Calcium carbide preparation and its uses

Objectives : At the end of this lesson you shall be able to

- **state the ingredients and grades of calcium carbide**
- **describe the properties of calcium carbide**
- **explain the method of production of calcium carbide**
- **explain the safe storage and handling of calcium carbide.**

Calcium carbide is a dark-grey stone like chemical compound which is used to produce acetylene gas.

Composition of calcium carbide: calcium carbide is a chemical compound consisting of:

- calcium = 62.5%

- carbon = 37.5%, by weight i.e., in 100g of calcium carbide, 62.5g will be calcium and 37.5g will be carbon.

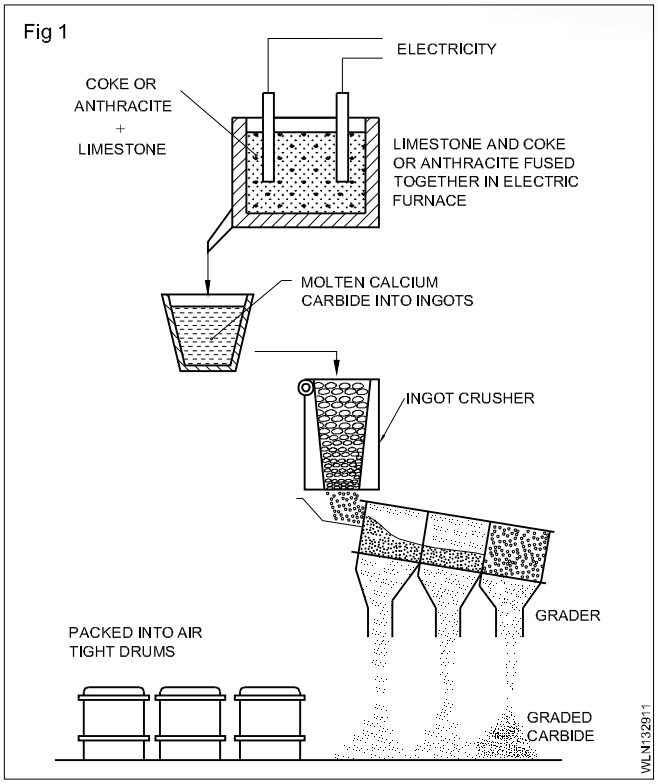
its chemical symbol is Ca C_2

Properties of calcium carbide: It is a solid chemical compound of dark-grey colour. It is brittle. Its density is 2.22 to 2.26 g/cc. It easily absorbs moisture from the atmosphere and gradually changes into slaked lime. It is not soluble in kerosene. If it is allowed to come into contact with water (or any mixture containing water), it produces acetylene gas.

Production of calcium carbide

Calcium carbide is produced in an electric furnace by smelting coke and lime in right proportion. (Fig 1)

Fig 1



Production of one metric ton of calcium carbide requires: (average)

- 950 to 1000 kg of lime
- 600 to 610 kg coke and anthracite
- 40 to 70 kg of carbon electrode material

It takes 0.875 kg calcium and 0.562 kg carbon to produce one kilogram of chemically pure calcium carbide. With the intense heat (3000 - 3600°c) of the carbon arc in the furnace, lime and coke turn to a liquid compound called calcium carbide. Lime + Coke + Heat = calcium carbide + carbon monoxide.

Carbon monoxide escapes and burns at the mouth of the furnace. Molten carbide is drawn out of the furnace and cast into ingots. The ingots are crushed, graded to definite sizes and packed into airtight steel drums.

Grades/sizes of calcium carbide: Different grades/sizes of calcium carbide are available for use in different types of acetylene generators.

These are designated as:

- Lump
- Egg
- Nut - 14 NDT.

The sizes given above indicate the range in the screening sizes. For example (LUMP) size 90*50 means that no piece is larger than 90 mm nor smaller than 50 mm.

