SAFE OPERATION OF ACETYLENE GENERATOR SYSTEMS

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1 Introduction

This document has been prepared by the European Industrial Gases Association (EIGA) to provide guidance for the safety requirements in acetylene generation.

2 Scope and purpose

2.1 Scope

This publication is intended to provide general guidelines for safe operation of acetylene generator systems.

This publication is limited to acetylene generation systems using calcium carbide added to water known as wet generation.

The scope includes:

- the carbide supply from receipt at site to entry into the generator
- the generation of acetylene to the pipe leaving the generator
- the control of temperature via water supply into the generator
- the control of level via the discharge of lime out of the generator
- gasholders and buffers

The scope does not include:

- water utilities
- lime handling after discharge from the generator
- response to emergency or abnormal situations (refer to EIGA Doc 231, *Response to Operational Issues in Acetylene Plants*) [1]

3 Definitions

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 generator

Equipment in which acetylene is generated from the reaction of calcium carbide with water.

3.2.2 Backflow prevention device

Double check valve arrangement device used to ensure proper backflow prevention of water/acetylene.

3.2.3 Bridging

When a solid material, such as calcium carbide, gets jammed/compacted and blocks/restricts flow of material.

3.2.4 Calcium Carbide containers

Vessels normally made of sheet steel with a rectangular or cylindrical shape. They are water-tight and are handled either by forklift or crane. The containers can be classified into intermediate bulk container (IBC) with a capacity up to 3 m^3 or 2,5 t other containers up to 22m^3 or 20 t.

3.2.5 Calcium Carbide island

Unreacted calcium carbide floating on the liquid surface in the generator.

3.2.6 Calcium Carbide conveyor

Mechanical device for the controlled transfer of calcium carbide from the feed hopper to the generator tank.

3.2.7 Calcium Carbide hoist.

Hoist that is intended to lift Carbide to the top of the generator. Terms that are used for the object lifted are skip, container, fill cart, flow bin, turn bin.

3.2.8 Closed charging hopper

The closed charging hopper is permanently mounted on top of the feed hopper and is separated from it by an isolation valve. It is fitted with an isolation valve on top to which a charging turn bins / flow bins can be connected. It has connections so that it can be purged with nitrogen and the gas contents analysed.

3.2.9 Drums

Drums are vessels manufactured from sheet steel with a capacity up to 400 kg but usually not exceeding 110 kg. They are water-tight and, depending on the design, drums can be used for one or multiple trips. Larger drums are sometimes referred to as barrels.

3.2.10 Feed hopper

Permanent part of the generator and provides a continuous supply of calcium carbide to meet the demand of the acetylene production.

3.2.11 Feed hopper cover

device which isolates the feed hopper from the atmosphere. It is only used in the open charging systems of generators.

3.2.12 Fill cart

Calcium carbide transport vessel, typically conical (funned) shaped, with a bottom valve. This unit is used to transfer calcium carbide for transportation packages to the generator feed hopper. See figure 1 for an example of a fill cart.
NOTE Also referred to in the industry as buggy, skip, cart, transfer hopper/cart.

3.2.13 Flash back arrestor

Device to stop a flame front and the flow of gas in the case of acetylene decomposition. This device can be activated either by a pressure shock wave or by a temperature sensing device.

3.2.14 Generator carbide isolation valves

Carbide isolation valves separate the various permanent and removable parts of the generator system. They are gastight and can be operated by hand or remote control. In generators with a closed charging system the isolation valve takes the place of the feed hopper cover/lid.

3.2.15 Generator feed hopper

Conical shaped vessel permanently installed on the generator and used to supply calcium carbide to the generator for acetylene production.

3.2.16 Grain size

The grain size defines the dimension of the calcium carbide pieces. The specification for the grain size of calcium carbide will depend upon the requirements of the generator system.

3.2.17 Hot spot

Phenomenon where calcium carbide accumulated under water and the reaction with the water allows it to potentially exceed the ignition temperature of acetylene inside a generator.

3.2.18 Open charging hopper

Is permanently mounted on top of the feed hopper and is separated from it by an isolation valve. It is used as an intermediate storage for the calcium carbide and is filled from either a charging skip or a turn bin / flow bin.

3.2.19 Turn Bins and Flow Bins

Bulk container (approximately 1.5 tonnes) which has only one opening at the base which is used for filling and emptying. The bin is turned at the carbide manufacturers to enable it to be filled.
Flow Bin is a bulk container (approximately 1.5 tonnes) which is filled from the top and emptied from the bottom.
Both systems reduce the amount of handling required when recharging the generator hopper and can be fitted with a pull out slide valve or with flaps to release the calcium carbide. The turn bin / flow bin is normally sealed to the plant hopper by a soft seal to ensure that there is no release of gas or dust.
Both flow bins and turn bins are fitted with quick connectors to allow a nitrogen supply and a vent line to be connected for the purpose of purging the turn bin / flow bin.

3.2.20 Wet generation

Process of making acetylene gas where calcium carbide is added to water.

