Oxygen gas - properties and production

Objectives : At the end of this lesson you shall be able to
- **explain the composition and properties of oxygen gas**
- **describe the method of producing oxygen by air liquefaction process and by electrolysis of water.**

Oxygen gas: Oxygen is a supporter of combustion. Its chemical symbol is O_2

Properties of oxygen gas

- Oxygen is colourless, odourless and tasteless gas,
- It has atomic weight of 16.
- Its specific gravity at 32° F and at normal atmosphere pressure is 1.1053, as compared with air.
- It is slightly soluble in water.
- It does not burn itself. but readily supports combustion of fuels.

When compressed oxygen comes in contact with finely divided particles of combustible material (i.e., coal dust, mineral oil, grease) it will self-ignite them, leading to fire or explosion. Self-ignition in such cases may be initiated by the heat given up suddenly by compressed oxygen,

Oxygen becomes liquefied at a temperature of -182.962°C at normal atmospheric pressure.

Liquid oxygen has a pale blue colour.

Liquid oxygen becomes solid at - 218.4 C° at normal atmospheric pressure. It combines rapidly with most of the metals and forms oxide. i.e.,

Iron + oxygen = Iron oxide

Copper + oxygen = Cuprous oxide

Aluminium + oxygen = Aluminium oxide

The process of making oxide is called oxidation. Oxygen is found everywhere in nature, either in free state or in a combination with other elements. It is one of the chief constituents of atmosphere i.e., 21% oxygen 78% Nitrogen. Water is chemical compound of oxygen and hydrogen, in which approximately 89% is oxygen by weight and 1/3 by volume. One volume of liquid oxygen produces 860 volumes of oxygen gas. One kg of liquid oxygen produces 750 liters of gas. The weight of the container used to store liquid oxygen is several times less than the weight of cylinders required to store an equivalent quantity of gaseous oxygen.

Production of oxygen gas

Air liquefaction process: This method is based upon the idea of separating the various gases that constitute the air by liquefaction process.

This process is done in three stages.

- purification
- liquefaction
- Distillation

The composition of air and the boiling points of its components are given in Table 1.

Air is a mixture of roughly 78% nitrogen, 21% oxygen and 1% argon and other inert gases.

Table 1
Composition of air

Name of component	Quantity by volume %	Boiling point °C
Nitrogen	78.0300	-195.80
Oxygen	20.9300	-182.96
Argon	00.9325	-185.70
Neon	00.0018	
Helium	00.0005	
Krypton	00.0001	
Xenon	00.000009	
Hydrogen	00.00005	
Carbon dioxide	00.030000	

The basis of the separation of the elements in air by this method depends on the difference in the boiling point of the major elements.

Between nitrogen and oxygen - 13°C

Between nitrogen and argon - 10°C

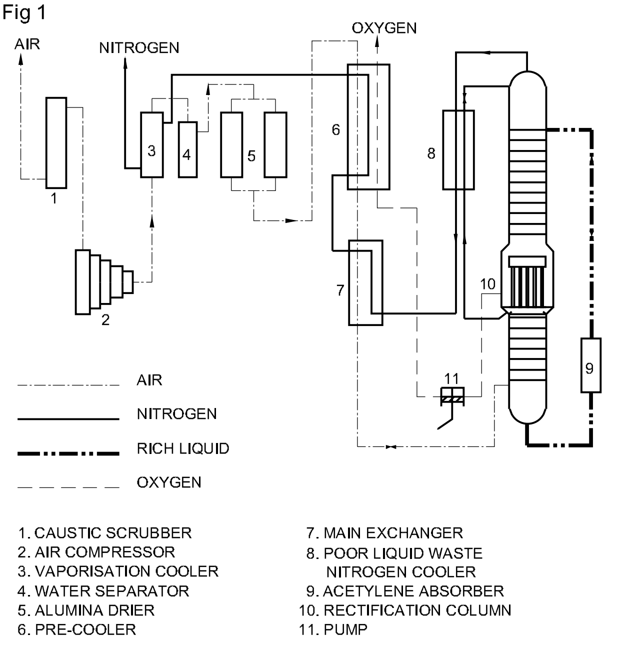
Between oxygen and argon - 3°C

Steps for separating oxygen (Fig 1)

Purification: Air is drawn from the atmosphere into large containers called washing towers, where it is washed and purified of carbon dioxide dust particles by means of caustic soda solution. The washed air from the washing towers is compressed by a compressor to 150 atmospheric pressure and passed through oil purging cylinders and then through aluminium driers, which remove the remaining carbon dioxide and water vapours.

