinders at an efficient rate compression is required.

7.1 Pressure

Acetylene becomes more "active" (easier to start the effect) in terms of decomposition / deflagration / detonation as it is pressurized and heated – so compression of acetylene increases the hazardous nature of acetylene. Different regulations apply in different countries, but it is common in Europe to not permit the acetylene compression to reach pressures greater than 25 bar. Relief valves for the restriction of the high pressure shall not have a lift pressure greater than 110% of operating pressure i.e. 27,5 bar.

7.2 Temperature

Acetylene also becomes more "active" as it becomes warmer - so the heat of compression is removed in steps or stages. It is common for an acetylene compressor to have 3 or more stages with a heat exchanger between each stage that brings the temperature of the acetylene down to below 70°C before it enters the next stage, and after the final stage.

7.3 Liquification

Another step change in the hazardous properties of acetylene occurs should it liquify. This is sufficiently hazardous that it must be avoided by process design not by instrumented safeguards. This change of state defines the operating parameters (pressure and temperature) of the high-pressure part of the plant. The Mollier curve is the line for liquefaction of acetylene and a description of how it is used to define the operating parameters of a plant is given in TB 34, *Acetylene Plant Safe Operating Pressures and Temperatures* [3]

Beyond the restriction defined by the Mollier curve some countries have regulations pertaining to the maximum pressure allowed in the high-pressure part of an acetylene plant. The sites operating permit shall be consulted to see if there are such local restrictions.

7.4 Design considerations for acetylene compressors

The design of acetylene compressors is a specialist engineering subject and should not be attempted without suitable understanding and knowledge. This document does not provide enough detail for the design of an acetylene compressor, it describes the hazards, operation and maintenance of acetylene compressors.

1. The overpressure design of the stages of the compressor shall be based upon the three pressure categories used for piping. The final stage and downstream elements (intercooler) shall be designed for a minimum of 300 bar operation.

2. The theoretical temperature at the outlet of each stage based upon adiabatic compression shall not exceed 140°C (when using oil lubricated compressors), see TRAC 203, Acetylenverdichter, Abschnitt 5 (Technische Regeln für Acetylenanlagen und Calciumcarbidlager) [4]

3. The outlet temperature of the compressor final stage, after intercooler, shall not exceed 70°C, see TRAC 203, Acetylenverdichter, Abschnitt 5 (Technische Regeln für Acetylenanlagen und Calciumcarbidlager) [4]

Each stage of compression shall be provided with overpressure protection relief valves.

Intercoolers between stages of compression may be air/acetylene or water/acetylene. Water/acetylene intercoolers may be either a water bath or a flowing heat exchanger design. Where water is used as the cooling media it is normal to have either an overflowing water bath or a monitor of water flow. The temperature of the acetylene after the intercooler shall be visible and may be alarmed.

The pressure after each stage of compression shall be displayed.

It is common practice to use compressors designed for other gas service in acetylene service. Authorities will find compressors in use for acetylene that are not stamped “acetylene”. Common stamping will include air and helium.

It is normal for water and oil from the compressor stages to be removed at intercooler stages. It is not possible to advise how much water and oil removal will be normal as it depends on both the prior steps of the process and the compressor design. Oil contamination of cylinders normally occurs only when the moisture traps and drip legs of compressors are not drained on a routine basis. At such times a mixture of oil and water can be carried forwards – creating pressure drop at flash back arrestors and getting into the cylinders. It can also contaminate the material used in the high-pressure driers.

However, a regular and practiced pattern of withdrawing liquid from intercooler and final cooling stages is required. The normal amounts should be established at commissioning so that operators can report any significant deviation, and so that the quantities do not drift with time/age of the compressor without being recognised as wear and tear of the compressor indicating the need for maintenance.

7.5 Use of flash back arrestors (FBA) after compression before drying

Care must be taken when fitting FBA after compression but before drying. The acetylene is saturated with water – the moisture in the acetylene has been “knocked” out after a cooler section. If the acetylene passes through a restrictive element (FBAs are often creating a pressure drop due to their design) then a gas expansion may/will occur which cools the gas. The cooling gas can lead to either hydration of the acetylene or the water released from the acetylene may lead to increased flow restriction through the FBA. Either effect leads to significant pressure drop across the FBA.

