

Safety

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

- state the importance of safety in welding shop
 - list the general safety precautions to be observed in welding shop.
-

Safety

Welding can be dangerous and unhealthy if the proper precautions are not taken. However, using new technology and proper protection greatly reduces risks of injury and death associated with welding. Since many common welding procedures involve an open electric arc or flame, the risk of burns and fire is significant, that is why it is classified as a hot work process.

To prevent injury, welders wear personal protective equipment in the form of heavy leather gloves and protective long-sleeve jackets to avoid exposure to extreme heat and flames. Additionally, the brightness of the weld area leads to a condition called arc eye or flash burns in which ultraviolet light causes inflammation of the cornea and can burn the retinas of the eyes. Goggles and welding helmets with dark UV-filtering face plates are worn to prevent this exposure.

Since the 2000s, some helmets have included a face plate which instantly darkens upon exposure to the intense UV light. To protect bystanders, the welding area is often surrounded with translucent welding curtains. These curtains, made of a polyvinyl chloride plastic film, shield people outside the welding area from the UV light of the electric arc, but can not replace the filter glass used in helmets.

Welders are often exposed to dangerous gases and particulate matter. Processes like flux-cored arc welding and shielded metal arc welding produce smoke containing particles of various types of oxides. The size of the particles in question tends to influence the toxicity of the fumes, with smaller particles presenting a greater danger. This is because smaller particles have the ability to cross the blood brain barrier. Fumes and gases, such as carbon-di-oxide, ozone, and fumes containing heavy metals, can be dangerous to welders lacking proper ventilation and training. Exposure to manganese welding fumes, for example, even at low levels (<0.2 mg/m³) may lead to neurological problems or to damage to the lungs, liver, kidneys, or central nervous system. Nano particles can become trapped in the alveolar macrophages of the lungs

and induce pulmonary fibrosis. The use of compressed gases and flames in many welding processes possess an explosion and fire risk. Some common precautions include limiting the amount of oxygen in the air, and keeping combustible materials away from the workplace.

General safety

- To prevent injury to personel, extreme caution should be exercised when using any types of welding equipment. Injury can result from fire, explosions, electric shock, or harmful agents. Both the general and specific safety precautions listed below must be strictly observed by workers who weld or cut metals.
- Do not permit unauthorized persons to use welding or cutting equipment.
- Do not weld in a building with wooden floors, unless the floors are protected from hot metal by means of fire resistant fabric, sand, or other fireproof material. Be sure that hot sparks or hot metal will not fall on the operator or on any welding equipment components.
- Remove all flammable material, such as cotton, oil, gasoline, etc., from the vicinity of welding.
- Before welding or cutting, warn those in close proximity who are not protected to wear proper clothing or goggles.
- Remove any assembled parts from the component being welded that may become warped or otherwise damaged by the welding process.
- Do not leave hot rejected electrode stubs, steel scrap, or tools on the floor or around the welding equipment. Accidents and/or fires may occur.
- Keep a suitable fire extinguisher nearby at all times. Ensure the fire extinguisher is in operable condition.
- Mark all hot metal after welding operations are completed. Soapstone is commonly used for this purpose.

Safety precautions in handling gas welding plant

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

- state the general safety precautions in oxy-acetylene plants.
- state the safety rules for handling gas cylinders
- state the safety practices for handling gas regulators and hose-pipes.
- state the safety precautions related to blowpipe operations.

To be accident-free, one must know the safety rules first and then practise them as well. As we know can 'accident starts when safety ends'.

Ignorance of rules is no excuse!

In gas welding, the welder must follow the safety precautions in handling gas welding plants and flame-setting to keep himself and others safe.

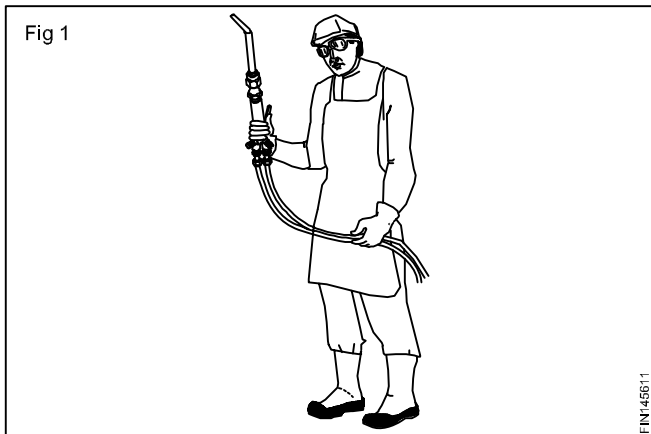
Safety precautions are always based on good common sense.

The following precautions are to be observed, to keep a gas welder accident-free.

General safety

Do not use lubricants (oil or grease) in any part or assembly of a gas welding plant. It may cause explosion.

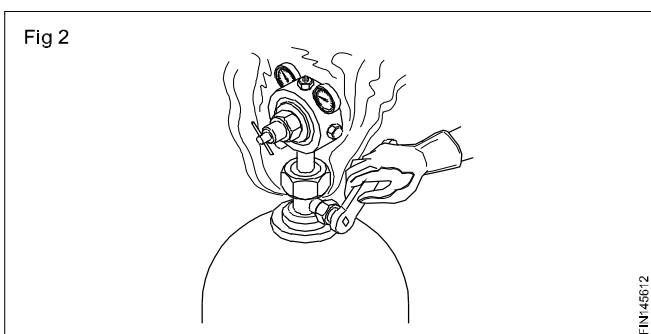
Keep all flammable material away from the welding area. Always wear goggles with filter lens during gas welding. (Fig 1)



Always wear fire resistant clothes, asbestos gloves and apron.

Never wear nylon, greasy and torn clothes while welding.

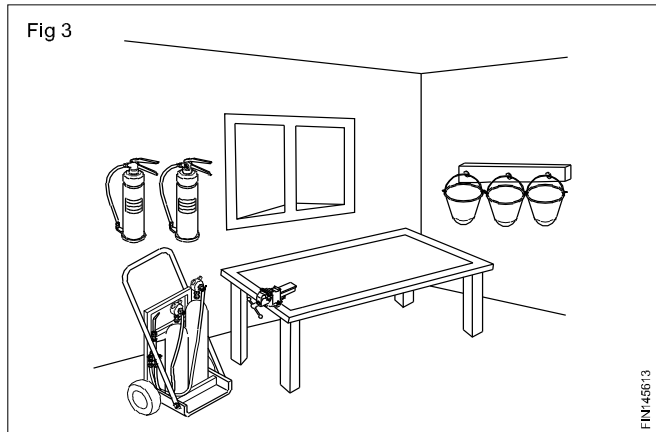
Whenever a leakage is noticed rectify it immediately to avoid fire hazards. (Fig 2)



Even a small leakage can cause serious accidents.

Always keep fire-fighting equipment handy and in working order to put out fires. (Fig 3)

Keep the work area free from any form of fire.



Safety precautions before gas welding

Safety for cylinders.

Do not roll gas cylinders or use them as rollers.

Use a trolley to carry the cylinders.

Close the cylinder valves when not in use or empty.

Keep full and empty cylinders separately.

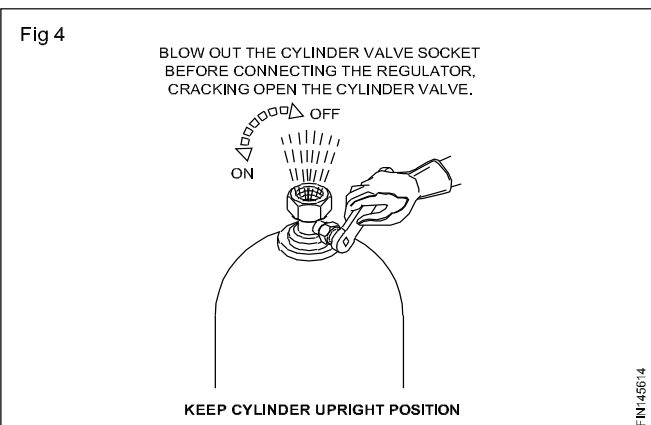
Always open the cylinder valves slowly, not more than one and a half turn.

Use the correct cylinder keys to open the cylinders.