Liquefaction: The dry, clean, compressed air then goes into liquefaction columns, where it is cooled and then expanded to change into liquid form.

Fig 1



PRODUCTION OF OXYGEN BY AIR LIQUEFACTION METHOD

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Distillation: The liquid air is then rectified in the CONDENSER column by increasing the temperature on the basis of difference in the boiling points of its elements.

Nitrogen having a lower boiling point (-195.8°C) evaporates first.

Argon having a boiling point (-185.70°C) evaporates second leaving liquid oxygen in the bottom of the condenser.

Liquid oxygen can be stored in liquid form as shown in the liquid oxygen container. (Fig 2)

The liquid oxygen next passes through a heated coil which changes the liquid into a gaseous form.

The gaseous oxygen goes into a storage tank from where it is drawn and compressed into oxygen gas cylinders.

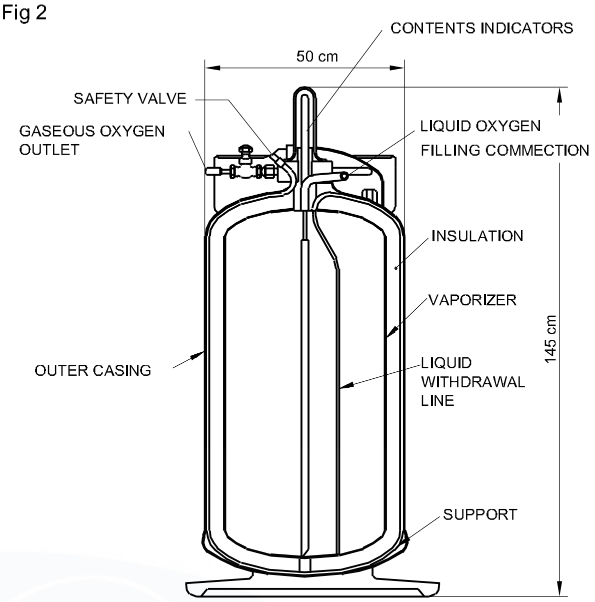
Electrolysis of water (Fig 3): In this method. DC electricity is passed through water causing the water to separate into its elements which are oxygen and hydrogen oxygen will collect at the positive terminal and hydrogen at the negative.

Caustic soda is added to the water to make it a good electrolyte since pure water will not allow the current to pass.

This method produces two volumes of hydrogen and one volume of oxygen.

The cost of producing oxygen by this method is more the oxygen contains more moisture and it is difficult to obtain 99% purity and the process requires enormous quantity of water and electricity. So the air liquefaction method is more commonly used to produce commercial oxygen with a purity of 99.99%.

Fig 2



SECTIONAL VIEW OF THE LIQUID OXYGEN VESSEL OR CONTAINER (FLASK TYPE)

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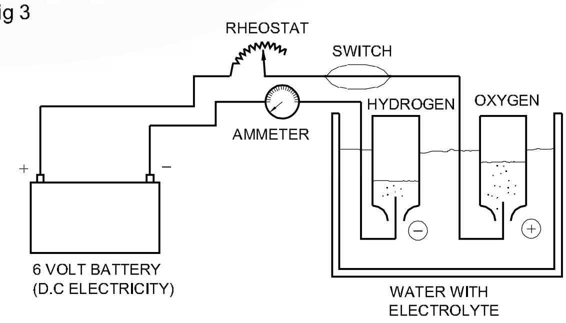
Fig 3



PRINCIPLE OF PRODUCING OXYGEN BY ELECTROLYSIS OF WATER METHOD

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Oxygen gas cylinder

Objectives : At the end of this lesson you shall be able to
- **identify different gas cylinders**
- **explain the constructional features of oxygen gas cylinder and the method of charging.**

Definition of a gas cylinder: It is a steel container, used to store different gases at high pressure safely and in large quantity for welding or other industrial uses.