7.6 Compressors with no separation between piston and crank case

Compressors come in two types with regard to oiling of the stages – direct connection to the crankcase or separation of crankcase and compression stage (indirect oilers).

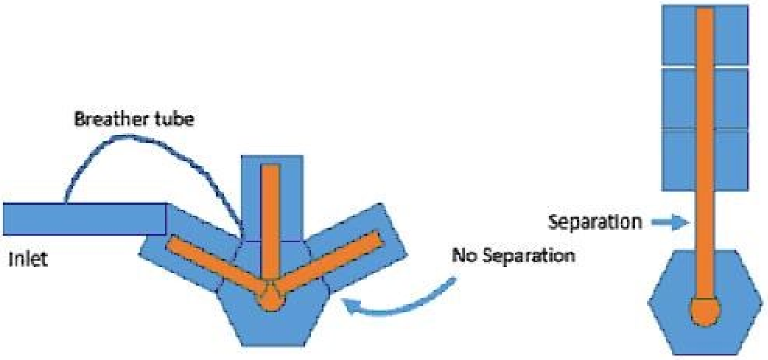

Figure 2 Examples of acetylene compressor configuration

A review of incidents involving acetylene compressors without separation sections has shown that there is a risk of elevated pressure in the crankcase should the breather tubing become blocked. Then If there would be a cause of decomposition the crankcase is not designed for the resulting pressure and failure of containment occurs.

A feature of acetylene compressor design that differs between manufacturers is whether the crankcase is directly or indirectly connected to the piston heads of the compressor. Some manufacturers have a separation section between the crankcase and the piston heads, using a lubrication pump to provide oil to the pistons. Others have the piston heads directly associated to the crankcase, providing oil to the piston by means of splashing. Both are valid designs for acetylene service, and both have positive and negative considerations.

This section applies to compressors without a separation section between the crankcase and the cylinder/piston section and that are equipped with a breather tube for pressure equilibrium in the crankcase. On these compressors the gas that passes the piston via the piston rings accumulates in the crankcase and is relieved via a breather to the suction side of the first stage of compression. Operating correctly, the crankcase will have a pure acetylene atmosphere at suction side pressure.

Typically, these compressors will have a pressure indicator on the crankcase that the operator can regularly monitor, for example on an hourly basis, confirming that the crankcase is not running at elevated pressure. However, a fault condition can occur if the breather tube becomes blocked. Under these circumstances the acetylene pressure in the crankcase can rise, in theory, to the compressor discharge pressure. The crankcase is not designed for this pressure, nor for the overpressure that could result from an acetylene decomposition.

This event poses a risk of injury or fatality to a worker if near the compressor. EIGA recommends that production plants consider the implementation of further safeguards to avoid this risk.

The primary safeguard should be a pressure relief valve (PRV). The PRV would allow excessive acetylene pressure to be vented safely, that is piped to a safe location, commonly by piping into the exhaust line of the piston head relief valves. The PRV should be set at a value to avoid inadvertent lifting of the relief valve. This value is typically between 50% to 100% above the peak value experienced in normal operation. As the quantity of gas that should pass the piston rings is very small, even with one of the piston rings in a fault condition, the PRV sizing would be nominal (small), but large enough that condensed oil vapour cannot block it.

The facility may consider the use of an additional pressure switch high (PSH) monitoring the crankcase pressure. The PSH would stop the compressor if an abnormally high pressure developed in the crankcase. This PSH would be set at a value high enough to avoid nuisance trips typically in the range of 25% to 50% above the peak value experienced in normal operation.

The safety devices (PRV and PSH) should be mounted a minimum 0.5 m above the upper edge of the crankcase. The piping shall be installed with a permanent slope towards the crankcase, so that condensed oil vapour will safely flow back into the crankcase and does not block the piping. The connection point of this safety device piping to the crankcase shall be above the normal oil level in the crankcase to ensure oil does not enter the piping. Figure 3 shows one possible arrangement of safeguard.