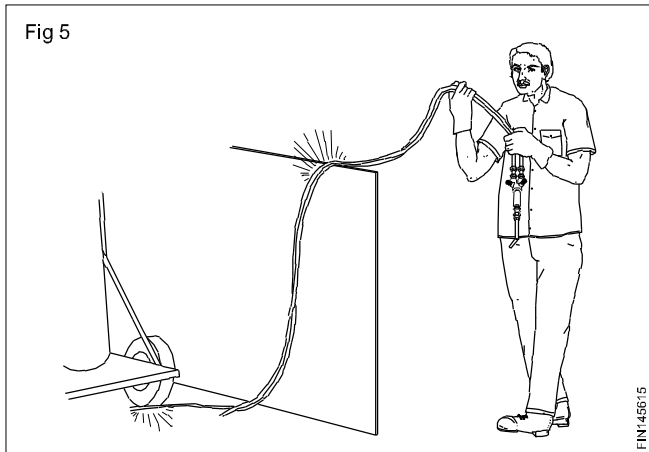
Do not remove the cylinder keys from the cylinders while welding. It will help to close the cylinders QUICKLY in the case of a back-fire or flash-back.

Always use the cylinders in an upright position for easy handling and safety.

Always crack the cylinder valves to clean the valve sockets before attaching regulators. (Fig 4)



Safety for rubber hose pipes (Fig 5)



Inspect the rubber hose pipes periodically and replace the damaged ones.

Do not use odd bits of hose pipes / tubes.

Do not replace the hose pipes for acetylene with the ones used for oxygen.

Always use a black hose pipes for oxygen and maroon hosepipes for acetylene.

Safety for regulators

Prevent hammer blows to the gas cylinders and ensure that water, dust and oil do not settle on the cylinders.

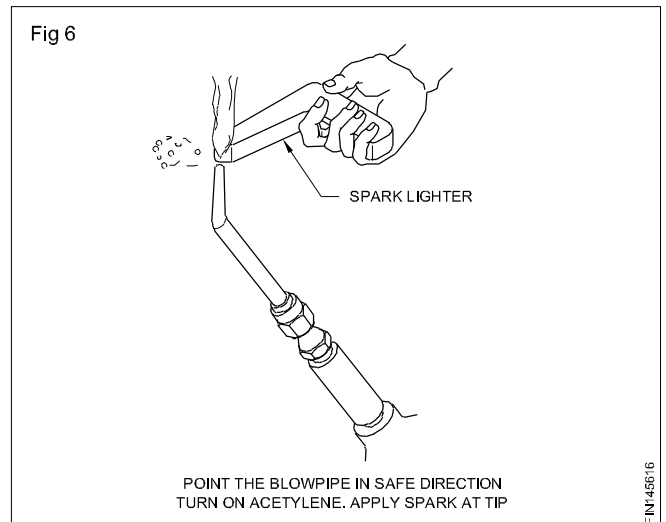
One right hand threaded connection for oxygen and left hand threaded connection for acetylene.

Safety for blowpipes

When a blowpipe is not in use put out the flame and place the blowpipe in a safe place.

When flame snaps out and backfires, quickly shut both the blowpipe valves (oxygen first) and dip in water.

While igniting the flame, point the blowpipe nozzle in a safe direction. (Fig 6)



While extinguishing the flame, shut off the acetylene valve first and then the oxygen valve to avoid a backfire.

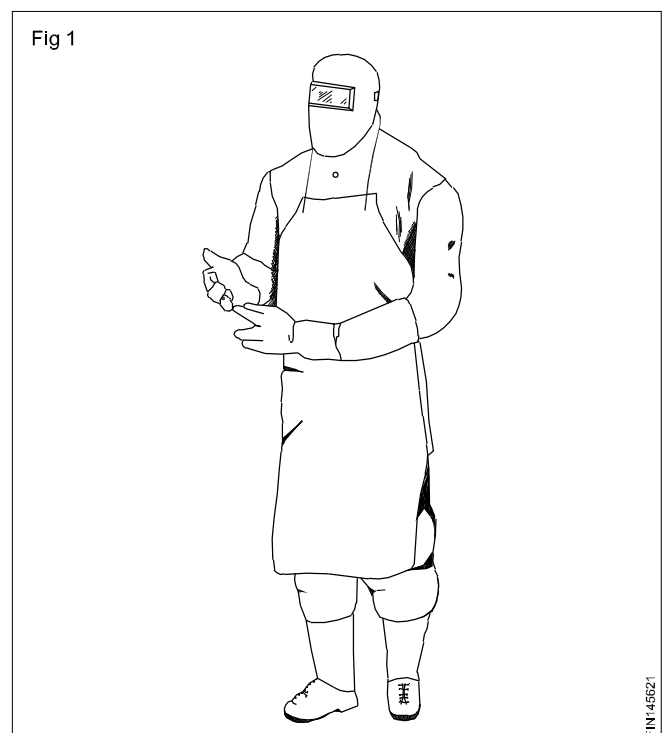
Safety precautions before, during, after arc welding

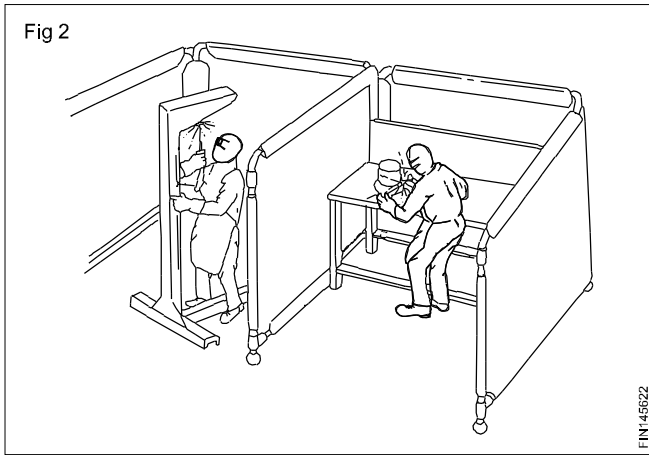
Objective : At the end of this lesson you shall be able to

- state the precautions necessary in arc-welding.

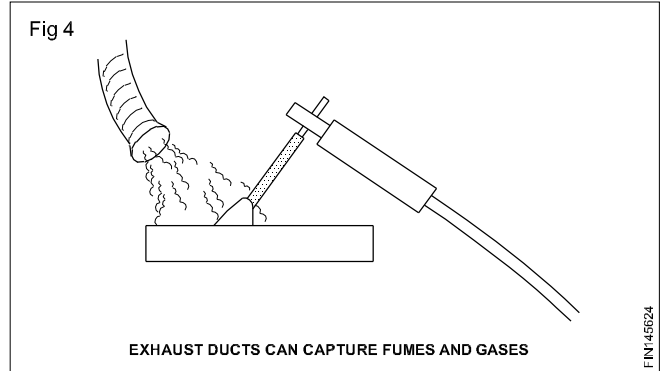
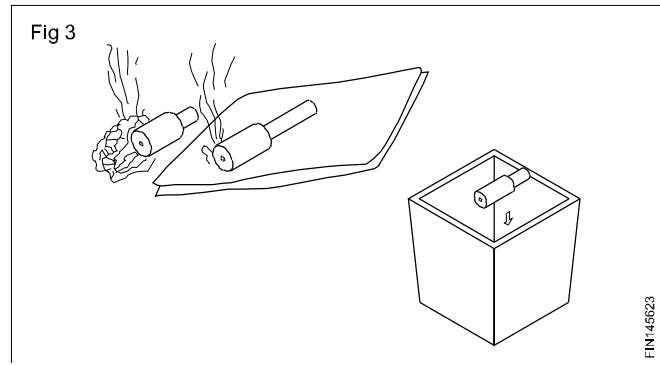
Safety precautions

- Never stand on a damp or wet place while arc-welding.
- Always wear all the safety apparels (gloves, apron, sleeves, shoes). (Fig 1)
- Use welding and a chipping screen during welding and chipping respectively, for the protection of the eyes and the face.
- Switch off the machine when not in use.
- Keep the clothes free from oil and grease.
- Use tongs while handling hot metals.
- Do not carry matches or petrol lighters in your pocket during arc-welding.
- Protect the outsiders from radiation and reflection of rays, by using portable screens or welding booths. (Fig 2)
- Keep the welding area free from moisture and flammable material.
- Do not try to rectify electrical faults yourself; call an electrician.





- Do not throw the electrode stubs on the floor. Put them in a container. (Fig 3)
- Use exhaust fans to remove the arc-welding smoke and fumes. (Fig 4)
- Safety precautions after gas and electric welding after working gas welding and gas cutting bleed the lines to take pressure off regulators, neatly coil the hoses and replace equipment.
- Store hoses, torches, blow pipes regulators safety in proper place.
- Store away the gas cylinders from in flammable and combustible materials.
- After electric welding operations are completed the welder will mark the hot metal or provide some other means of warning other workers.



- Welding machines will be disconnected from the power source.
- Disconnect the welding cables from welding equipment.
- Neatly coil the cable and kept in place safety.
- Place and store electrode holder and other hand tools safely.