Safety precautions for handling and storage of calcium carbide: It can be stored in approved places only, Storage building must not have either water line or high temperature. It must be stored in perfect airtight containers. Fire breakout in a carbide storage room must be extinguished with Co_2 fire extinguishers or dry sand and not with water. Do not allow the carbide to come in contact with water/moisture outside the acetylene generator. Never put a naked light of any kind or any other source of ignition into or near the carbide container. Carbide drums should be opened with tools which will not produce sparks.

Use a brass chisel and hammer.

After taking out the carbide from a drum, it must be closed and made air tight immediately. Preserve carbide in kerosene oil in case of emergency. The person, handling calcium carbide, must wear rubber gloves. Empty carbide drums must be filled completely with water before disposing off.

Acetylene gas - Properties

Objectives : At the end of this lesson you shall be able to

- **explain the composition and properties of acetylene and oxygen gas**
- **describe the method of producing oxygen by air liquefaction process and by electrolysis of water.**

Acetylene is a fuel gas, which produces a very high temperature flame with the help of oxygen, because it has more amount of carbon (92.3%) than any other fuel gas. The temperature of oxy-acetylene flame is 3100°c - 3300°c.

Composition of acetylene gas: Acetylene is composed of:

- carbon 92.3% (24 parts)
- hydrogen 7.7% (2 parts)

Its chemical symbol is C_2H_2 which shows that two atoms of carbon are combined with two atoms of hydrogen.

Properties of acetylene gas: It is a colourless gas, lighter than air. It has a specific gravity of 0.9056 as compared with air. It is highly inflammable and burns with a brilliant flame. It is slightly soluble in water and alcohol. Impure acetylene has pungent (garlic like) odour. It can be easily detected by its peculiar smell. Acetylene dissolves in acetone liquid.

Impure acetylene reacts with copper and forms an explosive compound called copper acetylene. therefore, copper should not be used for acetylene pipeline. Acetylene gas can cause suffocation if mixed 40% or more in air. Acetylene mixed with air becomes explosive on ignition. It is unstable and unsafe when compressed to high pressure i.e. its safe storage pressure in free state is fixed as 1 kg/cm^2. The normal temperature pressure (N.T.P) is 1.091 kg/cm^2.The normal temperature is 20°C and the normal pressure 760mm of mercury or 1 kg/cm^2. It can be dissolved in liquid acetone. at high pressure. One volume of liquid acetone can dissolve 25 volumes of acetylene under N.T.P. It can dissolve 25X15=375 volume of acetylene cylinder if it is dissolved with a pressure of 15kg/cm^2 pressure. In an acetylene cylinder it is dissolved acetylene. For complete combustion one volume unit of acetylene requires two and a half volume units of oxygen.

Acetylene gas generation

Objectives: At the end of this lesson you shall be able to

- **explain the principle and name the different methods of acetylene gas generation**
- **explain the working principle of the types of acetylene generators**
- **compare the types of acetylene generators**
- **state their care and maintenance.**

Composition of acetylene: Acetylene is a fuel gas composed of:

carbon 92.3% and Hydrogen 7.7%

Its chemical symbol is C_2H_2

Principle of acetylene gas generation: It is the product of chemical reaction between calcium carbide and water.

When water is added to calcium carbide it reacts and produces acetylene gas and calcium hydroxide (slaked lime).

Calcium carbide is composed of calcium and carbon.

Water is Composed of hydrogen and oxygen.

When calcium carbide is allowed to react with water the carbon of the calcium carbide combines with the hydrogen of water forming acetylene gas. calcium combines with oxygen and hydrogen in water to form slaked lime (Calcium hydroxide).

Methods of acetylene generation: Acetylene is produced in acetylene generators based on two methods.

- Water-to-carbide method
- Carbide-to-water method

In the water-to-carbide method water falls on calcium carbide to produce acetylene.

Carbide-to-water means calcium carbide grains fall on a mass of water producing acetylene.

An acetylene generator is a device which brings proper amounts of calcium carbide and water together to generate the acetylene gas at the required rate.

Acetylene generators are of two types.