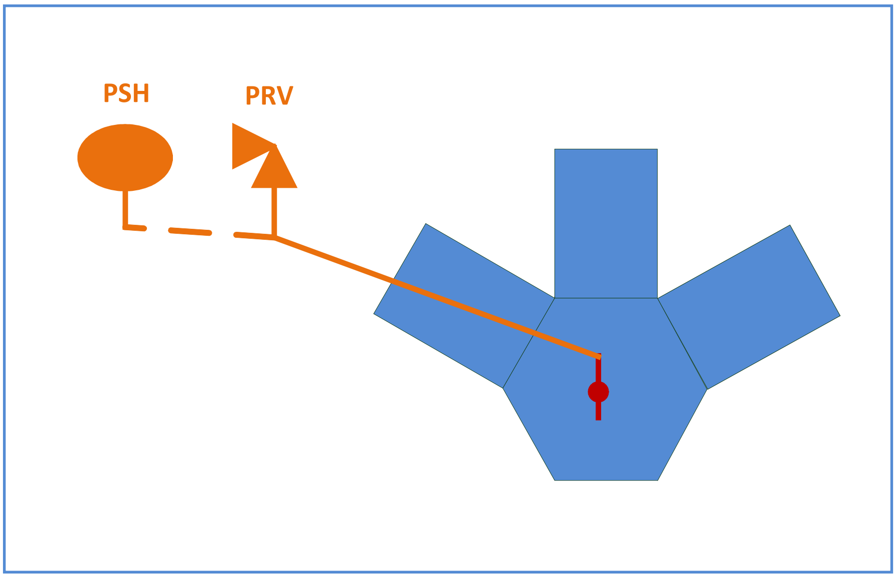

Figure 3 Example of crankcase overpressure protection

EIGA recognises there are alternative approaches to the protection of the worker from the hazards of compressors in acetylene service. The facility is required to undertake risk assessment of their facility and may find that an alternative to the method described is suitable to their process.

8 High pressure drying

After compression and cooling/condensing the water content (humidity) of the acetylene is still too high for putting into the cylinders and requires some further form of drying. Various designs exist.

An effective high-pressure drier will achieve moisture values in the range of 100 ppmv or below.

Exceeding this value (filling using wetter acetylene) will not become apparent immediately unless measured, only over time will all cylinders become harder to fill. A regime of regularly testing the humidity of the compressed acetylene (often after letting down the pressure by regulator) is advised.

Being lower than this value is not harmful. The acetylene is already “dry” in terms of its potential ability to decompose and becoming drier does not materially increase that risk. The system design needs to account for this higher potential “desire” of the acetylene to decompose – see Doc 123 for info on flame arrestors and flash back arrestors [2].

There are three types of absorption materials used for drying:

- Once used it is discarded = Calcium chloride
- Once used it may be regenerated offline = Silica gel

  Normally regenerated (if regenerated) by taking the material to a separate oven to be baked dry
- Once used it is regenerated “online” = Zeolite molecular sieve

  Used in twin vessels with one being regenerated whilst the other is used.

  Regeneration may be either/both pressure & temperature

8.1 Operation and hazards of different drying methods

Issues common to all forms of acetylene drying include:

8.1.1 Removal of moisture before drying - back pressure of compressors and high-pressure driers

To reduce the moisture loading on the driers in acetylene plants the water is removed earlier in the process, such as at the compressors. To ensure compressors are removing as much moisture as practical they have to discharge against pressure, typically provided by a back-pressure regulator. The back-pressure regulator is normally placed after the driers as this will also ensure suitable contact time for the drying media. If the system does not incorporate a back pressure regulator and it is decided to fit one, then an engineering management of change process shall be followed to ensure that the overall design is not compromised, see EIGA Doc 51, Management of Change [5].

8.1.2 Absorption efficiency

Absorption efficiency of drying materials depends upon contact time between the gas and the material – residence time. In high pressure drying the residence time is impacted by the pressure in the high-pressure system i.e. what stage the filling of the cylinders has reached. This can mean the gas will not have enough residence time at the beginning of the fill when the pressure is low. To avoid this a back-pressure regulator set at 10 bar to 14 bar is placed after a high pressure dryer to ensure the residence time required is achieved.

8.1.3 Voids

Voids in the absorption material can create larger than desired volumes of gaseous acetylene at high pressure. Larger volume voids (>3 litre) of acetylene create a risk of a high-pressure event inside the vessel that could lead to vessel failure. Vessels using material that is consumed during high pressure drying of acetylene e.g. calcium chloride driers, need to be designed for potential detonation not deflagration.