Safety equipments and their uses in welding

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

- Name the safety apparels and accessories used in arc welding
- Select the safety apparels and accessories to protect from burns and injuries
- learn how to protect yourself and others from the effect of harmful arc rays and toxic fumes
- select the shielding glass for eye and face protection.

Non-fusion welding

This is a method of welding in which similar or dissimilar metals are joined together without melting the edges of the base metal by using a low melting point filler rod but without the application of pressure.

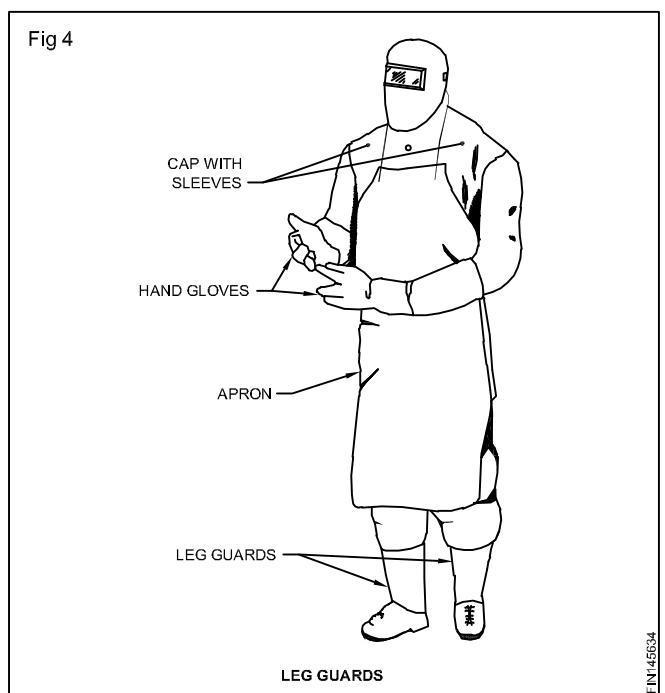
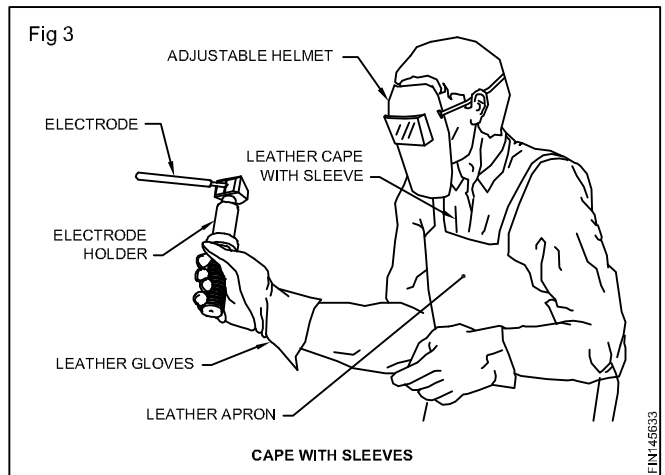
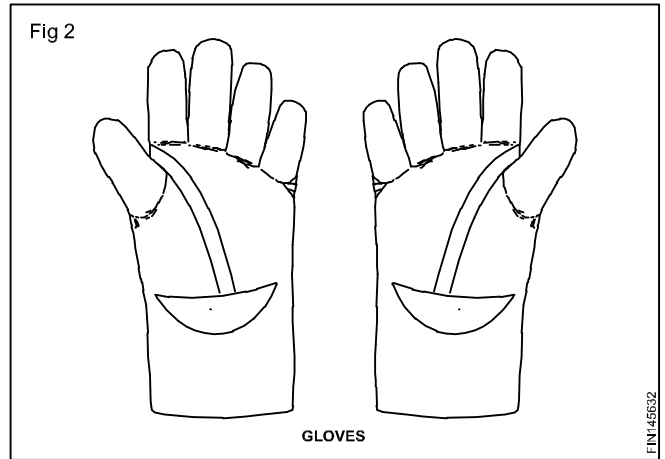
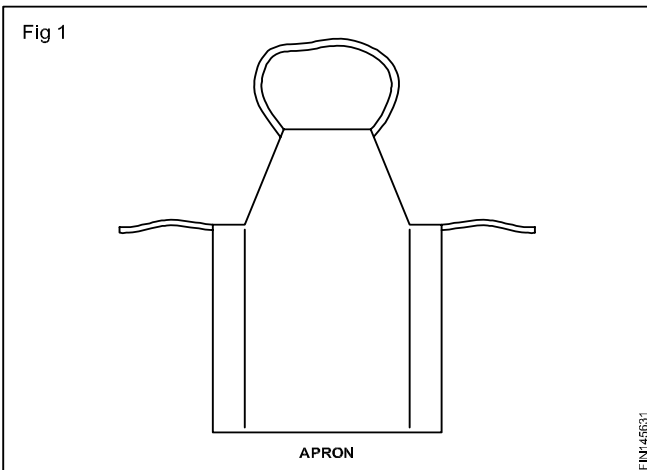
Example: Soldering, Brazing and Bronze welding.

During arc welding the welder is exposed to hazards such as injury due to harmful rays (ultra violet and infra red rays) of the arc, burns due to excessive heat from the arc and contact with hot jobs, electric shock, toxic fumes, flying hot spatters and slag particles and objects falling on the feet.

The following safety apparels and accessories are used to protect the welder and other persons working near the welding area from the above mentioned hazards.

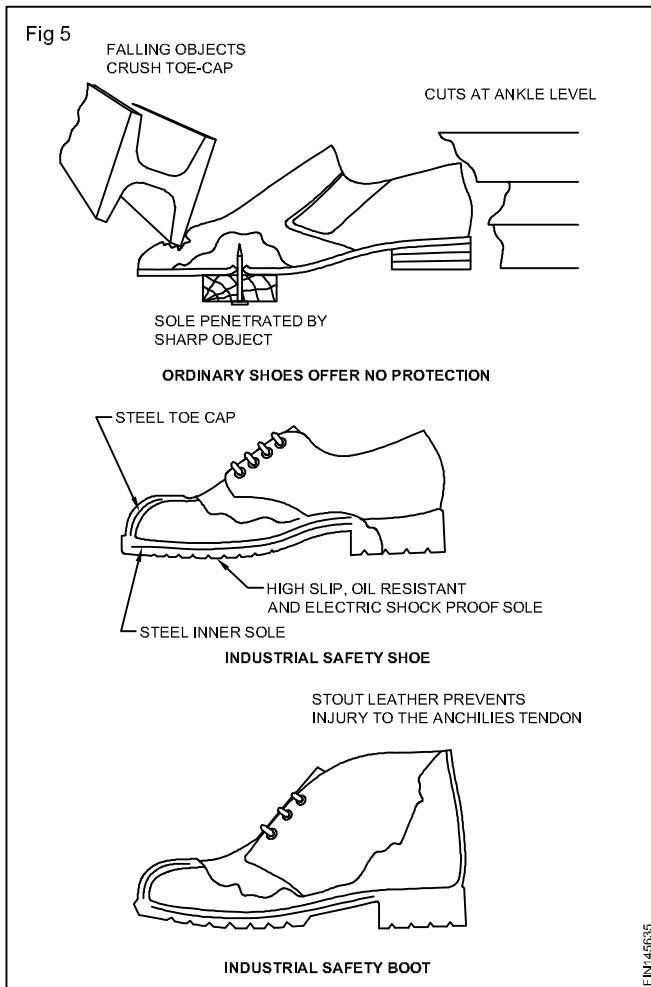
- 1 Safety apparels
 - a Leather apron
 - b Leather gloves
 - c Leather cape with sleeves
 - d Industrial safety shoes
- 2
 - a Hand screen
 - b Adjustable helmet
 - C Portable fire proof canvas screens
- 3 Chipping/grinding goggles
- 4 Respirator and exhaust ducting

The leather apron, gloves, cape with sleeves and leg guard Fig 3,4,5 and 6 are used to protect the body, hands, arms, neck and chest of the welder from the heat radiation and hot spatters from the arc and also from the hot slag particles flying from the weld joint during chipping off the solidified slag.



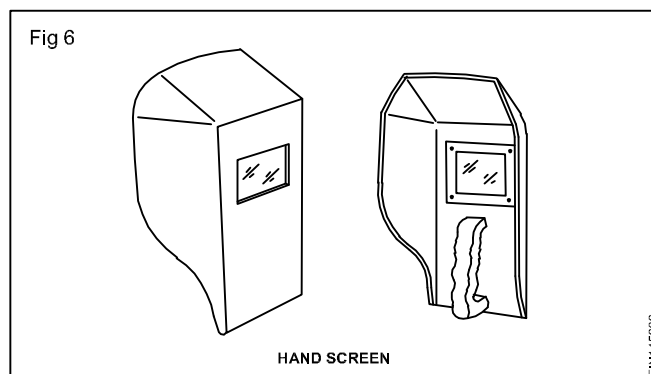
All the above safety apparels should not be loose while wearing them and suitable size has to be selected by the welder.