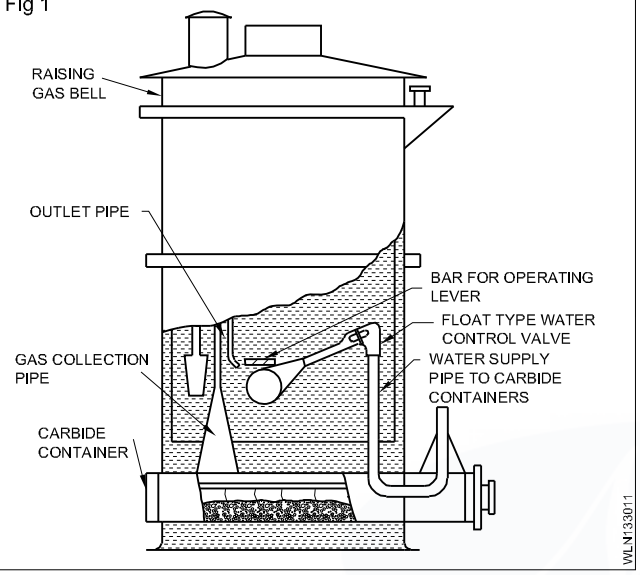
- Water-to-carbide type acetylene generator (low pressure)
- Carbide-to-water type acetylene generator (medium pressure).

Water to carbide acetylene gas generator

Features of water-to-carbide acetylene generator: In this low pressure acetylene gas generator, water falls on the carbide to generate acetylene gas. Acetylene pressure up to 0.17 kg / cm^2 can be generated. Carbide is placed in a carbide container located at the bottom of the generator. Water (Controlled by a float valve) is fed into the carbide container. The generated acetylene is collected in a gas bell which rises and then cuts off the water supply automatically.

The features of a generator are shown in Fig 1.

Fig 1



Working principle: Water is filled in the outer vessel through the water filling pipe and the water tap is turned off when there is sufficient water.

Calcium carbide is filled in the carbide container, inserted through the door at the bottom.

Initially the rising bell is at its bottom level and the cross (fixed to the rising bell) holds the float ball down thus opening the water valve. Water flows down the water supply pipe and enters the carbide container. Acetylene gas is generated due to chemical reaction.

The generated gas goes up in the gas collection pipe, passes through the water in the form of bubbles (washed and cooled) and enters the rising bell. The rising bell rises with gas pressure and lifts the crossbar up, thus closing the water valve automatically and preventing further supply of water into the carbide container.

The gas is taken out through the outlet pipe from where it goes into the purifier and then to the hydraulic safety valve before its use in welding. A weight is provided on the top of the rising bell to keep it in position and enable it to supply the gas with the required pressure.

A safety outlet pipe is also provided with the rising bell to release excess (generated) gas in emergency.

Further generation of acetylene gas is controlled automatically by the downward and upward movement of the rising gas bell.

When the gas is consumed, the rising bell comes down and its crossbar presses the float ball down to open the water valve. Water flows down into the carbide container to generate acetylene gas again. With the entry of the generated gas, the rising bell moves up again and stops the water supply to carbide container.

This operation continues till all the calcium carbide in the carbide container has reacted with water.

Non-automatic type generators are also available, in which the welder himself pours water on the carbide, by a hand operated valve, as per his requirements of acetylene gas.

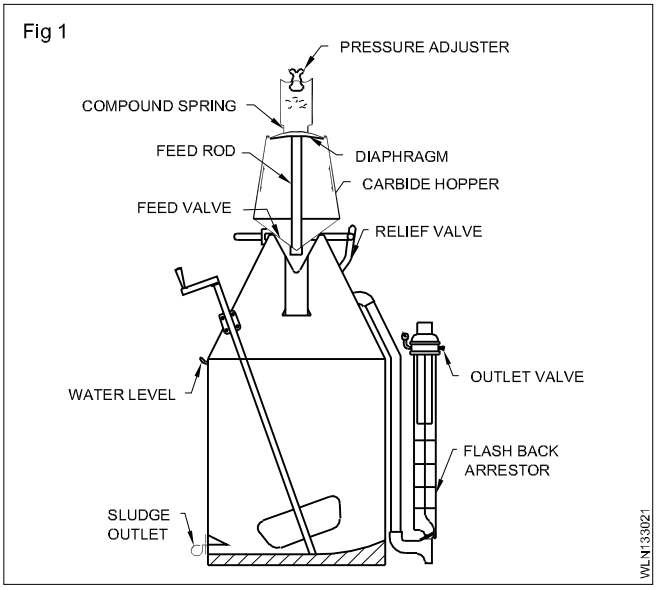
Carbide to water acetylene gas generator