8.2 Calcium chloride driers

Calcium chloride absorption driers can be at risk of voids from two causes:

8.2.1 Voids forming during normal operation

The calcium chloride is consumed during use. Consumption leaves void space in the drier vessel. The size of this void needs to be minimised by regular replacement of the calcium carbide. It is recommended that the void size not be allowed to be greater than the lesser of 10% of the vessel volume or 3 litres (water volume). Normal operation of calcium chloride driers will, by experience, determine the frequency of calcium chloride replacement.

However, the rate of consumption of the calcium chloride depends on the rate of production of acetylene and the moisture content of that acetylene. Moisture loading of the acetylene entering the high-pressure drier is impacted by the rest of the plant operation – temperature of generator, draining of the knock-out pots of the compressor etc. Also increased acetylene production rate is a cause of increased moisture content per m^3 of acetylene.

Before opening any vessel in the acetylene process it is critical to complete a nitrogen purge. Detailed procedures of purging are out of the scope of this document.

8.2.2 Potential to form a bridge within the vessel

Bridging is where voids form under the apparent level of the calcium chloride. This void can be detrimental as the operator may believe there is sufficient absorbent when there is not.

The void may form under a significantly solid/strong bridge of calcium chloride. On top of the bridge there may be a layer of dry granular material obscuring the bridge. To identify if there is or is not a bridge the drier shall be out of operation and purged. An appropriate tool should be used to push through the remaining calcium chloride to reach the bottom of the drier. Once found it can be quite hard to physically breakdown the bridge – requiring a metal shaft and a hammer.

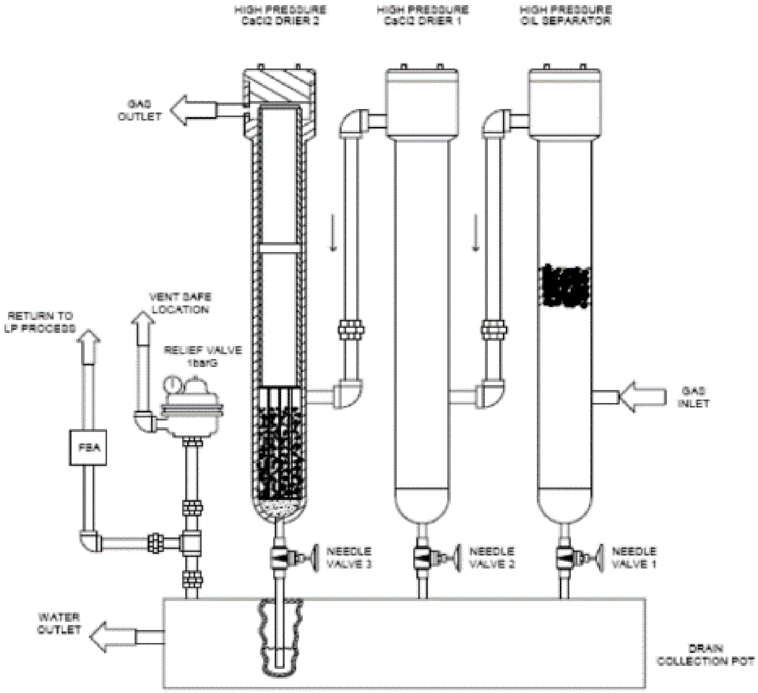

Figure 4 Typical high-pressure calcium chloride drier installation including oil separator

8.2.3 Good practices to consider for calcium chloride driers

8.2.3.1 Draining of the driers

$CaCl_2$ driers require periodic (typically hourly) “blowing down” to remove accumulated moisture. This involves discharging the water until gas is released. There is a risk when doing so that material draining from the drier could cause ignition in the outlet of the drainage system via either a static charge or a particle impact spark. This could then lead to a flashback that initiates a decomposition of acetylene within the drier vessel. One possible safeguard against this is to direct the drains of the drier to a locally placed water collection vessel where the drain lines are permanently below the height of the water, thus providing a seal against any flame returning to the drier. An alternative is to combine the individual vessel drains into a collection manifold at the bottom of the driers and drain this common vessel only when the pressure of the system is blown down to less than 1 bar. The draining valve of the vessels should be designed so as to restrict the gas velocity that is discharged. The use of quick opening valves (e.g. ball valves) is not recommended unless a method of restriction is incorporated into the valve design.