The industrial safety boot (Fig7) is used to avoid slipping, injury to the toes and ankle of the foot. It also protects the welder from the electric shock as the sole of the shoe is specially made of shock resistant material.

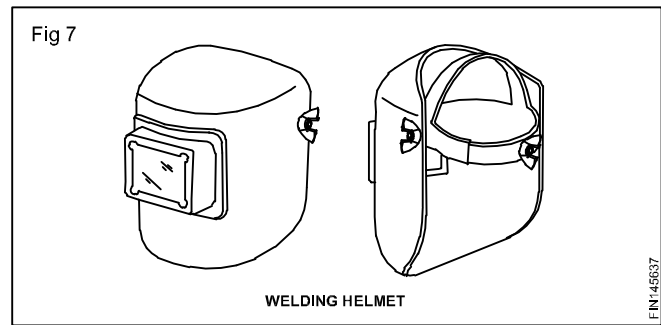


Welding hand screens and helmet: These are used to protect the eyes and face of a welder from arc radiation and sparks during arc welding.

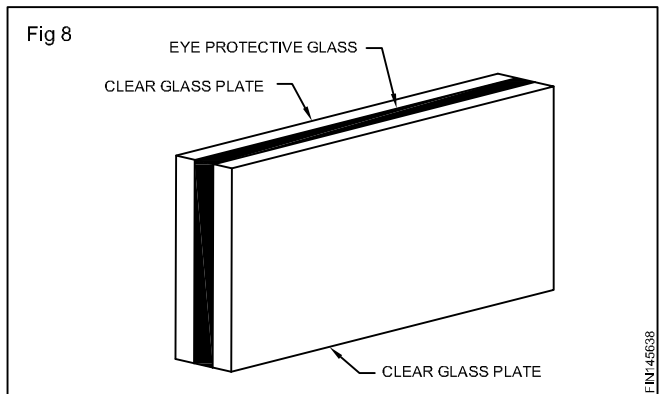
A hand screen is designed to hold in hand (Fig.8)



A helmet screen is designed to wear on the head.(Fig.9)



Clear glasses are fitted on each side of the coloured glass to protect it from weld spatters. (Fig.10)



The helmet screen provides better protection and allows the welder to use his both hands freely.

Coloured (filter) glasses are made in various shades depending on the welding current ranges used. (Table 1)

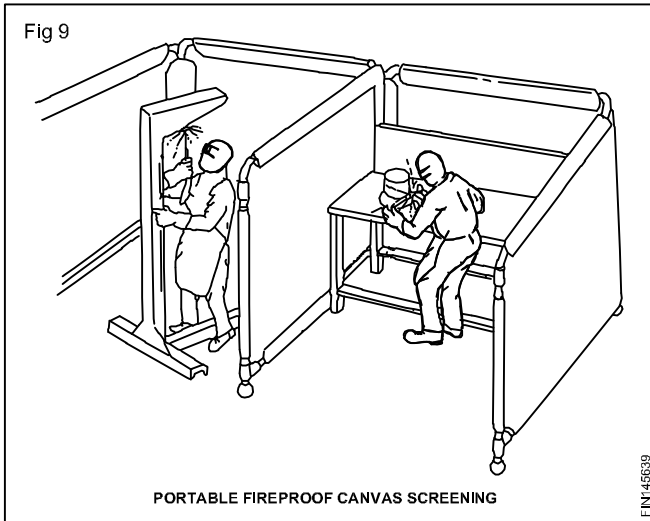
Table 1

Recommendations of filter glasses for manual metal arc welding

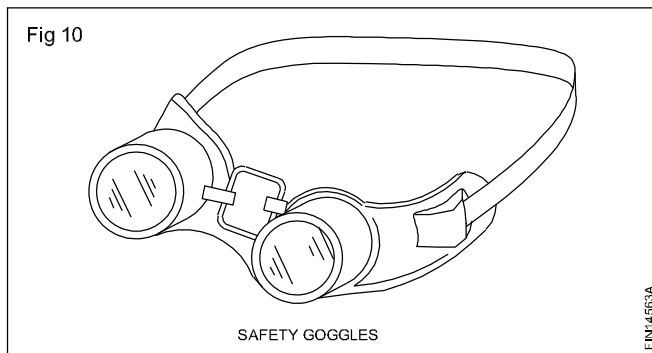
Shade No of coloured glass	Range of welding current in amperes
8-9	Up to 100
10-11	100 to 300
12-14	Above 300

Portable fire proof canvas screens. Fig.11 are used to protect the persons who work near the welding area from arc flashes

Plain goggles are used to protect the eyes while chipping the slag or grinding the job. Fig12



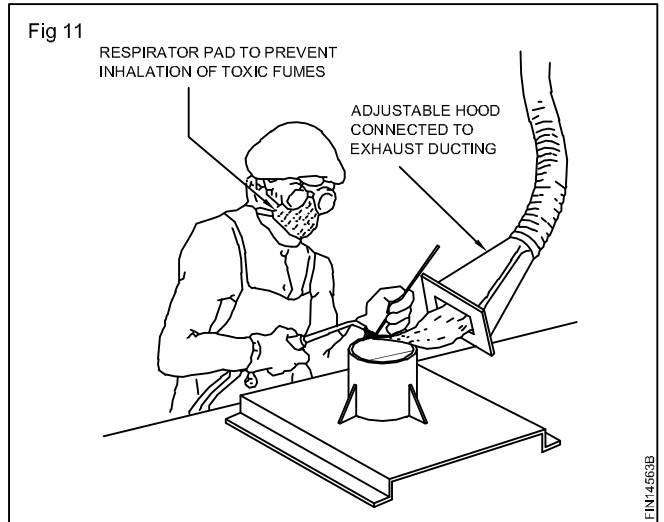
It is made of Bakelite frame fitted with clear glasses and an elastic band to hold it securely on the operator's head.



It is designed for comfortable fit, proper ventilation and full protection from all sides.

Sometimes toxic fumes and heavy smoke may be liberated (given out) from the weld while welding non-ferrous alloys like brass etc. Use a respirator and use exhaust ducts and fans near the weld area to avoid inhaling the toxic fumes and smoke. Fig13.

Inhaling toxic fumes will make the welder to become unconscious and fall on the hot welded job/ on the floor. This causes burns or injury.



Gas welding equipment and accessories

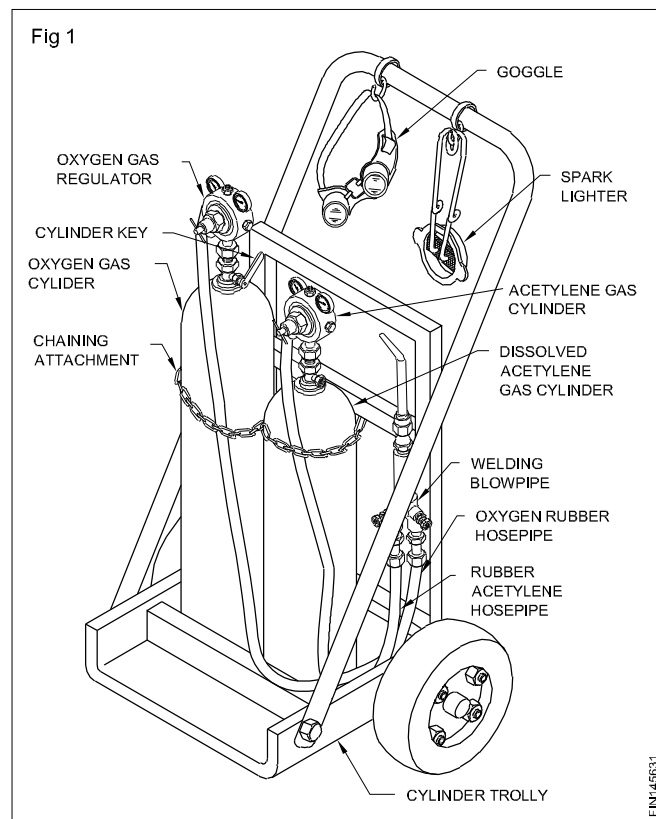
Objectives : At the end of this lesson you shall be able to

- brief the process of gas welding
- list the equipment used in gas welding
- state the functions of each equipment used in gas welding.

Oxy-acetylene welding, popularly known as gas welding is simple, cheap and easy to operate. The heat input can be closely controlled to weld even thin, tiny components. In oxy-acetylene welding process, the metal is heated by an intense flame (3300°C) produced by burning proper quantity of oxygen and acetylene at the tip of welding torch. The flame is directed towards the weld location to melt the metal to be joined and are fused together thus producing weld.