3.2.21 Turnplate

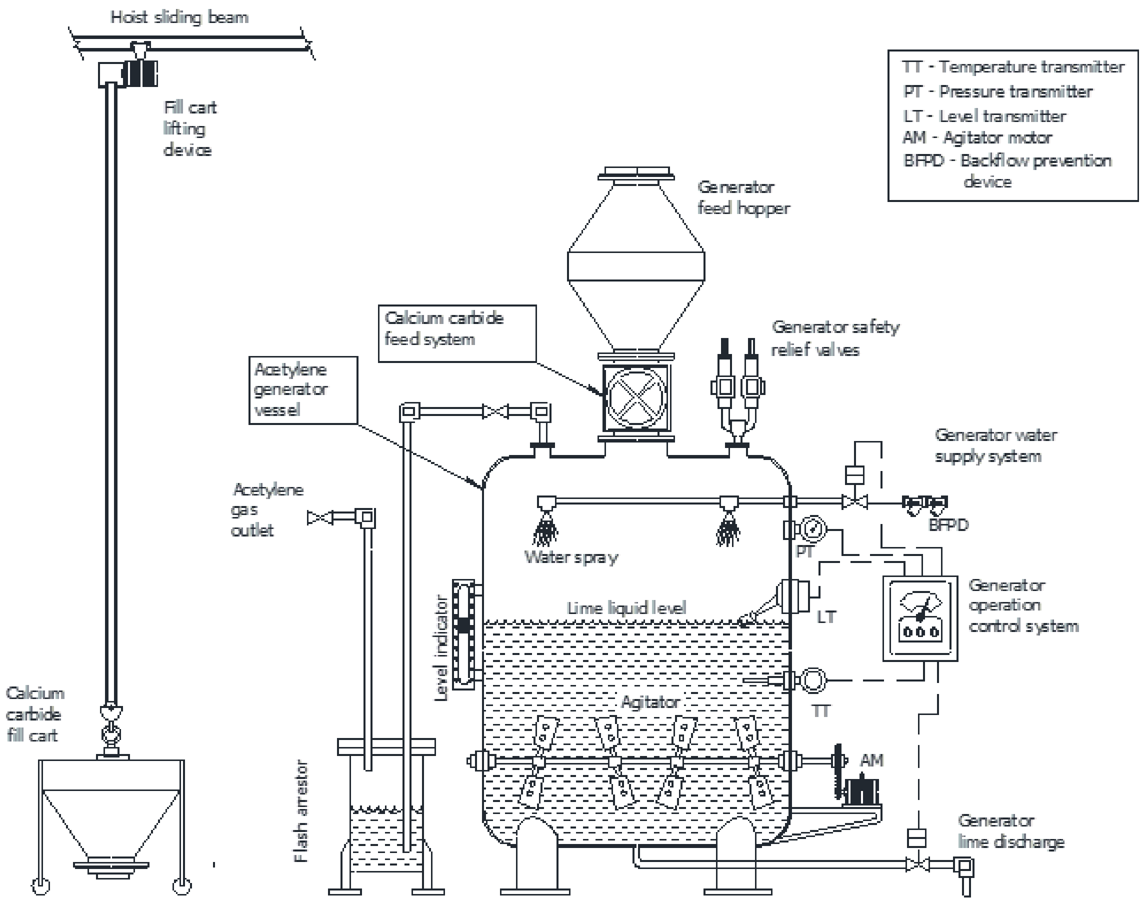
Grid in the generator body that holds the calcium carbide to improve the gas generation process. Once the calcium carbide has completely reacted, the grid is turned over to remove the calcium carbide residues from the grid.

4 Acetylene generator

4.1 Description of the equipment

The generator system typically consists of the following components:

- Calcium carbide fill cart
- Carbide hoist (fill cart lifting device).
- Carbide feed hopper.
- Calcium carbide feed system, typically a screw feed, gravity feed or vibrators.
- Acetylene generator vessel
  - Generator carbide feed control system
  - Generator agitator
  - Generator safety relief system
- Acetylene piping
  - Acetylene flash-back protection.
- Generator water supply system
  - Generator temperature control system
  - Reverse flow protection.
- Generator lime discharge system
  - Generator level control system
- Inert gas supply system for
  - The acetylene generator when doing cleaning/maintenance.
  - The carbide supply when recharging the carbide feed hopper.
  - Handling emergencies on the acetylene generator (e.g. fire).



4.2 Acetylene generation chemical process

Acetylene is generated by the reaction of calcium carbide with water. This reaction is expressed by the formula:

$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$ ΔH= 129.9 kJ

Pure calcium carbide would liberate 2028 kJ per kg at 18º C and 1 bar. Commercial calcium carbide (typically about 80 % purity) would generate 1793 kJ of heat per kg of calcium carbide.

Calcium carbide reacts rapidly with water or even moisture in the atmosphere to generate acetylene and a carbide lime residue. This reaction creates considerable heat (exothermic reaction). The heat of reaction in the generator is controlled by use a large excess of water so that the heat can be dissipated.

The water to carbide ratio is approximately 8:1, but may vary between 7:1 and 10:1.

Calcium carbide is a grey rock-like solid that comes in irregular sized pieces, typically ranging from 5 mm–80 mm depending on customer specifications. The colour could be different when some of the minor impurities dominate (e.g. if there is a high content of ferrous oxide the colour can be browner).

Calcium carbide typically contains 15-20% impurities. The main impurities are un-reacted lime (7-14%) and coke (0, 4-3, 0%). Additionally, there are a minor number of chemical compounds containing iron, silicon, aluminium and magnesium. The impurities present also depend on the source and quality of the raw materials used.

Calcium carbide shall be kept dry, to avoid unwanted reactions generating uncontrolled acetylene release. The yield from the acetylene production process is expressed in terms of the volume of acetylene gas recovered from the weight of calcium carbide used. The maximum yield is maintained by ensuring the generator water reaction temperature is kept between 70°C and 80°C.
The yield also depends on the grade size of the calcium carbide, in general the greater the size the higher the yield. Typical yields are between 265–300 litres of gaseous acetylene per kilogram of solid carbide.

4.3 Generator carbide charging systems – open and closed

The generator charging systems can be classified as open and closed charging systems:

- Open systems have a fill cart that is loaded with carbide from the supplier's carbide supply package away from the generator. This open fill cart is lifted to the generator feed hopper for charging.

  A typical example would be the use of several 100kg drums of carbide placed into an open fill cart of 500kg capacity that is then lifted above the feed hopper of the generator. The feed hopper is loaded from the fill cart when it is becoming empty.

- Closed systems make use of the supplier's turn bins / flow bins to directly load the generators feed hopper. There is no time period when the carbide is open to atmosphere in a closed charging system as there is a seal between the supplier's turn bin / flow bin and the feed hopper during the load of the feed hopper.

  Closed charging systems shall be purged before transfer of the carbide as acetylene may have been created in either the supplier's turn bins / flow bins or the receiving hopper. To avoid transfer of this nitrogen purge gas into the generator some generator systems have a pair of feed hoppers, one above the other, to allow the nitrogen to be removed before transfer of the carbide to the feed hopper of the generator.

  In general closed charging systems are preferred because they are safer during charging – but they do depend upon adequate purging for that extra safety.

The following general safety aspects shall be observed when charging carbide:

- Closed containments of carbide (suppliers' turn bins / flow bins and generator hoppers) shall be adequately purged with nitrogen before use.
- Lifting limits of equipment shall not be exceeded.
- The lifting method and equipment must be suitable.
- The generator feed hopper shall not be overfilled – the intended load must fit into the hopper.
- Generation of static electricity shall be avoided and discharged safely.
  - All components of the generator system shall be electrically connected and earthed to the same point to ensure equalization of the electrical potential.
  - The fill cart or turn bin/flow bin shall be earthed to the same potential as the generator during the flow of the carbide into the feed hopper.