Features of carbide-to-water type acetylene generator: In this generator carbide falls on water automatically to generate the acetylene gas. Acetylene pressure up to 1 kg/cm^2 can be generated.

Calcium carbide is placed in the hopper at the top of the generator. The generator is partially filled with water to the required level. A feed mechanism in the hopper feeds the carbide into the water and acetylene is generated. At a predetermined acetylene pressure (inside the generator) carbide feeding stops. Carbide feeding starts, when the acetylene is drawn out and its pressure in the generator decreases.

The features of this type of generator are shown in Fig 2.

Fig 1



Working principle: The water tank cum gas-holder is filled with clean water to the water level. The carbide hopper is charged with ND 14 size calcium carbide through the carbide hopper door. (The hopper door is closed.) The carbide hopper is attached at the top of the water tank tightly.

After starting the generator, the outlet valve and relief valve are closed. Calcium carbide is allowed to fall into the water by operating the feeding lever with the assistance of the other mechanism mentioned below.

The carbide feed valve is controlled by the feed rod and diaphragm (all connected to one another). A compound spring fitted to the opposite side of the diaphragm is supported by a pressure by a pressure adjusting screw. Then pressure adjusting screw controls the carbide feeding i.e., more pressure, more feeding and vice versa. By operating the feeding lever the pressure of the compound spring pushes the diaphragm down and thus the feeding rod also moves down to open the feed valve.

The falling carbide reacts with water to generate acetylene gas. The acetylene gas passes up through the water (washed and cooled) into the gas storage chamber. When the pressure of the generated acetylene increases in the gas chamber more than the pressure of the compound spring, the feeding rod moves up with the help of the diaphragm to close the feeding valve. Thus the carbide flow stops automatically. The generated acetylene is taken out through the gas outlet pipe, flashback arrester cum purifier and outlet valve. The pressure of the generated gas is indicated on the pressure gauge fitted near the outlet valve. When the pressure of gas in the gas chamber decreases, the carbide falls into the water and as the pressure increases, the carbide flow stops automatically. This operation continues until all the carbide in hopper is exhausted.

The calcium hydroxide (slaked lime or sludge) collected at the bottom of the generator is cleaned out through the sludge outlet by operating the agitator. The agitator prevents the formation of solid form of calcium hydroxide and mixes the calcium hydroxide with water and this makes it easy to remove (the thin milky fluid) from the generator completely. The generation of gas in this generator is completely automatic and is under close control of pressure with the demand. An emergency relief valve is provided to discharge the gas out of the generator immediately if the pressure exceeds the safety limit and in case of any emergency.

Flashback arrestor: The purpose of the flashback arrestor cum purifier is to save the generator from the danger of backfire or flashback and also to purify the generated acetylene gas before it is used for welding.

Comparison of acetylene gas generators

Water-to-carbide type

Consumption of water is less.

Recharging is not a problem.

Sludge disposal is not easy.

Pressure of the gas is low.

Has lower gas generation.

The gas is slightly hot as there is no proper cooling system.

Any grade of calcium carbide can be used.

May be automatic or non-automatic.

Care and maintenance is not easy.

Control on working pressure difficult.

Cost of generator less.

Only injector type blowpipe can be used.

Suitable for one operation and no need of the manifold system.

Carbide-to-water type

Consumption of water is very high.

Recharging takes more time.

Sludge disposal is easy but takes more time.

Pressure of the gas is medium and high.

Has higher gas generation.

Gas is cool as the gas is produced at the bottom level of water tank and travels the full height of the water.