Gas welding equipment

The principle function of the oxy-acetylene welding equipment is to supply the oxy-acetylene gas mixture in the correct ratio to the welding tip at the correct rate of flow and velocity. (Fig 1)

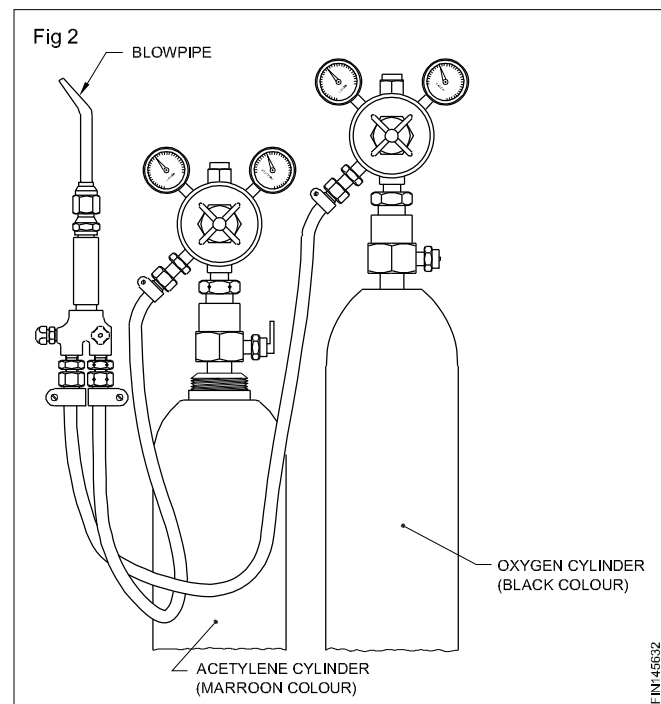


The basic equipments used to carry out gas welding are

- Oxygen gas cylinder
- Acetylene gas cylinder
- Oxygen pressure regular
- Oxygen gas hose (black/green)

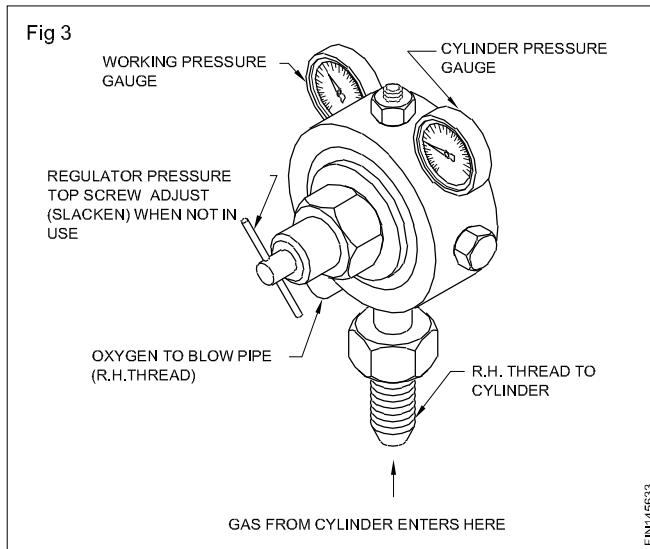
- Acetylene gas hose (Maroon)
- Welding torch or blow pipe with a set of nozzles and gas lighter.
- Tralleys for transportation of oxygen and acetylene cylinder.
- A set of keys and spanners
- Filler rod and fluxes
- Protective clothing for welder (Leather apron, gloves, goggles, etc)

Oxygen gas cylinders: The oxygen gas required for gas welding is stored in bottle-shaped cylinders. These cylinders are painted in black colour. (Fig 2) Oxygen cylinders can store gas to a capacity of 7m³ with the pressure ranging between 120 to 150 kg/cm². Oxygen gas cylinder valves are right hand threaded.

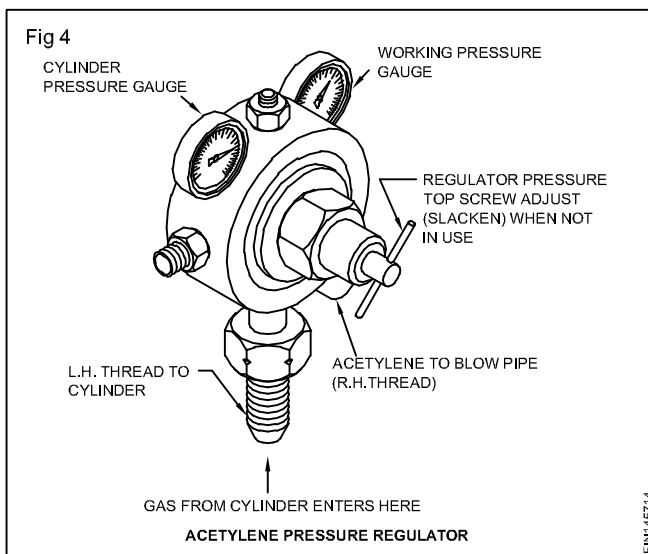


Dissolved acetylene cylinders: The acetylene gas used in gas welding is stored in steel bottles (cylinders) painted in maroon colour. The normal storing capacity of storing acetylene in dissolved state is 6m³ with the pressure ranging between 15-16 kg/cm².

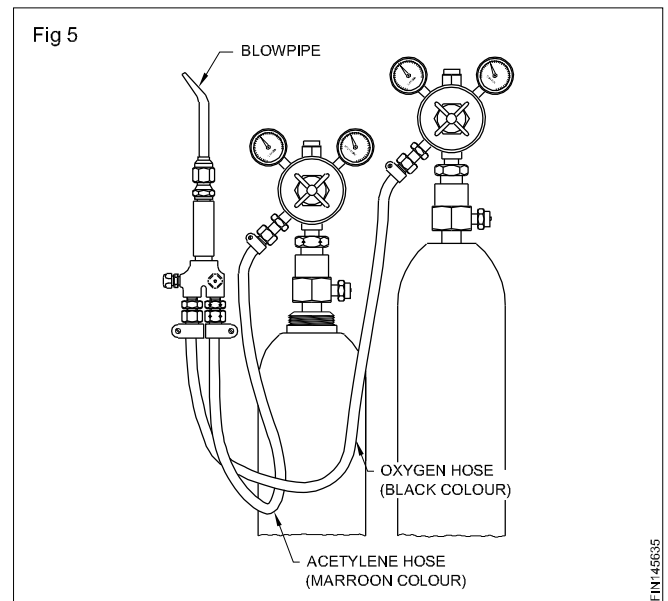
Oxygen pressure regulator: This is used to reduce the oxygen cylinder gas pressure according to the required working pressure and to control the flow of oxygen at a constant rate to the blowpipe. The threaded connections are right hand threaded. (Fig 3)



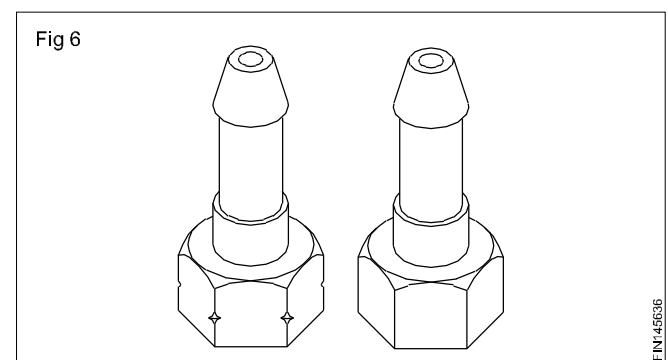
Acetylene regulator: As with the case of oxygen regulator this also is used to reduce the cylinder gas pressure to the required working pressure and to control the flow of acetylene gas at a constant rate to the blowpipe. The threaded connections are left handed. For quickly identifying the acetylene regulator, a groove is cut at the corners of the nut. (Fig 4)



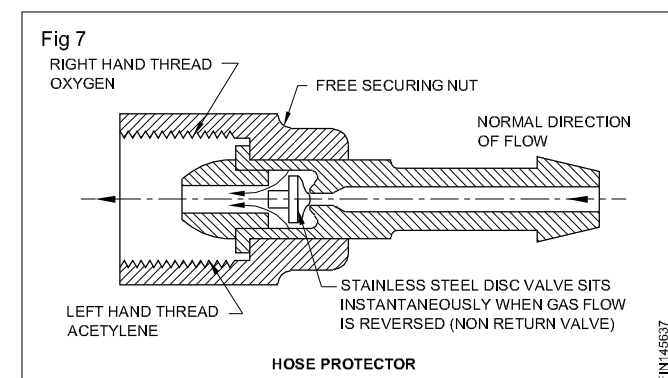
Rubber hose-pipes and connections: These are used to carry gas from the regulator to the blowpipe. These are made of strong canvas rubber having good flexibility. Hose-pipes which carry oxygen are black in colour and the acetylene hoses are of maroon colour. (Fig 5)