4.4 Generators classification

Acetylene generators operate at "low" (below 0.2 barg) or "medium" (from 0.2 to 1.5 barg) pressure. Overpressure protection systems shall ensure that the generator is not operated at pressures greater than intended.
Generator vessels shall be designed in accord with local regulation but in general are designed only for the nominal operating pressure, not for pressures related to the decomposition of the acetylene.

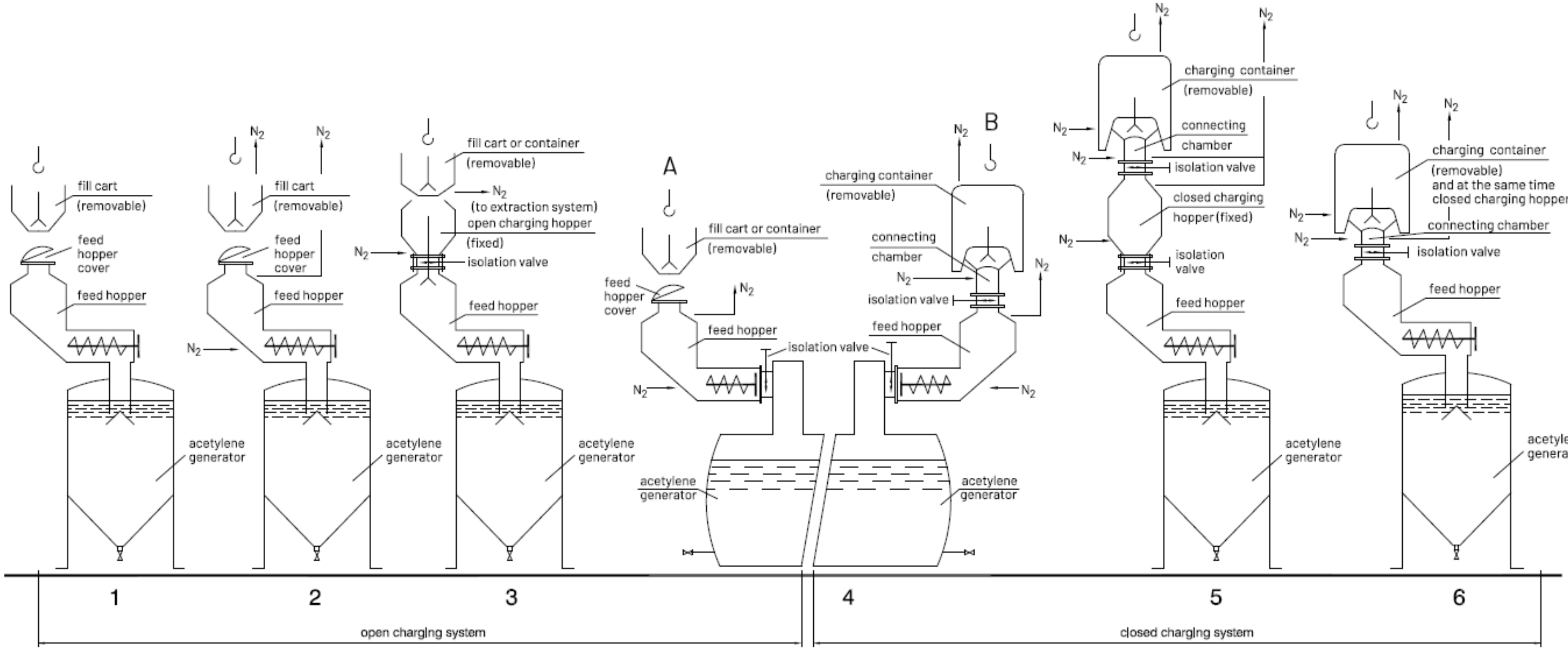
NOTE High pressure generators operating above 1.5 barg are not permitted.

There are four forms of carbide feed to a generator:

- *Batch*: these generators are shut down, drained and refilled with water at the end of each charge of calcium carbide*.*
- *Semi-continuous (manual):* these types of generators have manual water addition and drain controls making it necessary to drain and refill the generator with water at the end of each charge of calcium carbide. A short shutdown is required at the end of each charge to refill the calcium carbide hopper.
- *Semi-continuous (automatic):* these types of generators have automatic water addition and drain controls making it unnecessary to drain and refill the generator with water at the end of each charge of calcium carbide. However, a short shutdown is required at the end of each charge to refill the calcium carbide hopper.
- *Continuous:* these types of generators have automatic water addition and drain controls and the charging turn bin / flow bin is connected to the feed hopper via a connecting chamber and usually a gastight seal. The feed hopper usually has an isolation valve at the top. Other continuous type generators are equipped with a double carbide hopper arrangement to permit continuous carbide feed.

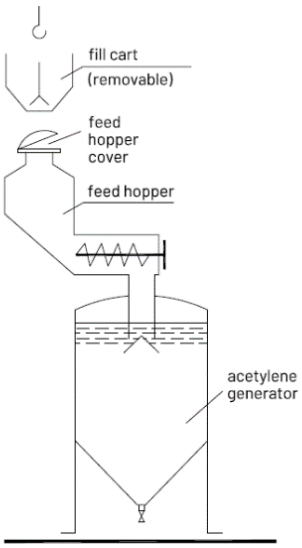
The operating and safety controls depend on the manufacturer and generator type.

4.5 Description of typical generator systems



4.5.1 Generator - System 1

The generator system consists of a generator and feed hopper connected by a calcium carbide conveyor. The calcium carbide addition is carried out by using a fill cart, which is held above the feed hopper. The calcium carbide conveyor is stopped reducing acetylene generation. Then the feed hopper cover is opened and the fill cart is lowered on to the feed hopper.
The calcium carbide is discharged, the charging skip raised and the lid closed. Finally, the carbide conveyor is restarted.