Only a particular grade (14 NDT) of calcium carbide can be used.

Operation is always automatic.

Care and maintenance easy.

Control on working pressure easy.

Cost of generator more.

Both injectors and non-injector type 'blowpipes' can be used.

Many operations can be done at a time and a manifold system is essential.

Care and maintenance of acetylene generators: Display 'no smoking' boards near generators. Generators must be fitted with safety devices, (Hydraulic back pressure valve). Avoid overcharging of calcium carbide in the generator's chamber or carbide hopper, before recharging from the carbide chamber or generator. Avoid the creation of sparks inside the carbide chamber generator during cleaning. Acetylene generators should be cleaned, checked and painted periodically by competent persons, clean and recharge the acetylene generator in a well ventilated place, away from naked flame of fire. Leakages in valves, connection joints or any other fitting of acetylene generator must be checked daily (before use) using soap solution. Maintain the required water level in the generator daily. Keep and operate the generator away from sparks/ fire or combustible materials. Disposal of slaked lime (Sludge) should be made in sludge pits (Away from fire or sparks) in open space. The recommended grade/size of calcium carbide should be used in each generator (type). Joints of carbide container and carbide hopper must be pressure-tight joints with generators.

Acetylene gas purifier

Objectives : At the end of this lesson you shall be able to
- **explain the necessity and the features of the acetylene gas purifier**
- **explain the working principles of a purifier.**

Acetylene purifier: It is a cylindrical device which is used to purify the generated acetylene gas. It is fitted between the acetylene generator and blowpipe of a low pressure system of oxy-acetylene welding.

Necessity of a purifier: The generated acetylene gas will have the following impurities.

- Sulphuretted hydrogen
- Phosphorated hydrogen
- Ammonia
- Lime dust
- Water vapour

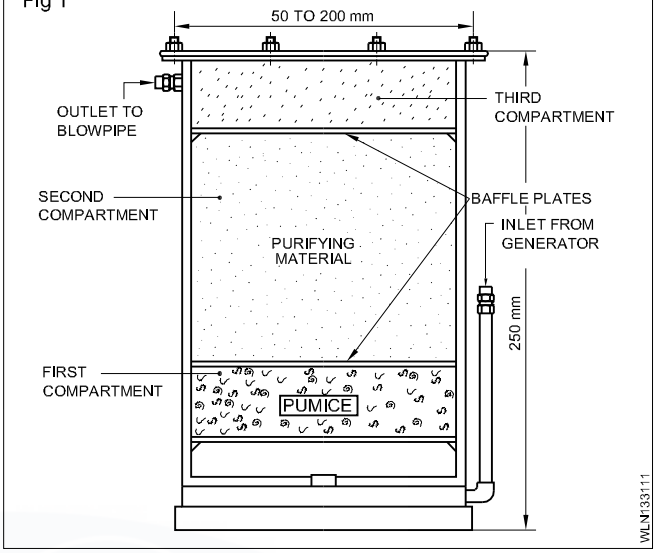
These impurities, if not removed, may have the following harmful effects.

- Reduction in flame temperature.
- Reaction with metal and influencing welding defects like blow holes, porosity etc.

Acetylene gas used for gas welding and cutting must be free from impurities. To remove these impurities, a suitable gas purifier must be used.

Gas purifier-working principle: The acetylene gas from the generator enters the purifier at the bottom chamber through the gas inlet pipe and passes through three compartments and comes out at the top through the outlet pipe. (Fig 1)

Fig 1



The first compartment contains pumice stone which absorbs moisture from the acetylene. The second compartment contains purifying chemicals, which remove sulphuretted and phosphorated hydrogen. The third compartment contains filter wool, which filters the lime dust and other foreign materials. Ammonia is removed within the generator when the gas passes through the water.

Hydraulic back pressure valve

Objectives: At the end of this lesson you shall be able to
- **state the necessity of the hydraulic back pressure valve**
- **explain the Working principle of a hydraulic back pressure valve.**

Necessity of hydraulic safety valve: In the low pressure system the oxygen pressure is always greater than the generated acetylene gas pressure.