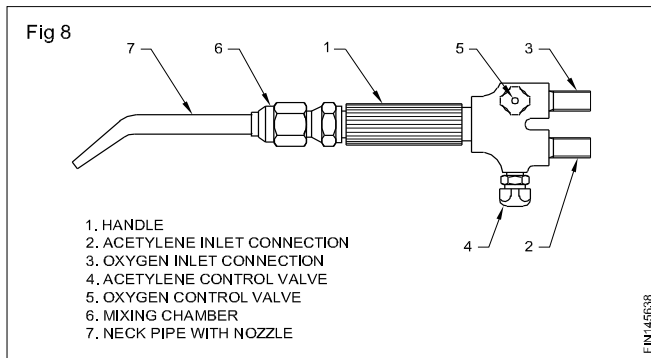
Rubber hoses are connected to regulators with the help of unions. These unions are right hand threaded for oxygen and left hand threaded for acetylene. Acetylene hose unions have a groove cut on the corners. (Fig 6)



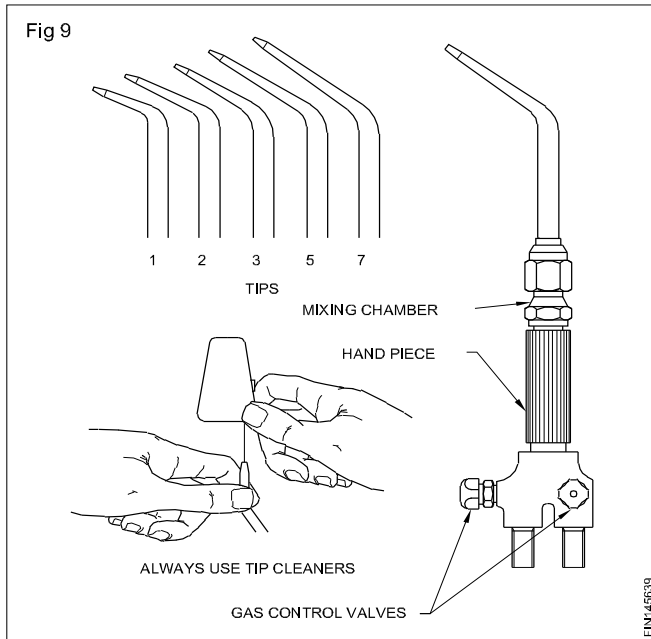
At the blowpipe end of the rubber hoses hose-protectors are fitted. The hose protectors are in the shape of a connecting union and have a non-return disc fitted inside to protect from flashback and backfire during welding. (Fig 7)



Blowpipe and nozzle: Blowpipes are used to control and mix the oxygen and acetylene gases to the required proportion. (Fig 8)



A set of interchangeable nozzles/tips of different sizes is available to produce smaller or bigger flames. (Fig 9)



The size of the nozzle varies according to the thickness of the plates to be welded. (Table 1)

TABLE 1

Plate thickness (mm)	Nozzle size (Number)
0.8	1
1.2	2
1.6	3
2.4	5
3.0	7
4.0	10
5.0	13
6.0	18
8.0	25
10.0	35
12.0	45
19.0	55
25.0	70
Over 25.0	90

Arc welding machines and accessories

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

- state the function of arc-welding machines
- name the different types of arc-welding machines.

In the arc-welding process, the source of heat is electricity (high ampere low voltage). This heat is supplied by the arc-welding machine which is the power source.

Function (Fig 1)

The equipment is used to

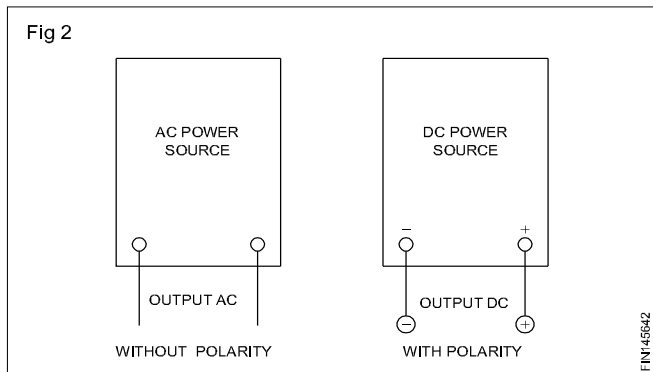
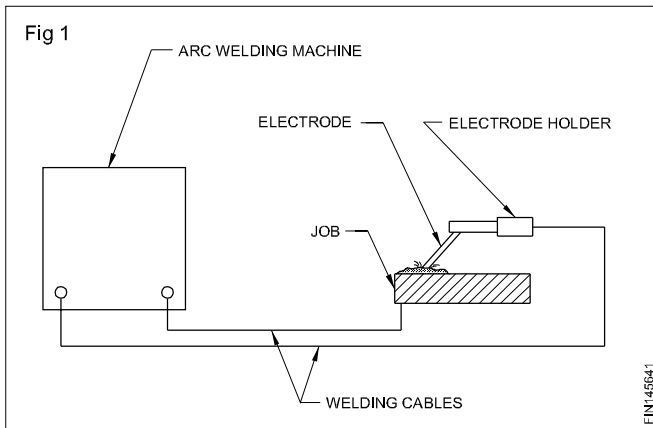
- provide A.C. or D.C. supply for arc welding
- change the high voltage of main supply (A.C.) to low voltage, heavy current (A.C. or D.C.) suitable for arc welding

- control and adjust the required supply of current during arc welding

Types (Fig 2)

Basically the power sources are

- alternating current (A.C.) welding machine
- direct current (D.C.) welding machine.



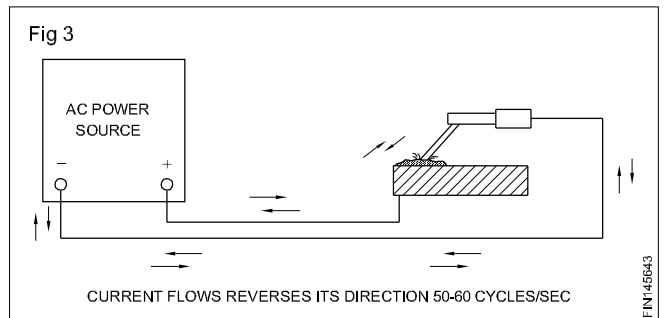
These may be further classified as

- D.C.Machines
- motor generator set
- engine generator set
- rectifier sets.

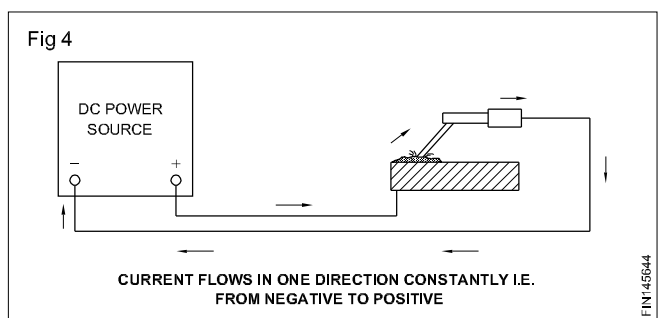
A.C.Machines

- Transformer sets

A.C. means Alternating Current. It changes or reverses its direction of flow 50-60 cycles per second. (Fig 3)



D.C. means Direct Current. It flows steadily and constantly in one direction. (Fig 4)



A.C. welding transformer and welding generator

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

- state the features of A.C. welding transformers
- state the advantages and disadvantages of A.C. welding machines.

A.C. welding transformer

An A.C.welding transformer is a type of A.C. welding machine which converts the A.C. main supply into an A.C. welding supply. (Figs 1 and 2)

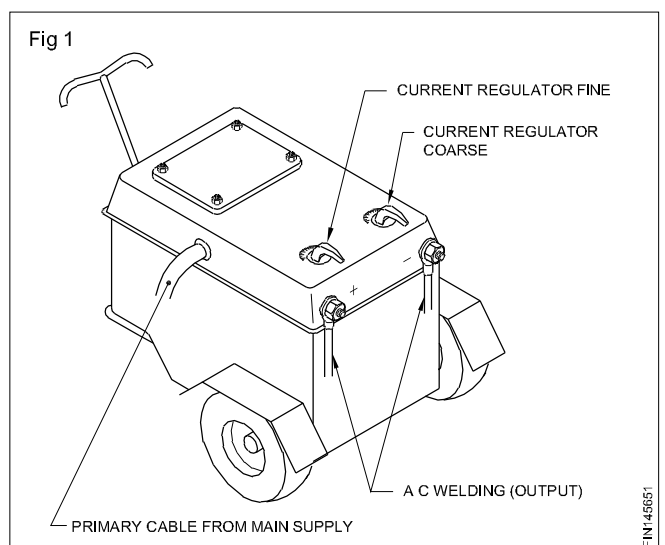
The A.C. main supply has high voltage - low ampere.