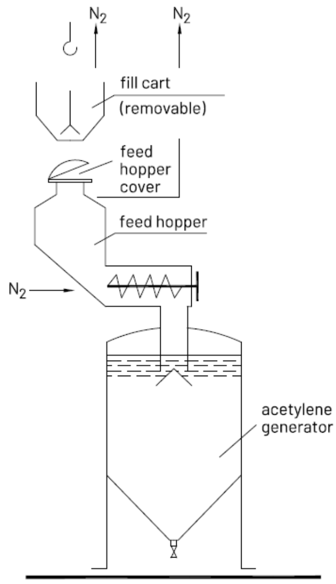
Characteristics:

- Simple and reliable technology
- Typical operating pressure 0,03 bar gauge
- Possibility of air entering the feed hopper during charging
- Necessity for rapid charging
- Release of acetylene into the generator room, which could form an explosive atmosphere
- Batch operation.

In this generator system, which operates at a low pressure, there is no inert gas purge, and the safety of the charging is dependent upon the upflow of acetylene from the generator preventing the ingress of air with the calcium carbide charge. Consequently, this transfer shall be carried out rapidly before the acetylene gas flow falls significantly. This procedure can only be operated where the generator pressure is low. Additionally, it is recommended that an inert gas purge should be available in case of ignition at the feed hopper inlet. It is very important that all the components including the fill cart are earthed and are electrically bonded. It must be accepted that whilst the calcium carbide transfer is taking place there will be an acetylene/air mixture adjacent to the fill cart. Therefore, this generator charging system should be operated with care, regarding the risk of this operation (e.g. hopper fire).

4.5.2 Generator - System 2

The generator system consists of an acetylene generator and a feed hopper connected by a calcium carbide conveyor. Calcium carbide addition is carried out using a fill cart, which is held above the feed hopper. The calcium carbide conveyor is stopped, reducing acetylene generation, and the feed hopper cover is opened starting an inert gas purge. The fill cart is lowered on feed hopper and sealed by an antistatic rubber sealing ring. The calcium carbide is discharged, and the fill cart removed. The, feed hopper cover is closed, automatically stopping the purge. Finally, the calcium carbide conveyor is restarted.



Characteristics:

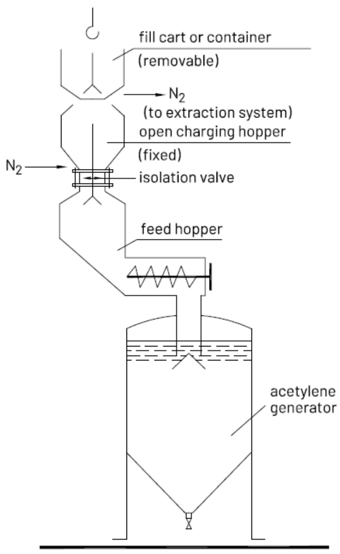
- Simple and reliable technology
- Typical operating pressure 0,05 bar gauge.
- During purge small amounts of calcium carbide dust are emitted which may be recovered by an extraction system.
- Acetylene/inert gas mixture is released into the generator room, which could form an explosive atmosphere with ambient air.
- Batch operation.

In this generator system which operates at low pressure, an inert gas purge automatically commences in the feed hopper when the feed hopper cover is opened. Since the charging skip is sealed to the feed hopper the purge gas passes through the calcium carbide charge as it is transferred to the feed hopper. Closure of the feed hopper cover automatically discontinues the purge. It is very important that all the components including the charging skip are earthed and electrically bonded. In the case of generator system 2 there is a release of acetylene which can form an explosive atmosphere with ambient air adjacent to the fill cart. But the overall hazards are less than in the generator system I.

4.5.3 Generator - System 3

The generator system consists of a generator and a feed hopper to which an open charging hopper is connected. The open charging hopper is separated from the feed hopper by an isolation valve.

Calcium carbide addition is carried out using a charging skip or turn bin / flow bin which is held above the open charging hopper. During calcium carbide transfer the open charging hopper is purged with an inert gas. On completion of the transfer of calcium carbide to the open charging hopper the calcium carbide conveyor is stopped and the open charging hopper re-purged with inert gas. The isolation valve is opened and the calcium carbide is transferred into the feed hopper after which, the isolation valve is closed and the calcium carbide conveyor restarted.
Same open charging hoppers can be equipped with an extraction system in order to recover calcium carbide dust.



Characteristics:

- Typical operating pressure 0.1 bar gauge
- During purge small amounts of calcium carbide dust are emitted. The dust may be recovered by an extraction system.
- Acetylene/inert gas mixture is released into the generator room and can form an explosive atmosphere with ambient air.
- Batch operation.

If there is an extraction system an explosive atmosphere could occur in the ducting.

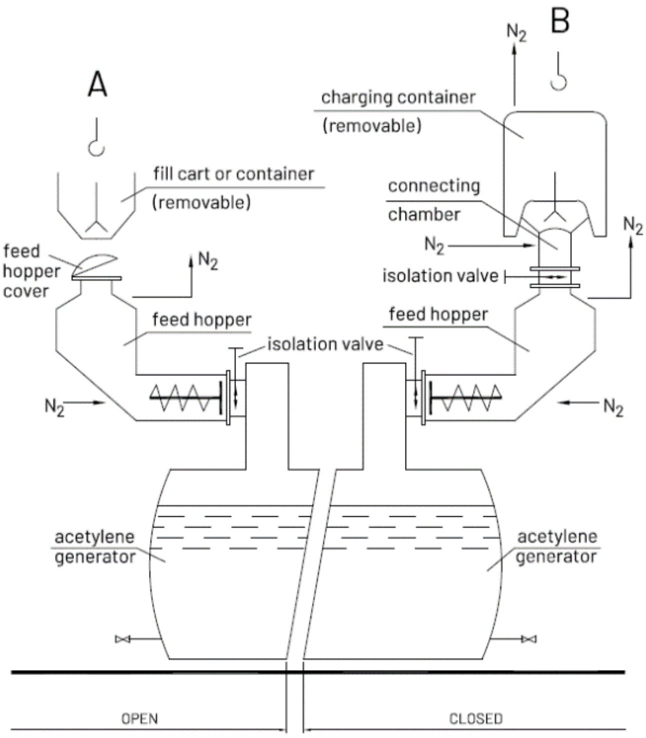
In this generator system, the addition of an open charging hopper alters the purge routines. There are two calcium carbide transfers, firstly from the charging skip or turn bin / flow bin to the open charging hopper, and secondly from the open charging hopper to the feed hopper. In both cases the open charging hopper must be purged with an inert gas before and during the transfer. Under no circumstances shall there be a direct transfer of calcium carbide from the charging skip or turn bins / flow bins directly into the feed hopper.