8.2.3.2 Provision of separating material at base of vessel

One of the causes for potential ignition of the gas released during blowing down is $CaCl_2$ crystals impacting a hard surface, such as concrete or steel. Provision of a separation layer between drying agent and space for liquid (e.g. stone, Raschig rings) at the bottom of the drier vessels can reduce this potential.

8.2.3.3 Cleaning of the vessel

Exposure of $CaCl_2$ to moisture creates a water discharge rich in $CaCl_2$ that can be viscous. If this is allowed to thicken it can lead to restriction in the discharge line. One safeguard against this is to thoroughly clean the drier vessels on a periodic basis. This can be accomplished by removing the unused $CaCl_2$ and washing with hot water or steam. Manufacturers recommend flushing the material at the base of the driers with at least 4 litres of warm water every time that $CaCl_2$ is changed or added.

8.2.3.4 Vessel corrosion

Maintenance programs need to include verification that vessels, especially those exposed to moisture, are inspected for corrosion to ensure that the mechanical integrity of the vessels, valves, and other components remain within the design parameters.

8.2.3.5 Electrostatic earthing

As with all parts of the acetylene filling process, especially those at high pressure, the equipment shall be adequately protected from the build-up of static potential by provision of earth strap wiring in accordance with International Electrotechnical Commission (IEC) codes of practice.

8.2.3.6 Rotation of cages

When refreshing $CaCl_2$, if contained in cages, the cages should be rotated from the top to the bottom in the same drier body, so that the older $CaCl_2$ gets consumed next. This ensures that all the cages are checked at every rotation and that the older $CaCl_2$ is used before it solidifies.

NOTE Not all constructions enable this rotation

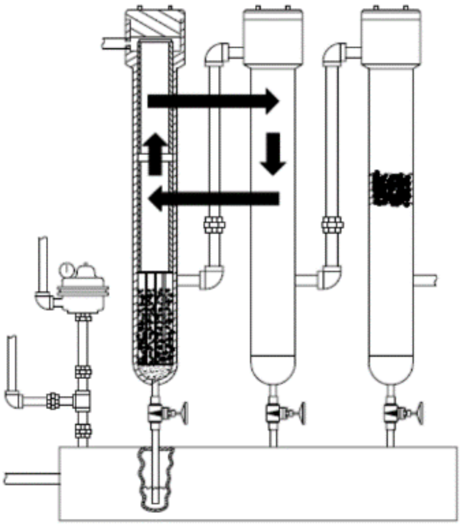

Figure 5 Examples of rotation of cages

8.2.3.7 Chemically purified acetylene

For wet purification systems, it shall be ensured that sodium hydroxide scrubbers remove the sulfur dioxide (formed in sulfuric scrubbers), otherwise, the gas flowing through the drier filled with $CaCl_2$ will react with the sulphur-dioxide and form the calcium sulphite dust and hydrogen chloride. Hydrogen chloride can combine with the acetylene to form vinyl chloride which is an impurity which can cause acetylene to decompose inside the drier.

8.3 Silica gel driers

Silica gel driers require material regeneration via an external oven so the vessel design and installation to facilitate easy replacement of the absorbent material.

8.4 TSA/PSA driers

TSA/PSA driers for acetylene typically have a swing time of 15 to 30 minutes.

The regeneration gas is typically a small (5-10%) flow from the dried side of the onstream vessel.

8.4.1 Temperature of the regeneration gas

The regeneration gas is expanded to low pressure to allow it to absorb more water than the vessel onstream, then after regenerating the off-stream vessel it is passed back to before the compression stage to blend with low pressure acetylene that is saturated with water. The additional water is then removed at the compression stage.

A potential problem occurs at the expansion step. The pressure drops from 25 bar to 1 or 2 bar leads to cooling below the freezing point of water. Water from the air, outside the piping, starts to freeze on the piping of the expansion circuit. That creates insulation and cold, which leads to a spiral of lower temperatures.