Types and identifications of gas cylinders: Gas cylinders are called by names of the gas they are holding. (Table 1)

Gas cylinders are identified by their body colour marks and valve threads. (Table 1)

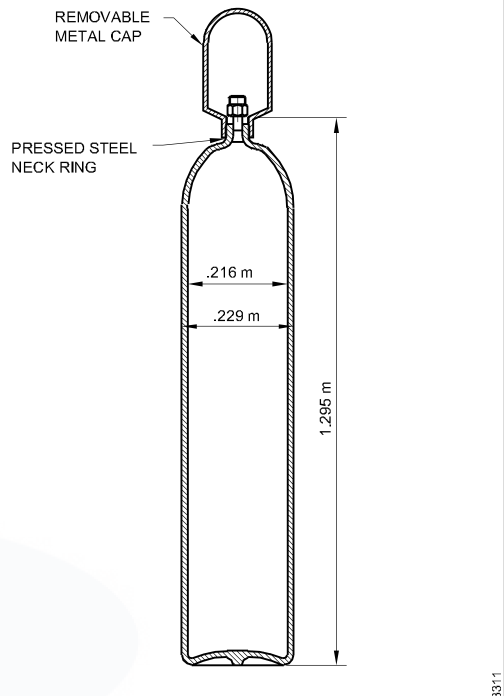
Table 1
Identification of gas cylinders

Name of gas Cylinder	Colour codling	Valve threads
Oxygen	Black	Right hand
Acetylene	Maroon	Left hand
Coal	Red (With name coal gas)	Left hand
Hydrogen	Red	Left hand
Nitrogen	Grey (With black neck)	Right hand
Air	Grey	Right hand
Propane	RED (with larger diameter and name propane)	Left hand
Argon	Blue	Right hand
Carbon-di-Oxide	Black (With white neck)	Right hand

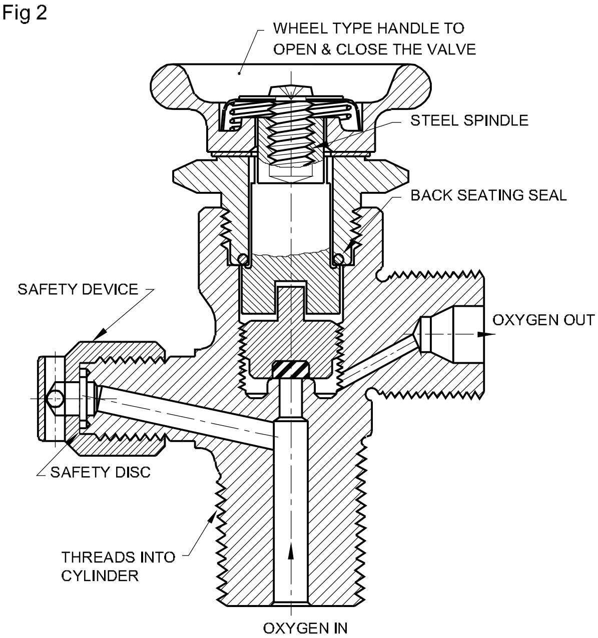
Oxygen gas cylinder: It is a seamless steel container used to store oxygen gas safely and in large quantity under a maximum pressure of 150 kg /cm^2, for use in gas welding and cutting.

Constructional features of oxygen gas cylinder (Fig 1)

It is made from seamless solid drawn steel and tested with a water pressure of 225kg/cm^2. The cylinder top is fitted with a high pressure valve made from high quality forged bronze. (Fig 2)

Fig 1


CONSTRUCTIONAL FEATURE OF OXYGEN GAS CYLINDER

Fig 2


CONSTRUCTIONAL FEATURES OF A CYLINDER VALVE

The cylinder valve has a pressure safety device, which consists of a pressure disc, which will burst before the inside cylinder pressure becomes high enough to break the cylinder body. The cylinder valve outlet socket fitting has standard right hand threads, to which all pressure regulators may be attached. The cylinder valve is also fitted with a steel spindle to operate the valve for opening and closing. A steel cap is screwed over the valve to protect it from damage during transportation. (Fig 1)

The cylinder body is painted black.

The capacity of the cylinder may be $3.5m^3$ - $8.5m^3$.

Oxygen cylinders of $7m^3$ capacity are commonly used.

Dissolved acetylene gas cylinder

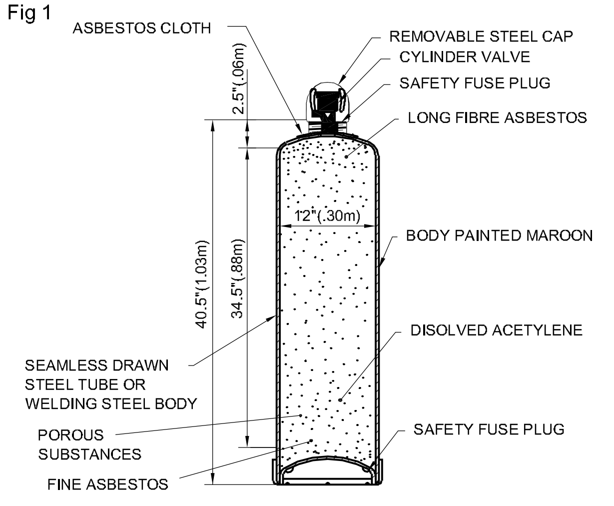
Objectives: At the end of this lesson you shall be able to
- **describe the constructional features of the DA gas cylinder and the method of charging**
- **state the safety rules for handling gas cylinders**
- **explain the safe procedure to be followed in handling an internally fired DA cylinder.**