It is very important that all the components including the charging skip or turn bins / flow bins are earthed and electrically bonded.

4.5.4 Generator - System 4

The generator system 4 which operates at medium pressure is fitted with two feed hoppers connected by individual calcium carbide conveyors. The addition of calcium carbide can be carried out by

A) the use of a charging skip (open charging system 4 A)
B) a charging turn bin / flow bin (closed charging system 4 B)



In both systems the feed hopper is isolated from the generator by stopping the calcium carbide conveyor and closing the appropriate isolation valve.

In system 4A the feed hopper is depressurized and purged with inert gas and the feed hopper cover removed. The charging skip is then placed on the feed hopper and the calcium carbide transferred. The charging skip is removed and the feed hopper, cover replaced. The feed hopper is then re-purged and brought on stream automatically when the second feed hopper has been emptied.
In system 4 B the feed hopper is depressurized, and the charging turn bin / flow bin is placed on the connecting chamber. The charging turn bin / flow bin and the connecting chamber are then purged with inert gas before the feed hopper isolation valve and charging turn bin / flow bin outlet valve are opened to transfer the calcium carbide. After transfer the valves are closed and the connecting chamber and charging turn bin / flow bin re-purged. The feed hopper may be purged with acetylene if desired and is brought on stream automatically when the second feed hopper has been emptied.

Characteristics:

- Continuous operation
- Typical operating pressure 0.5 bar gauge
- In system 4 A, during purge, small amounts of calcium carbide dust are emitted - in system 4 B, which is a closed charging system, no dust is emitted into the generator building.
- Acetylene/inert gas mixture is vented safely into the atmosphere via pipework.

It is very important that all the components including the charging skip or charging turn bins / flow bins are earthed and electrically bonded.

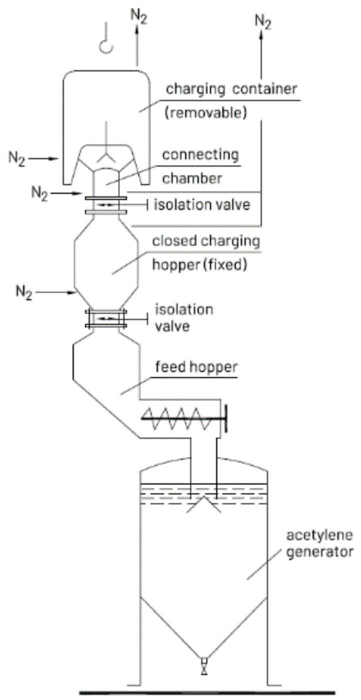
The generator system 4 B accepts that the feed hopper contains acetylene. The charging turn bin / flow bin and connecting chamber shall be purged with an inert gas before transfer of calcium carbide. At the end of the transfer the charging turn bin / flow bin and the connecting chamber will contain acetylene and shall be re-purged with an inert gas before the charging turn bin / flow bin is disconnected.

In generator systems 4A and 4B, the feed hopper to be charged is separated from the generator by closing an isolation valve which ensures that an uncontrolled release of acetylene is unlikely to occur. The chance of an ignition in the charging system 4 A is less than in systems 1 to 3. System 4 B additionally prevents the emission of calcium carbide dust into the generator building and is therefore preferred to system 4 A.

4.5.5 Generator - System 5

The generator system, which operates at low pressure, consists of a generator and a feed hopper which is connected by an isolation valve to a closed charging hopper having a second isolation valve at the top of it. The isolation valves should be interlocked to prevent both of them be opened at the same time. The charging turn bin / flow bin is connected to the closed charging hopper via the connecting chamber and a gastight seal.

A typical charging procedure could be:
The connecting chamber is purged with inert gas and subsequently the charging turn bin / flow bin is purged. The charging turn bin / flow bin outlet valve is opened, followed by the upper isolation valve and the calcium carbide is discharged into the closed charging hopper. The upper isolation valve is closed. The closed charging hopper may be purged with acetylene if desired. The lower isolation valve is opened and calcium carbide is fed to the feed hopper. The lower isolation valve is closed when the closed charging hopper is empty. No disconnection of the calcium carbide conveyor is necessary. The charging turn bin / flow bin shall be purged with inert gas and removed.



Characteristics:

- No dust and acetylene is emitted into the generator building
- Typical operating pressure 0.1 bar gauge
- Limited quantity of acetylene/inert gas mixture is vented into the atmosphere via pipework
- Continuous operation.

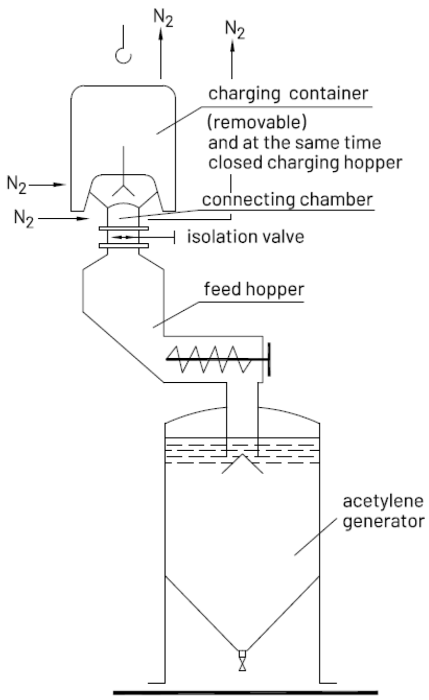
It is very important that all components including the charging turn bin / flow bin are earthed and electrically bonded.

The design of this generator system requires that the operating procedures consider that the closed charging hopper contains acetylene. The charging turn bin / flow bin and connecting chamber shall be purged with an inert gas before the upper isolation valve of the closed charging hopper is opened. At the end of the calcium carbide transfer the charging turn bin / flow bin and the connecting chamber will contain acetylene and shall be purged with an inert gas before the charging turn bin / flow bin is disconnected. System 5 is recommended in comparison to systems 1 to 4 A for environmental and safety reasons.

4.5.6 Generator - System 6

This system consists of a generator and a feed hopper. The charging turn bin / flow bin is connected to the feed hopper via a connecting chamber and a gastight seal. The feed hopper has an isolation valve at the top.