To avoid this issue the regeneration gas must be warmed during or immediately after the expansion. Keeping the regeneration gas warm at approximately 20°C avoids the problem

9 Monitoring water content after drying

There are various methods for determining the moisture content in acetylene. The frequency and required / target value of the monitoring will vary by process, but all plants need to establish a regime for monitoring moisture as no method of drying is without failure mode – so moisture breakthrough needs to be identified to stop causing significant commercial issues caused by addition of water to porous material in acetylene cylinders. Care is required with use of electronic equipment as the acetylene is a flammable / explosive gas.

10 Monitoring and maintenance

Each operation will have different manufacturers equipment and will use it with more or less intensity. Also each sites equipment will be of differing age. These and other factors will impact the need for and the frequency of maintenance.

This list of tasks and frequencies are only a starting point for a site to consider when making its site-specific maintenance task and frequency list.

The term “maintenance” may be interpreted differently by different people and may change within the context of the discussion. This chapter covers the following subjects:

- The regular checks made by operators on hourly, daily, weekly, monthly basis.
- The routine inspections and tasks made by technicians on longer time frames (yearly etc.).

10.1 Maintenance of ammonia scrubber (direct water contact)

Frequency	**Description of task**
Operator activities	
Hourly	Check and record temperatures and pressures
Daily	Check the water level or water flow
Weekly	Change the water
Technician activities	
Yearly	Visual inspection
	Function check of pressure, temperature and level/flow instruments
	Bolting down

10.2 Maintenance of cooler condenser (indirect water/media cooled drier)

Frequency	**Description of task**
Operator activities	
Hourly	Drain condensate (if automated, confirm operation)

	Check and record temperatures and pressures
Weekly	Check drain valves for leakage
Technician activities	
Yearly	Visual inspection
	Function check of pressure, temperature and level/flow instruments
	Bolting down

10.3 Maintenance of low-pressure purification systems

Frequency	**Description of task**
Operator activities	
Hourly	Check and record temperatures and pressures
	Check function of recirculation pumps on acid/alkali
Daily	Check the water level / flow in ammonia scrubber
	Check the level of acid/alkali
	As required by batch perform a purity test. This may be indicative of need to replace or regenerate purifier media Alternatively sites may have a operating time basis for replacement or regeneration of purifying media.
Monthly to 3-monthly	Routine cleaning and draining activities on purification units These tasks are equipment and usage dependant. Each site needs to create its own list and frequencies.
Technician activities	
Yearly	External Visual Inspection of flexible hoses on purification
	External Visual Inspection of vessels Leakages or bulges on any non-ferrous vessels
	External Visual Inspection of bunds for acids, alkalis and neutralising pits
	External Visual inspection of acid/alkali pumps
	Check for any blockages (pressure drop, lack of flow) in acid/alkaline systems.
	Check the function of pressure and temperature instruments
	Bolting down
	Check earth bonding
As per regulation	Mechanical integrity checks of vessels and other equipment

10.4 Maintenance of compressors

Frequency	**Description of task**
Operator activities	
Hourly	Check and record temperatures and pressures
	Drain condensate from all stages (if automated then confirm function)
	Check the cooling water temperature or water bath temperature or that air cooled system is functioning
Daily	Check oil level and replenish as required
Weekly	Visual check of the oil condition (colour and viscosity)
Monthly	Clean air-cooling elements for air cooled compressors
	Drain and replenish water form water bath compressors
	Check the belt drive condition and tension Main motor and oil pump
	Check and compare the pressure/temperature of each stage vs “good/clean” values
	Check and compare any differential pressure measurements of filters etc. vs “good/clean” values
Technician activities	
Yearly	Visual and audible inspection of compressor Belt drives. Noise. Oil and lubricants.
	Oil change if not completed during year

	Check, clean, replace suction filters
	Function check of pressure, temperature and level/flow instruments
	Bolting down
	Check earth bonding
	OEM recommended maintenance of compressor e.g. Cleaning of cooling coils or water bath Checking condition of corrosion prevention anodes
As per regulation	Relief valve testing/replacement
	Retesting of Pressure Equipment Directive (PED) components [6] e.g. oil-water separator Note local country regulations may require additional testing beyond PED
	Safety critical instrument calibration and loop test e.g. low pressure suction on the compressor high pressure, high temperature exiting the compressor