Charging of gas in oxygen cylinder: The oxygen cylinders are filled with oxygen gas under a pressure of 120-150 kg/cm^2. The cylinders are tested regularity and periodically. They are annealed to relieve stresses caused during 'on the job' handling. They are periodically cleaned using caustic solution.

Definition: It is a steel container used to store high pressure acetylene gas safely in dissolved state for gas welding or cutting purpose.

Constructional features (Fig 1): The acetylene gas cylinder is made from seamless drawn steel tube or welded steel container and tested with a water pressure of 100kg/cm^2 The cylinder top is fitted with a pressure valve made from high quality forged bronze. The cylinder valve outlet socket has standard left hand threads to which acetylene regulators of all makes may be attached. The cylinder valve is also fitted with a steel spindle to operate the valve for opening and closing. A steel cap is screwed over the valve to protect it from damage during transportation. The body of the cylinder is painted maroon. The capacity of the DA cylinder may be $3.5m^3$-$8.5m^3$.

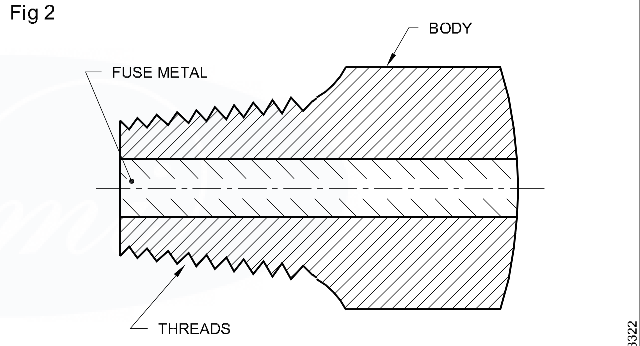
Fig 1



CONSTRUCTIONAL FEATURES OF A DISSOLVED ACETYLENE GAS CYLINDER

The base of the D A cylinder (Curved inside) is fitted with fuse plugs which will melt at a temperature of app. 100°C. (Fig 2) In case the cylinder is subjected to high temperature, the fuse plugs will melt and allow the gas to escape, before the pressure increases enough to harm or rupture the cylinder. Fuse plugs are also fitted on the top of the cylinder.

Fig 2



CONSTRUCTIONAL FEATURE OF A FUSE PLUG FITTED WITH THE CYLINDER TOP AND BOTTOM

Method of charging D A gas cylinder: The storage of acetylene gas in its gaseous form under pressure above 1kg/cm^2 is not safe. A special method is used to store acetylene safely in cylinders as given below.

The cylinders are filled with porous substances such as:

- pith from corm stalk
- fullers earth
- lime silica
- specially prepared charcoal
- Fiber asbestos.

The hydrocarbon liquid named acetone is then charged in the cylinder, which fills the porous substances (1/3rd of total volume of the cylinder).

Acetylene gas is then charged in the cylinder, under a pressure of app. 15 kg//cm^2.

The liquid acetone dissolves the acetylene gas in large quantity as safe storage medium: hence, it is called dissolved acetylene. One volume of liquid acetone can dissolve 25 volumes of acetylene gas under normal atmospheric pressure and temperature. During the gas charging operation one volume of liquid acetone dissolves 25X15=375 volumes of acetylene gas under 15kg/cm^2 pressure at normal temperature. While charging cold water will be sprayed over the cylinder so that the temperature inside the cylinder does not cross certain limit.