During welding, due to backfire or nozzle hole blockage, the high pressure oxygen may enter into the acetylene passage and enter the acetylene generator, which will lead to an EXPLOSION.

To prevent the entry of high pressure oxygen or backfire to the generator, a hydraulic safety valve must be fitted in the acetylene pipe line between the blowpipe and the generator or purifier.

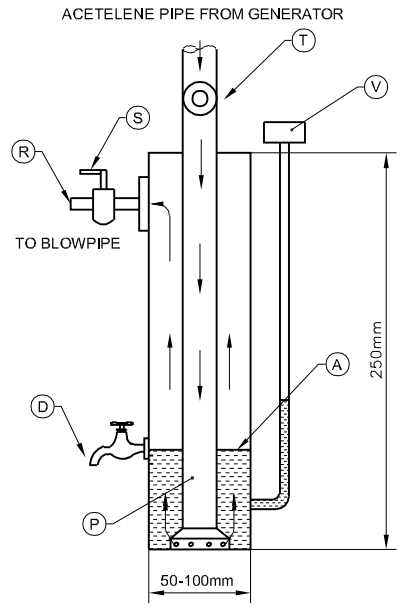
Constructional features of hydraulic back pressure valve: It is a cylindrical shaped device having 250mm depth and 50 to 100mm dia, as per the generator's capacity. (Fig 1)

Working principle

The cylindrical device is filled with water through the VENT PIPE (v) up to the level of water level (D). (Fig 1)

Gas enters from the generator through the inlet pipe valve (T) and comes down the center pipe (P), bubbles through the outlet pipe (R) and valve (S).

Fig 1



CONSTRUCTION AND NORMAL WORKING OF A HYDRAULIC SAFETY VALVE

WLN133121

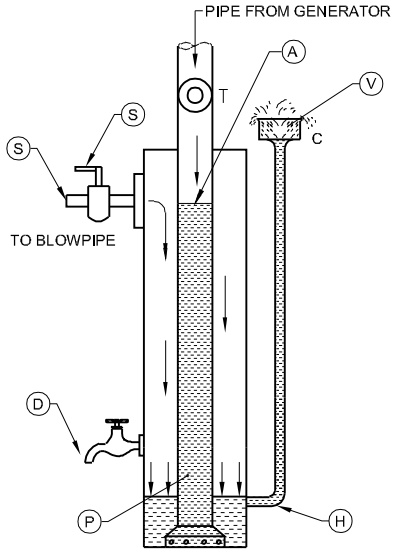
The pipe (P) has a baffle plate fixed at its lower end.

In the event of BACKFIRE or FLASHBACK (BACK PRESSURE) from the blowpipe side, the water level (A) is pushed down and water is forced up into the vent pipe until the hole (H) is exposed.

The burnt gases in case of a back fire, or the back pressure gases, pass up the vent pipe into the atmosphere and are prevented from getting into the generator. (Fig 2)

Each blowpipe must have a separate hydraulic safety valve.

Fig 2



WORKING OF HYDRAULIC SAFETY VALVE AT THE TIME OF BACK FIRE TO PREVENT EXPLOSION IN THE GENERATOR

WLN133122

Flash back arrestor

Introduction: It is a safety device and fitted with carbide to water acetylene generator. It is made out of mild steel cylindrical body.