10.5 Maintenance of high-pressure driers including oil separators

Frequency	**Description of task**
Operator activities	
Hourly	Check and record temperatures and pressures
	Drain $CaCl_2$ driers
Daily	Drain absorbent media driers (silica gel)
	Check the function of automated valves on PSA/TSA driers
Weekly	Check level and refill media in $CaCl_2$ driers This frequency is dependent on usage and equipment capacity
Monthly	Regenerate media in absorbent driers (Silica gel) This frequency is dependent on usage and equipment capacity
Technician Activities	
Yearly	Function check of pressure, temperature and level/flow instruments
	Clean and internally inspect $CaCl_2$ driers
	Check the earth bonding
	Check the nuts of flanges for suitability for re-use
As per regulation	Mechanical integrity checks of vessels and other equipment e.g. silica gel or PSA/TSA driers
	Retesting of Pressure Equipment Directive (PED) components [6] e.g. oil-water separator Note local country regulations may require additional testing beyond PED

11 Training and Procedures

The following guidance covers the aspects specific to acetylene purification, compression and drying elements. Lock out / tag out, work permits etc as described under safe working practices are not mentioned but shall be included in employee training as required. See EIGA SL6, *Life Saving Rules* [7]

Site specific training and procedures are required for activities undertaken by the operational team.

- Purification
    - Receipt, inspection and storage of purification materials
    - Changing out of the purification materials
        - Purging of process
        - Hazards of the materials during handling
    - Start up and shutdown (isolation or bypass)
    - Monitoring the function of the purification (sampling and analysis)
    - Operational issues applicable to the purification

        - Causes and identification of abnormal operation e.g. high temperature, pump operation, blockages or channelling
        - Causes of and identification of vessel damage

- Compression
    - Startup and shutdown
    - Use of individual compressors at different speeds
    - Use of one or more compressor at the same time
    - Use of a precompression blower to build required suction pressure as required
    - Operational monitoring of the compressor (a checklist and a frequency of observation). Temperature and pressure of each stage
    - Operation of the compressor – draining of water knock out vessels
    - Operational issues applicable to the type of compressor
- Driers

  Maintenance of PSA driers is not to be completed without technical support. The following applies to the operational activities associated to absorption driers:

    - Start-up and shut-down
    - Replacement of absorption material
    - Monitoring the function of the drier (sampling and analysis)
    - Operation of the dryer - draining of water knock out vessels
    - Operational issues applicable to the dryer
- Emergency procedures relating to purification, compression and drying equipment.
    - Identification of emergency situations
    - Emergency shutdown procedures.

12 Maintenance requirements and associated procedures

Maintenance shall be split into actions and tasks completed by:

- The operational team
- Those requiring technical support beyond the operations team.

All maintenance activities completed by the operational team shall have site specific procedures with step-by-step guidance. All maintenance activities completed by operational team members shall have written risk assessment and the procedure state the PPE (and other safeguards) required at each stage of the task. Before undertaking maintenance activities completed by the operational team all operators involved in the activity shall be trained in that activity.

Maintenance activities completed using non-operational technical support may not require site specific procedures, they may rely on the use of original equipment manufacturer manuals and guidance. Where such activities are required, it is recommended that company procedure managing the activity be implemented e.g. work permit, safe systems of work etc.

When it is required to maintain a system which has had or will have acetylene inside then it is necessary to purge the system before and after the maintenance. Refer to doc 123 [2]

Records of maintenance and inspections shall be retained as per company policies. It is recommended that the records are retained for the period of at least the last two relevant activities.

13 References

Unless otherwise specified, the latest edition shall apply.

[1] EIGA Doc 240, *Commodity Specification Acetylene,* www.eiga.eu

[2] EIGA Doc 123, *Code of Practice Acetylene,* www.eiga.eu

[3] EIGA TB 34, *Acetylene Plant Safe Operating Pressures and Temperatures,* www.eiga.eu

[4] TRAC 203, *Acetylenverdichter, Abschnitt 5 (Technische Regeln für Acetylenanlagen und Calciumcarbidlager),* www.arbeitssicherheit.de

NOTE this document is not officially published anymore and only mentioned to give background and to retain knowledge

[5] EIGA Doc 51, *Management of Change*, www.eiga.eu

[6] Directive 2014/68/EU of the European Parliament and of the Council of 15 May 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of pressure equipment (*PED), https://eur-lex.europa.eu/*

[7] EIGA SL6, *Life Saving Rules,* www.eiga.eu