Welding gas regulator

Objectives: At the end of this lesson you shall be able to
- **state the different types of regulators**
- **describe the working principle of a single and double stage regulator**
- **explain the parts of each type of regulator**
- **explain the care and maintenance of the regulators.**

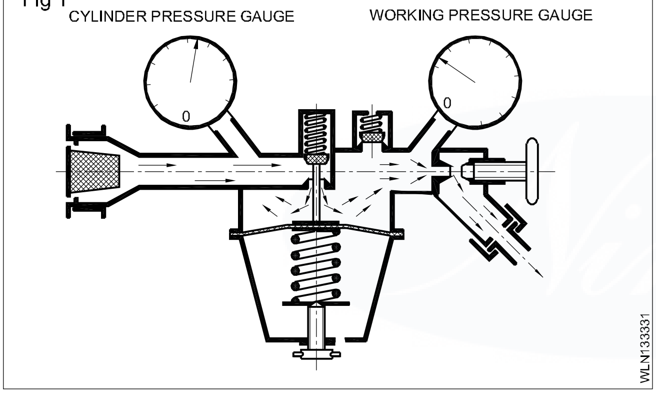
Types of regulators

- single stage regulator
- Double stage regulator

Welding regulator (Single stage)

Working principle: When the spindle of the cylinder is opened slowly, the high pressure gas from the cylinder enters into the regulator through the inlet valve. (Fig 1)

Fig 1



The gas then enters the body of the regulator which is controlled by the needle valve. The pressure inside the regulator rises which pushes the diaphragm and the valve to which it is attached, closes the valve and prevents any more gas from entering the regulator.

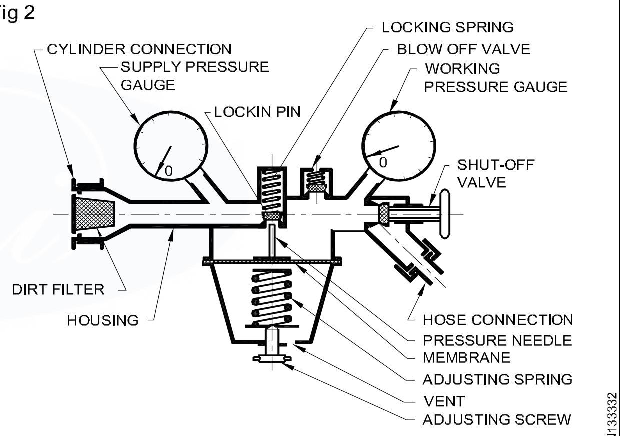
The outlet side is fitted with a pressure gauge which indicates the working pressure on the blowpipe. Upon the gas being drawn 'off from the outlet side, the pressure inside the regulator body falls, the diaphragm is pushed back by the spring and the valve opens, letting more gas 'in' from the cylinder. The pressure in the body, therefore, depends on the pressure of the springs and this can be adjusted by means of a regulator knob. (Fig 2)

Welding regulator (double stage)

Working principle: The two-stage regulator (Fig 3) is nothing but two regulators in one which operates to reduce the pressure progressively in two stages instead of one. The first stage, which is pre-set, reduces the pressure of the cylinder to an intermediate stage (i.e) 5 kg/mm^2 and gas at that pressure passes into the second stage, the gas now emerges at a pressure (Working pressure) set by the pressure adjusting control knob attached to the diaphragm. Two-stage regulators have two safety valves, so that if there is any excess pressure there will be no explosion. A major objection to the single stage regulator is the need for frequent torch adjustment, for as the cylinder pressure falls the regulator pressure likewise falls necessitating torch adjustment. In the two stage regulator, there is automatic compensation for any drop in the cylinder pressure.

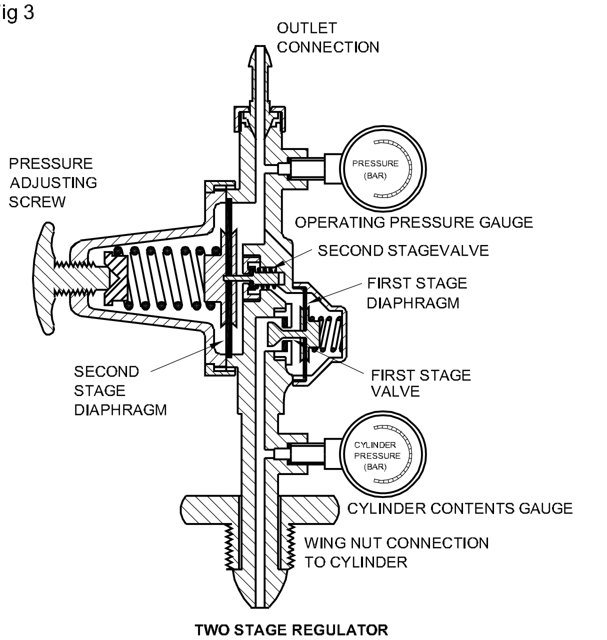
Single stage regulators may be used with pipelines and cylinders. Two stage regulators are used with cylinders and manifolds.

Fig 2



SINGLE STAGE REGULATOR

Fig 3



TWO STAGE REGULATOR