A typical charging procedure could be:
The connecting chamber is purged with inert gas and subsequently the turn bin / flow bin. The inlet valve of the feed hopper is opened and the inert gas may be purged with acetylene using a purge line from the turn bin / flow bin to the atmosphere. Then the turn bin / flow bin outlet valve is opened to transfer the calcium carbide into the feed hopper. The complete discharge will not happen immediately if the feed hopper is not empty. The isolation valve remains open until the calcium carbide is completely transferred, after which it is closed, the turn bin / flow bin is purged with inert gas and disconnected.



Characteristics:

- Continuous operation
- Typical operating pressure less than 0.1 bar gauge
- Reduced quantity of acetylene/inert gas mixture is vented into the atmosphere via pipework.
- No calcium carbide dust and acetylene is emitted into the generator building.
- Lower building costs for generator building than System 5

It is very important that all components including the charging turn bin / flow bin are earthed and electrically bonded.

In this low-pressure generator system there is a significant difference from system 5. The turn bin / flow bin forms a part of the generator system and the calcium carbide is fed on demand into the generator. During the charging process the turn bin / flow bin is filled with acetylene and shall therefore be purged with inert gas before disconnection.
The safety of this system is more dependent on proper purging than system 5 because the charging turn bin / flow bin forms an integral part of the generator system until it has been emptied and isolated.

5 Acetylene gasholder / buffer

5.1 Acetylene Gasholders / Gasometers

Acetylene gasholders comprise a water filled vessel fitted with an internal floating bell, which rises and falls with varying gas content to maintain a constant system pressure. The gasholder level position is used to control the generator carbide feed rate.

The gasholder(s) are installed in low-pressure acetylene generation plants to balance the generation rate with the compression rate.

The gasholder shall be equipped with:

- Inlet and outlet shut off valves.
- An emergency high-level alarm that trips to stop the carbide feed to the generator. Some gasholders may be equipped with a high-level cut out switch to stop the generator carbide feed before the gasholder reaches the high alarm level and to re-start the feed when the gasholder falls.
- An emergency low level cut out switch, which shall stop the compressors.
- Visual means of detecting the water level and an overflow device to drain water that exceeds the maximum water level of the gasholder.
- Drains for the acetylene pipes (inlet and outlet)

The gasholder(s) shall have sufficient capacity to contain any over-run after stopping the generator carbide feed drive during normal operation or in an emergency.

Gasholders located outside where freezing temperatures are encountered shall be provided with means to prevent the water in the gasholder from freezing. During extremely cold weather, the gasholder should be inspected frequently to make sure that any ice formation is not holding the bell in a fixed position.

5.2 Acetylene Buffers

Buffers are installed in some types of medium pressure acetylene generators to balance the generation rate to compression rate. The buffer is a vessel with an integrated water seal - the function of the water seal is as a safety device not a pressure relief device. A pressure regulator is installed at the top of the vessel with high and low pressure limits to regulate the calcium carbide feed to the generator.

The buffer shall be fitted with the following devices:

- Inlet and outlet isolation valves;
- Pressure gauge and a separate low pressure switch that shall stop the compressor(s) to prevent air ingress into the plant;
- Pressure relief valve.

The seal shall be equipped with a water level control.

6 Acetylene generator hazards & safeguards

Guidance on operational issues with a generator or a carbide hoist can be found in EIGA Doc 231 [1].

6.1 Acetylene gas hazards

Calcium carbide shipping packages should be purged with nitrogen, if they are equipped with a purged port. CO_2 gas is prohibited for acetylene inerting (static electricity).
Before transferring calcium carbide into the generator feed hopper, the hopper should be purged with nitrogen to remove acetylene gas from the hopper. Purging with nitrogen reduces the potential for ignition during the transfer process.
Lime slurry discharge from the generator contains dissolved acetylene, which can be release after discharge from the generator. Safe practices should be followed to avoid any flammable gas (acetylene) accumulations. Residual lime slurry inside the generator can degas during maintenance activity. Therefore, acetylene gas monitoring should be performed before and during maintenance activities on the generator. Unreacted calcium carbide in lime slurry can generate acetylene outside the acetylene generator, which can potentially form an explosive mixture (acetylene and air). Lime handling areas create hazardous zoned areas.

6.2 Elevated temperatures inside the generator

Temperatures inside the generator should be controlled to reduce the potential for ignition of acetylene in the generator. The reaction of calcium carbide with water is an exothermic reaction that, if not controlled, can exceed the ignition temperature of the acetylene. Typically, there are water sprays in the generator to reduce temperature. Water sprays should be placed at strategic locations inside the generator to ensure uniform cooling. Refer to the manufacturers' recommendations or instructions about location and flow required for the sprays based on generator design.
Temperature sensor(s) should be provided to monitor the temperature of the liquid and/or gas in the generator. Provisions such as an automatic water valve should be provided to ensure the generator does not overheat. Water flow to the sprays should be monitor ensuring proper flow is established when operated. Water pressure/flow switches are recommended to provide an alarm if the supply falls below the generator manufacturer specified limits.
To avoid calcium carbide island or hot spot formation inside the generator, an agitator should be used to ensure proper mixing of calcium carbide with water.
The outside of the generator vessel and the lime slurry that is discharged from the generator can become hot and cause personal injury, therefore appropriate personal protective equipment (PPE) should be provided.

6.3 Elevated and reduced pressure

6.3.1 Elevated pressure

Acetylene is an unstable gas. Its instability increases as the pressure increases. Do not operate generators beyond the design pressure rating.
Pressure relief of the generator shall be vented to a safe location – typically outdoors in a well-ventilated location. Note that the vents create a hazardous zoned area.
Pressure relief systems from an acetylene generator are exposed to potential blockage by lime. Spring loaded relief valves shall be regularly lifted to ensure they have not become stuck, discharge piping

systems shall be confirmed as being free flowing, and water trap pressure units shall be flushed with fresh water.

6.3.2 Reduced pressure

A generator should never develop a negative pressure (vacuum). This is to reduce the possibility of air contamination with acetylene gas in the generator, which can result in an ignitable gas mixture. If the pressure has been reduced to atmospheric pressure or air ingress may have occurred, the system shall be purged before use.

6.4 Improper calcium carbide sizing issue

Generators are designed for a specific range of calcium carbide size. Ensure that correct size of calcium carbide is used. For more information on calcium carbide size, see EIGA Doc 196, *Calcium Carbide Storage and Handling*, EIGA Doc 205, *Calcium Carbide Specifications*, and CGA G-1.7, *Standard for Storage and Handling of Calcium Carbide in Containers* [2, 3, 4].