The A.C. welding supply has high ampere - low voltage.

It is a STEP-DOWN transformer which reduces the main supply voltage (220 or 440 volts) to the welding supply open circuit voltage (O.C.V.), between 40 and 100 volts.

It increases the main supply low current to the required output welding current in a hundred or thousand amperes.

The A.C. welding machine cannot be operated without the A.C. main supply.



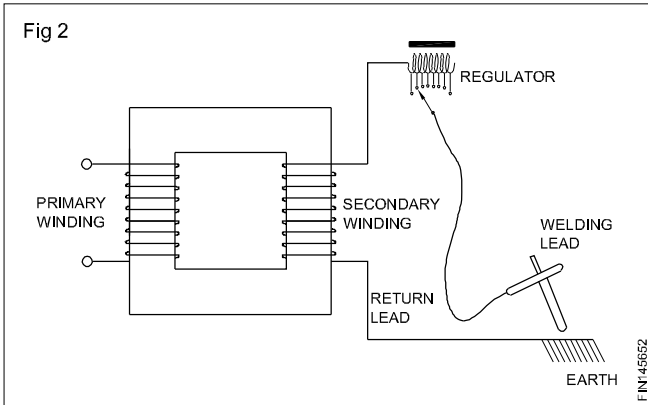
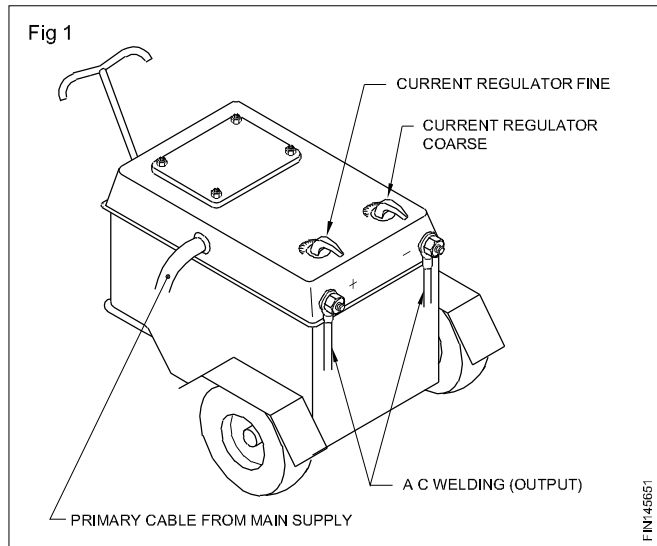
Advantages

- Less initial cost
- Less maintenance cost
- Freedom from arc blow.

Magnetic effect which disturbs the arc is called the arc blow.

Disadvantages

- Not suitable for the welding of non-ferrous metals, light coated and special electrodes.
- The A.C. cannot be used without special safety precautions.



D.C. Arc-welding machines

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

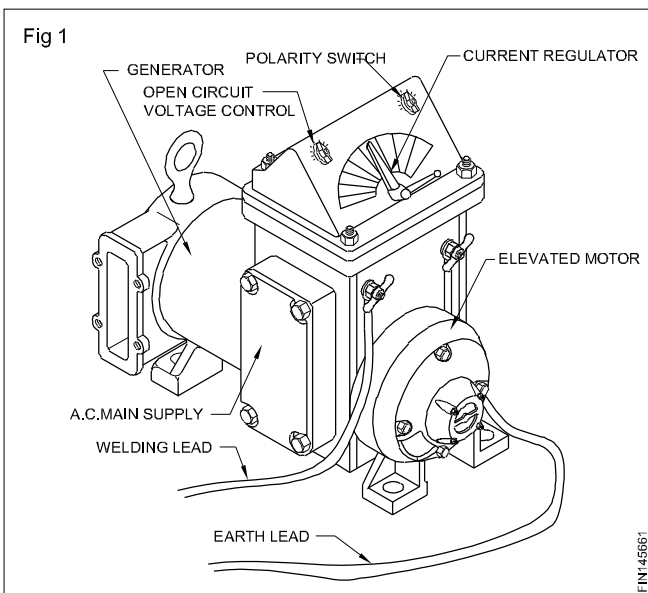
- state the features of a D.C. welding machine
- state its advantages and disadvantages.

Motor generator set (Fig 1)

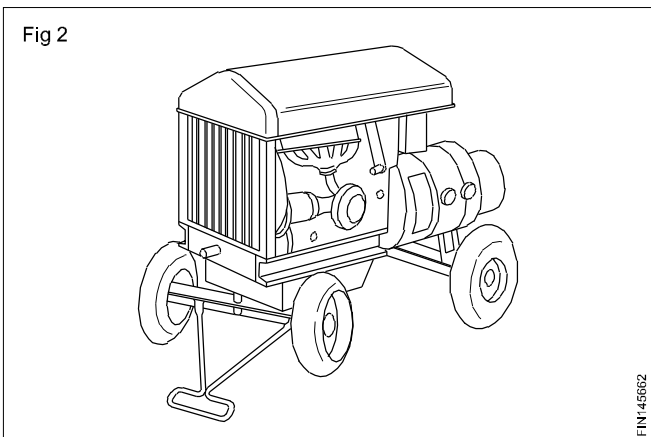
It is used to generate D.C. for arc-welding.

The generator is driven by an A.C. or D.C. motor.

Main supply is a must to run the machine.



Engine generator set (Fig 2)



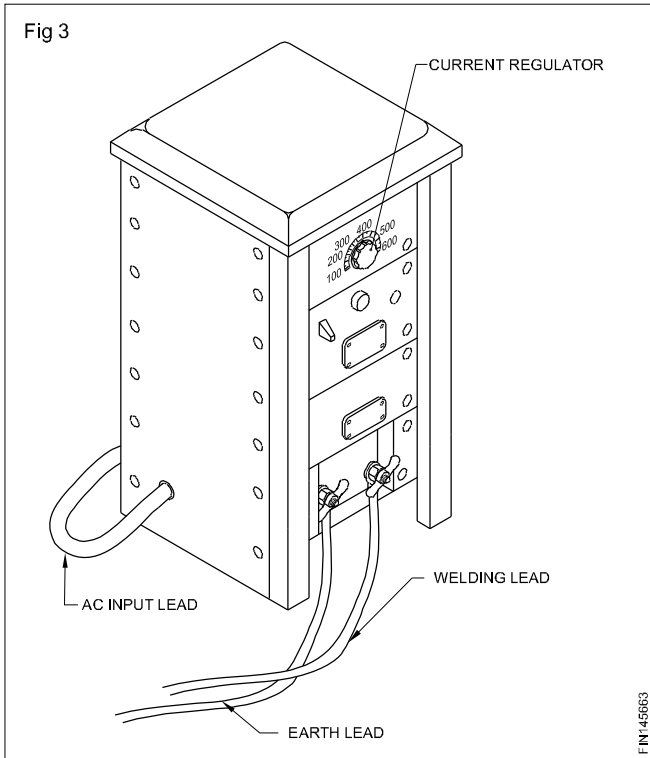
Equipment is similar to the motor generator set except that the generator is driven by a petrol or diesel engine.

Its running and maintenance charges are higher.

It can be used anywhere in field work, away from electric lines.

Rectifier set (Fig 3)

It is used to convert A.C. into D.C. welding supply.



Basically it is an A.C. welding transformer. The output of the transformer is connected with a rectifier to change the A.C. into D.C.

It may be designed to supply both A.C. and D.C. currents for welding (called A.C.-D.C. rectifier set).

Advantages

Suitable for welding all ferrous and non-ferrous metals using all types of electrodes

- Better heat distribution in the electrode and job due to polarity in the welding current supplies constant main load and accurate current setting.

It ensures safe working.

Disadvantages

- Initial cost is higher
- Maintenance cost is more
- Arc-blow trouble faced at certain times.

Polarity in arc welding

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

- state what is polarity in arc welding
- state the types of polarity.