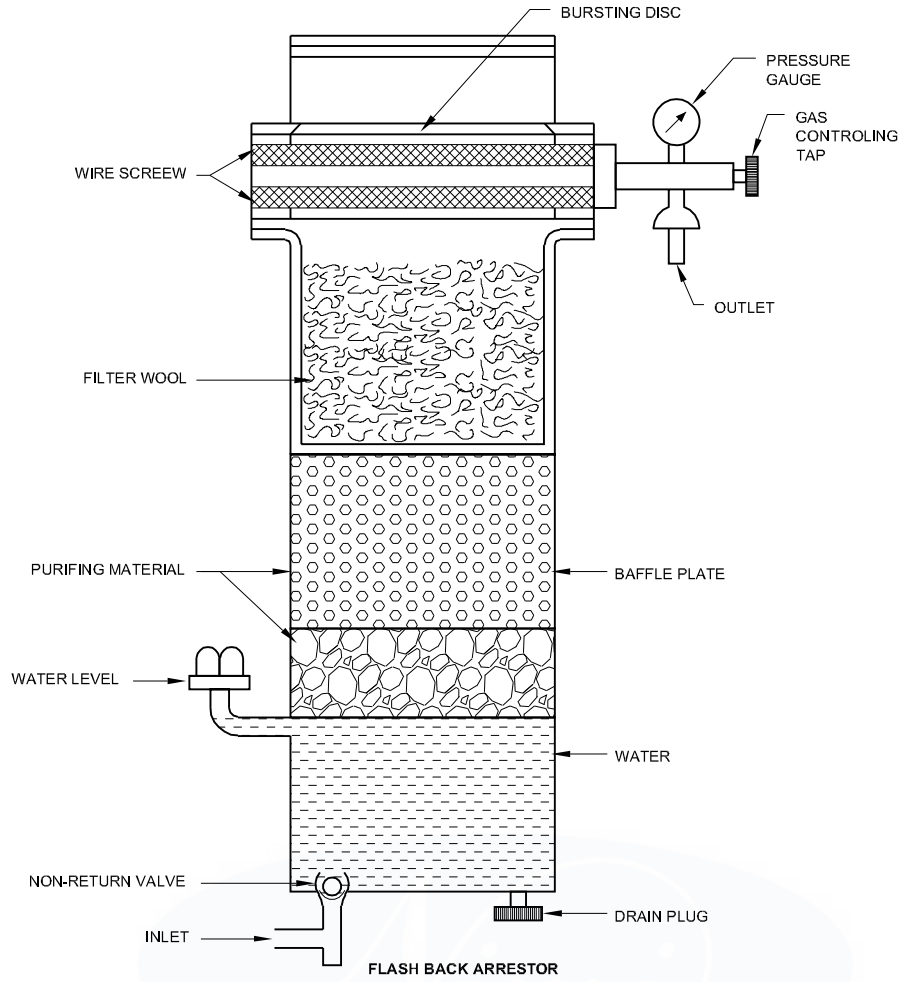
Parts: Flash back arrestor has the following parts

1 Inlet
2 Drain plug
3 Non-return value
4 Water level
5 Water
6 Baffle plate
7 Purifying materials
8 Filter wool
9 Wire screen
10 Bursting disc
11 Pressure gauge
12 Gas controlling tap

Working principle in normal stage: The acetylene gas from the carbide to water acetylene generator enters through the inlet connection of the flash back arrestor and goes to water compartment through non, return space valve and baffle plate, filter wool. Baffle plate reduces the velocity of acetylene gas whereas the purifying materials purify the generated acetylene gas that goes to outlet through the regulator and gas controlling tap.

Accidental condition: Flash back from the blow pipe enters through the outlet connection in flashback arrestor and goes to the non-return valve through the filter wool, baffle plate and water. Flash back creates the pressure and pushes the water downwards when the ball of non-return valve comes down and closes the inlet acetylene gas with the help of the disc. With the result, no more gas enters inside the flash back arrestor. The acetylene gas which is already in the flask back arrestor burns due to this pressure, the bursting disc bursts remaining gas in the flash back arrestor. So the damages of flash back arrestor outside the water acetylene generator is prevented from the accident. Thereafter water and the carbon particle are taken out through the drain plug and fresh water is filled in the flash back arrestor for further use. (Fig 1)

Fig 1


BURSTING DISC
PRESSURE GAUGE
GAS CONTROLING TAP
WIRE SCREEW
OUTLET
FILTER WOOL
PURIFING MATERIAL
BAFFLE PLATE
WATER LEVEL
WATER
NON-RETURN VALVE
DRAIN PLUG
INLET
FLASH BACK ARRESTOR
WLN133131