Oversized calcium carbide can:

- block the feeding mechanism.
- cause equipment damage.
- increase the potential of bridging.
- result in unreacted calcium carbide being discharged with the lime slurry, which can potentially generate excess acetylene outside the generator.

Undersized calcium carbide can:

- react very quickly, which can create elevated temperatures and pressures within the generator.
- lead to more dust on the water surface which when stirred could lead to sudden reaction.

Calcium carbide briquettes are formed from small calcium carbide particles which may react as undersized carbide. Before using briquettes a trial should be performed on the reaction rates.

6.5 Improper agitation

Lime slurry inside the generator should be kept agitated to prevent setting of solids than can cause blockages, calcium carbide islands and/or hot spots can form due to improper agitation.
If an agitator is installed, rotation monitoring may be provided to ensure the agitator is operating.

6.6 Improper handling of turnplates

The turnplate, where fitted in a generator, is there to provide a platform for the carbide to rest upon whilst reacting in the water. The turnplate is a grid plate through which the dissolving lime can pass, but which is intended to hold up larger pieces of carbide so they do not form an unreactive pile at the floor of the generator. The carbide contains impurities which will not react or dissolve, mainly ferro silicates in the form of stones. These stones become trapped on top of the turnplate over time. This gives rise to the need to turn over the plate to drop these stones to the floor of the generator so they do not block the passage of the carbide/lime.
Issues with the turnplate include:

- failure to turn the plate over in timely manner – the ferro silicates build up, the carbide/lime gets stuck and fails to react (a pile of unreactive carbide forms – this is similar to an unstirred generator without a turnplate).
- low level of water in a generator with a turnplate. The carbide forms a pile which can grow until the carbide feeder becomes blocked. In some generators with turnplates the carbide feeder area has its own water sprays to eliminate lime accumulation. A blockage in this area the pressure can build leading to loss of containment.

- low level of water in a generator with a turnplate. This can lead to hot spots of carbide which are a potential cause of decomposition of acetylene in the generator.

6.7 Improper generator liquid levels

High liquid level in the generator can react with calcium carbide in the calcium carbide feed systems. This can generate acetylene with limited water supply, which can result in high temperature and can ignite acetylene gas. High liquid level protection should be provided to reduce the possibility of a hazard. Low liquid level in the generator can cause the reaction to create excessive temperatures, which can lead to an acetylene gas ignition. If all liquid level is lost (i.e. if the lime slurry discharge valve fails open), acetylene can be released to atmosphere and potentially form an explosive mixture (acetylene and air).

6.8 Improper water flow

Excess water flow can cause:

- High liquid level in the acetylene generator, may lead to reaction with the carbide in the carbide feed or carbide hopper.
- Increased potential for unreacted calcium carbide to be discharged from the generator due to excessive lime slurry discharge.

Inadequate water flow can cause:

- Low liquid level in the acetylene generator.
- Overheating inside the acetylene generator.

Improperly decanted (high solid content) recycled lime water can cause:

- Plugging of spray nozzles.
- Water line blockage.

6.9 Carbide lifting device hazards

The lifting device shall be classified for use in an acetylene atmosphere (IIC). Typically, air hoists are used to lift the fill cart. The hoist lift/weight capacity shall be clearly labeled on the device and shall not be exceeded. Carbide hoists shall have a locking mechanism to hold the fill cart in place if the power supply and/or air supply are terminated.
Standing under the fill cart shall be prohibited.
PPE shall include hard hat whilst the fill cart is above head height.

6.10 Acetylene gas backflow into water supply systems

Backflow of acetylene gas into clean water supply systems shall be prevented.
Acetylene gas backflow into water supply systems can result in the release of acetylene in an unintended location that could potentially create a hazardous situation. Either a backflow prevention device should be installed, or an air gap should be provided in the water supply line to the generator. If used, the backflow prevention device should be installed on the water supply line as close as possible to where the waterline enters the generator.

6.11 Air ingress into generator

Air in the acetylene generator is a hazard. If air is suspected in the acetylene generator it shall be stopped and purged with nitrogen.
Known causes of air ingress into generators include:

- Low water level in the recycle water supply system, air-intake via the pump
- Failure of air-driven pneumatic water pumps

- Contamination in the nitrogen supply system
- Leaking seals (reduced pressure in the generator overnight due to reduced temperature)
- Improper water level in the water trap
- Improper purging of the carbide fill cart / turn bin / flow bin

6.12 Improper storage and handling of calcium carbide

See EIGA Doc 196 or CGA G-1.7 for more information [2, 4].

6.13 Improper usage of fill cart

The fill cart shall be designed for both the weight of the calcium carbide and to prevent any bridging. The fill cart should not be filled until is ready to be used to limit the reaction with moisture in the atmosphere.
Calcium carbide spills shall be attended to promptly to limit the reaction with moisture in the atmosphere.

6.14 Lime

Calcium carbide lime no longer needed shall be disposed of in an environmentally acceptable manner. Under waste legislation carbide lime is classified as hazardous (irritant) and is shipped under European Waste Catalogue code 06 02 01 for $Ca(OH)_2$.

Safety shower(s)/eye wash should be located within reach of lime handling areas and PPE shall be used.

To prevent someone falling into a lime pond, settlement tank or a cleared water basin perimeter protection should be provided. In the event that somebody falls in, rescue equipment shall be readily available. Fixed ladders shall not be installed.

Carbide lime contains residues of acetylene dissolved in it that can present a hazard when confined in road tankers for transport. Such tankers use a vacuum to draw the slurry and the reduction in pressure results on the release of free acetylene. Similar effects happen at high ambient temperatures in closed lime vessel trucks.

7 Startup & shutdown of acetylene generators

7.1 Startup

Before startup, ensure that the generator does not contain any air contamination. Air contamination should be purged with an inert gas in advance.

After maintenance, cleaning, and repair operations and before returning to service, procedures shall be followed to ensure that the installation is safe to start up.

These may include:

- Verification that there are no contaminants inside the equipment: solid particles (metal, plastics) which can lead to friction and a risk of ignition within the piping system.
- Verification that the instrument air/nitrogen supply is functioning.
- Ensuring the building ventilation system is operating correctly.
- Pressurising the equipment or the installation to normal working pressure with nitrogen.
- Performing pressure tests for new equipment (for example pipes).