Polarity in D.C. power source

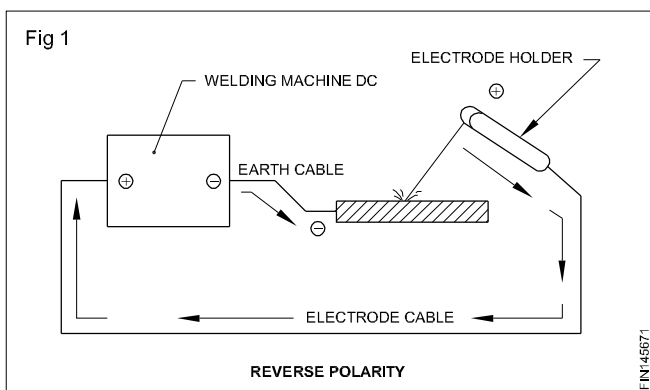
The polarity of a machine refers to the direction of the current flow.

The polarity can be obtained only in D.C.

Polarity may be straight or reverse.

Reverse polarity (Fig 1)

When the electrode cable is connected to the positive terminal, it is called positive polarity or reverse polarity.



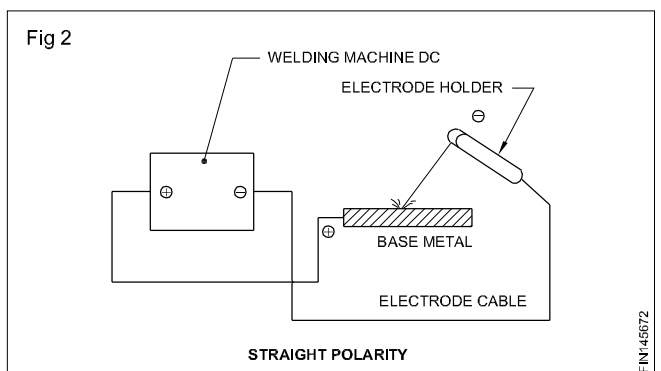
Straight polarity (Fig 2)

When the electrode cable is connected to the negative terminal as it is called negative polarity or straight polarity.

Remember

A.C. has no polarity

The total heat produced in D.C. arc consists of 2/3 heat from the POSITIVE Terminal (66%) and 1/3 heat from the NEGATIVE Terminal (33%).



Arc length and its effects

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

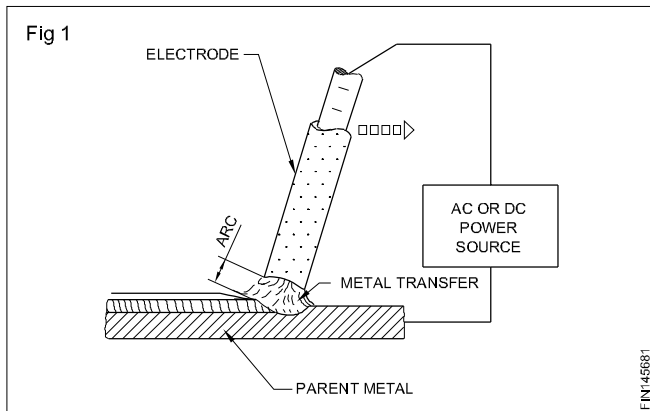
- state what is arc length
- differentiate normal arc, length arc and short arc
- explain the effects of different arc lengths.

Arc length (Fig 1)

It is the straight distance between the electrode tip and the job surface when an arc is formed.

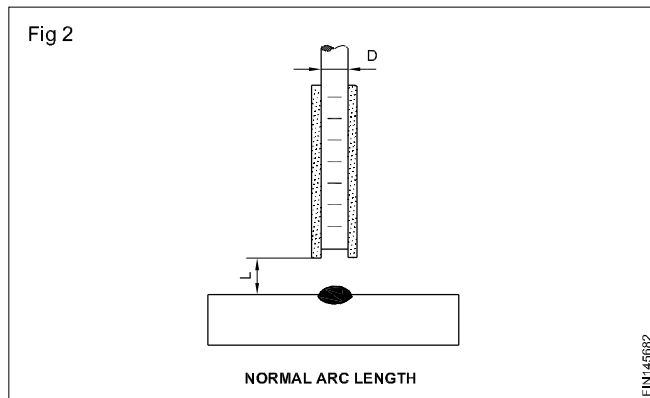
There are three types of arc length.

- Normal
- Long
- Short



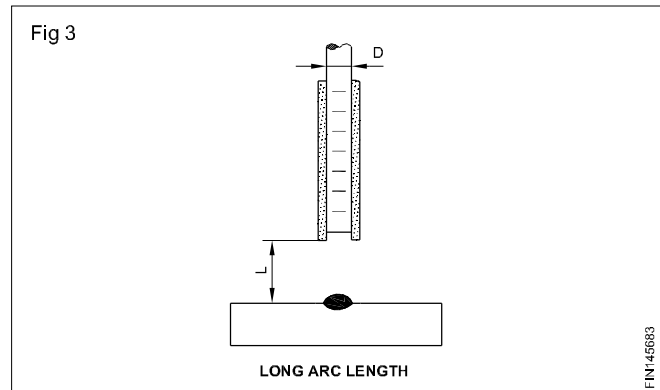
Normal arc length (Fig 2)

The correct arc length or normal arc length is approximately equal to the diameter of the core wire of the electrode.



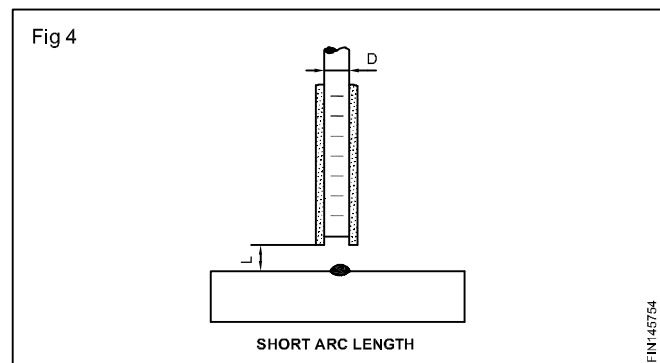
Long arc length (Fig 3)

If the distance between the tip of the electrode and the base metal is more than the diameter of the core wire, it is called 'long arc'.



Short arc length (Fig 4)

If the distance between the tip of the electrode and the base metal is less than the dia. of the core wire, it is called a 'short arc'.



Effects of arc length

- A long arc makes a humming sound
- The arc is unstable
- Causes oxidation of the weld metal.
- Fusion and penetration are poor.
- Poor control of the molten metal.
- Creates more spatters resulting in wastage of the electrode metal.

Short arc

- It makes a popping sound.
- The electrode to melt slowly and try to freeze the job.
- Higher metal deposition with narrow width bead.
- Less spatters.
- Fusion and penetration is less.

Normal arc

- A stable arc produces a steady sharp crackling sound
- Electrode burns evenly.
- Less spatters.

- Correct fusion and penetration.
- The size of metal deposition is correct.

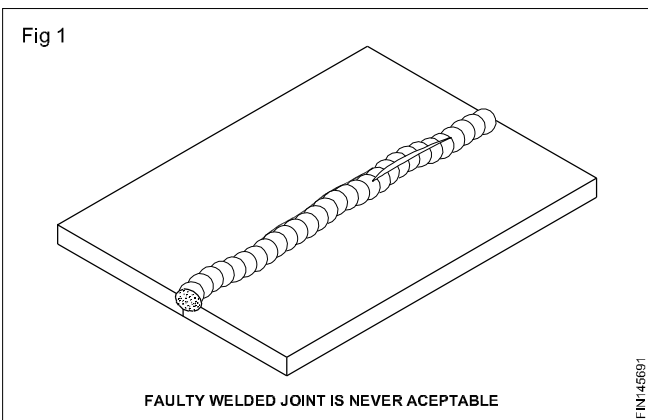
Faults in arc welding

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

- name the visible and invisible defects of weldments.

Weld defects

An imperfection in the weld, by which resulting in loss of strength, is known as weld fault or defect. (Fig 1)



Types

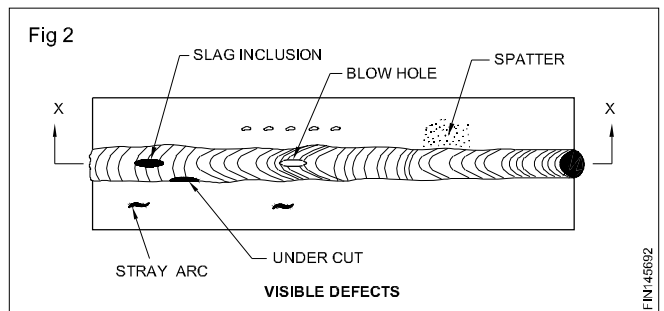
Weld faults are classified as:

- Visible faults, and
- Invisible faults.

Defective welds can result in grave damage to Men and materials.

Visible faults

These are visible to the naked eye on the weld surface. (Fig 2)



Invisible

These faults are inside the weld metal and cannot be seen by the naked eye. (Fig 3)