- Performing leak tests at the maximum operating pressure. Vent all pressure prior to repairing any leaks found as it is not recommended to repair leaks in equipment that are still under pressure.

7.2 Shutdown

Shutdown procedures should include:

- Stopping calcium carbide feed.
- Ensuring calcium carbide in the generator has completely reacted.
- Verifying temperature has stopped rising.
- Following the manufacturer's shutdown instructions.

When the generator cools down after shutdown, there is a possibility of creating a vacuum. The vacuum can aspirate air into the generator, which can produce an explosive atmosphere inside the generator. To avoid this situation, the following apply:

- For short-term shutdown, a positive pressure of acetylene and inert gas should be maintained for the duration of the shutdown period.
- For long-term shutdown, the generator should be purged with an inert gas. It is recommended to drain the generator of any remaining lime slurry and clean with fresh water to avoid any dry lime or corrosion issues. The water supply should be isolated, and the generator feed hopper(s) should be emptied.

8 Maintenance of acetylene generators

8.1 Generator cleaning

Generator cleaning is necessary because of the impurities in the carbide. Insoluble materials build up in the generator and will lead to blockages if the generator is not cleaned.
To clean most generators it is necessary to open the vessel and "enter".
To do this safely requires a specific assessment for the generator and the activity but the following steps and considerations are common to all generator cleaning activities.

- The carbide feed must be isolated from the generator.
- The generator must be emptied of lime/water – this contains dissolved acetylene.
- The generator atmosphere must be purged clear of acetylene with nitrogen.
- The nitrogen purge must be cleared by purging with air.
- The generator can be opened (unsealed).
  A common practice is to pause at this step, allowing time for any gas to clear.
- The cleaning activity can be undertaken.
  Consideration must be given to the potential confined space entry. A risk assessment shall be completed, and any safety measure required implemented.
- The generator must be resealed.
- The generator atmosphere must be inerted by purging with nitrogen.
- The correct water level must be reestablished.
- Un-isolate the carbide.
  The carbide may be permitted to enter the generator under normal control.
  It may be necessary to flush the nitrogen from the generator and piping to avoid nitrogen being compressed into the acetylene cylinders.

8.2 Common inspection/maintenance activities

The following list is not exhaustive, and the plant staff must create a site-specific list of inspection/maintenance activities for their specific generator. The list is intended to give aide memoir to the creation of that list.

8.2.1 Carbide transfer equipment

- Carbide hoist

- Cleaning of fill cart pit
- Carbide level sensor
- Purge system for hopper / turn bins / flow bins (flow rate, purge duration)

8.2.2 Control loops

- Settings
- Calibration
- Functionality

8.2.3 Instruments, safety shutdown

- Loop check
- Setting
- Calibration

8.2.4 Generator hydraulic system

- Blockage
- Cleaning

8.2.5 Generator carbide feed system

- Blockage
- Cleaning
- Wear

8.2.6 Generator containment

- Pressure drop (leak) test

8.2.7 Agitator

- Motor
- Blades
- Lubrication / packing
- Sensors designed to confirm function

8.2.8 Generator pressure relief

- Lift spring loaded relief valves
- Clear out any lime accumulation in hydraulic seals
- Inspect for vessel condition of hydraulic seals
- Confirm the discharge lines are clear

8.2.9 Flash back arrestors

- Water level check
- Clear out any lime accumulation
- Inspect for checkvalve condition

8.2.10 Mechanical inspection, vessel, hoppers, pipes

- Corrosion of vessels and pipework
- Bolting down of equipment
- Condition of stairways, handrails

- Blockages in pipes
- Cleaning of lime trenches, integrity of grating
- Integrity and operability of generator turnplates / grates

8.2.11 Static electricity

- Wiring conductance to ground

8.2.12 Gasholders / Buffers

Gasholder inspection
The water in the gasholder contains acetylene that may be released. Therefore, before undertaking any work on the gasholder, this shall be considered.

- Corrosion
- Ballast weights
- Counterbalance weights and wires
- Level controls / switches
- Water overflow
- Internal inspection and replacement of water (as per regulations)
- Freezing protection

Buffer inspection

- Corrosion

8.3 Purging

Purging is done to the companies' procedures which will have been developed to ensure a thorough and complete removal of acetylene. Prior to any maintenance on the generator or piping a suitable gas detector (calibrated for acetylene in nitrogen) shall be used to ensure the generator is free of acetylene and then before opening any part of the process another suitable gas detection (acetylene in air, and oxygen in nitrogen) shall be used to ensure that there is neither acetylene above LEL in air, nor depleted oxygen before exposure of personnel.
Ensure safe atmosphere is maintained inside the generator if personnel enter or hot work is going to occur inside or near the opened parts.

9 Training and procedure

The following procedures cover the aspects specific to an acetylene generator.
Elements such as lock out / tag out, work permits, … as described under safe working practices are not mentioned but shall be included in employee training as required.

- Carbide
  - Receipt, inspection and storage of calcium carbide
  - Calcium carbide charging procedures.
    - Electrical earthing
    - Purging of containers and feed hopper
    - Use of the carbide hoist
    - Clearing blockages
  - Calcium carbide spill containment or cleaning procedures.
  - Empty calcium carbide container handling, shipping, disposal
- Generator operation
  - Startup and shutdown
  - Temporary, short-term, shutdown between shifts
  - Cleaning

    - Gasholder / buffer functional switches, mode of operation
- Emergency procedures.
    - Identification of emergency situations
    - Emergency shutdown procedures.
- Maintenance requirements and associated procedures.

Record of maintenance and inspections per company retention policies should be maintained.

10 References

Unless otherwise specified, the latest edition shall apply.

[1] EIGA Doc 231, *Response to Operational Issues in Acetylene Plants,* www.eiga.eu

[2] EIGA Doc 196, *Calcium Carbide Storage and Handling,* www.eiga.eu

[3] EIGA Doc 205, *Calcium Carbide Specifications,* www.eiga.eu

[4] CGA G-1.7, *Standard for Storage and Handling of Calcium Carbide in Containers,* www.cganet.com

11 Additional references

CGA G-1.10, *Guideline for the Safe Operation of Acetylene Generators,* www.cganet.com