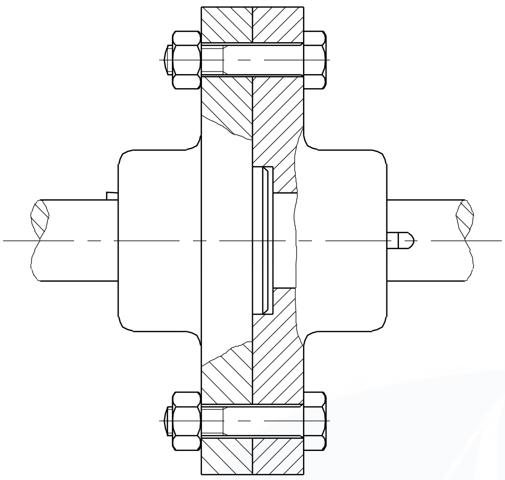
Bolted Joints

Objectives: At the end of this lesson you shall be able to
- **state the situations in which bolts and nuts are used**
- **state the advantages of using bolts and nuts**
- **identify the different types of bolts**
- **state the applications of the different types of bolts**
- **state the situations in which studs are used**
- **state the reason for having different pitches of threads on stud ends.**

Bolts and nuts (Fig 1)

Fig 1



WLN110911

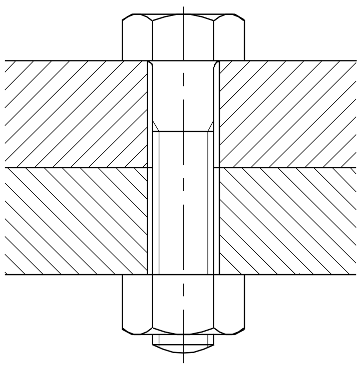
These are generally used to clamp two parts together.

When bolts and nuts are used, if the thread is stripped, a new bolt and nut can be used. But in the case of a screw directly fitted in the component, when threads are damaged, the component may need extensive repair or replacement.

Depending on the type of application, different types of bolts are used.

Bolts with clearance hole (Fig 2)

Fig 2



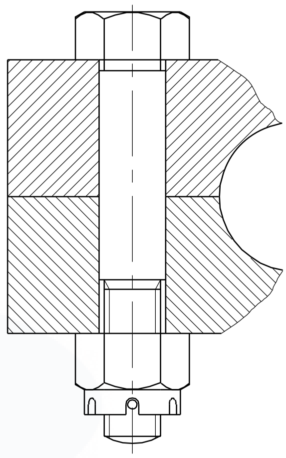
WLN110912

This is the most common type of fastening arrangement using bolts. The size of the hole is slightly larger than the belt (Clearance hole).

Slight misalignment in the matching hole will not affect the assembly.

Body fit bolt (Fig 3)

Fig 3



BODY FIT BOLT

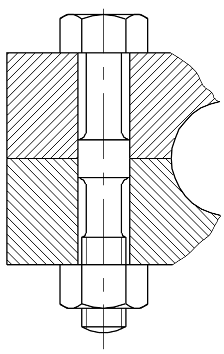
WLN110913

This type of bolt assembly is used when the relative movement between the work pieces has to be prevented. The diameter of the threaded portion is slightly smaller than the shank diameter of the bolt.

The bolt shank and the hole are accurately machined for achieving perfect mating.

Anti-fatigue bolt (Fig 4)

Fig 4



ANTI-FATIGUE BOLT

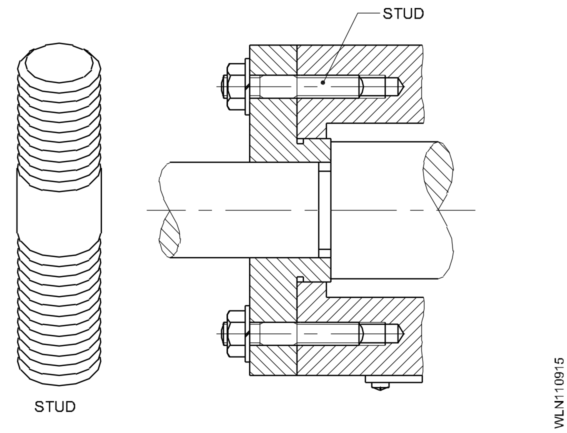
WLN110914

This type of bolt is used when the assembly is subjected to alternating load conditions continuously. Connecting rod with big ends in engine assembly are examples of this application.

The shank diameter is in contact with the hole in a few places and other portions are relieved to give clearances.

Studs (Fig 5)

Fig 5



Studs are used in assemblies which are to be separated frequently.

When excessively tightened, the variation in the thread pitch allows the fine thread or nut end to strip. This prevents damage to the casting.

Designation of bolts as per B.I.S. specifications

Hexagonal head bolts shall be designated by name, thread size, nominal length, property class and number of the Indian Standard.

Example

A hexagonal head bolt of size M10, nominal length 60mm and property class 4.8 shall be designated as:

Hexagonal head bolt M10 60 - 4.8 - IS: 1363 (Part)

Explanation about property class.

The part of the specification 4.8 indicates the property class (mechanical properties). In this case it is made of steel with minimum tensile strength - 40 kgf/mm^2 and having a ratio of minimum yield stress to minimum tensile strength = 0.8.

NOTE

Indian standard bolts and screws are made of three product grades - A, B, & C and 'A' being precision and the others, of lesser grades of accuracy and finish.

(For more details on the designation system, refer to IS: 1367, Part XVI 1979.)

While there are many parameters given in the B.I.S. Specification, the designation need not cover all the aspects and it actually depends on the functional requirement of the bolt or other threaded fasteners.

Rivet joines

Objectives: At the end of this lesson you shall be able to
- **state the purpose of rivets**
- **identify the different types of rivets**
- **name the different types of riveted joints**
- **name the materials from which rivets are made**
- **calculate the length of rivets.**

Rivets are used to join together two or more sheets of metal permanently. In sheet metal work riveting is done where;

- brazing is not suitable,
- the structure changes owing to welding heat,
- the distortion due to welding cannot be easily removed etc.

Specification of rivets

Rivets are specified by their length, material, size and shape of head.

Rivets

There are various kinds of rivets as shown in Fig 1. Snap head rivets, countersink rivets and thin bevel head rivets are widely used in sheet metal work.

The materials used for rivets are mild steel, copper yellow brass, aluminium and heir alloys.

The length of the rivets 'L' is indicated by the shank length. (Fig 1)

Rivet joints (Fig 2)

Rivet joints are classified as lap joints and butt joints.

In the case of butt joints, a plate called a butt strap is used.

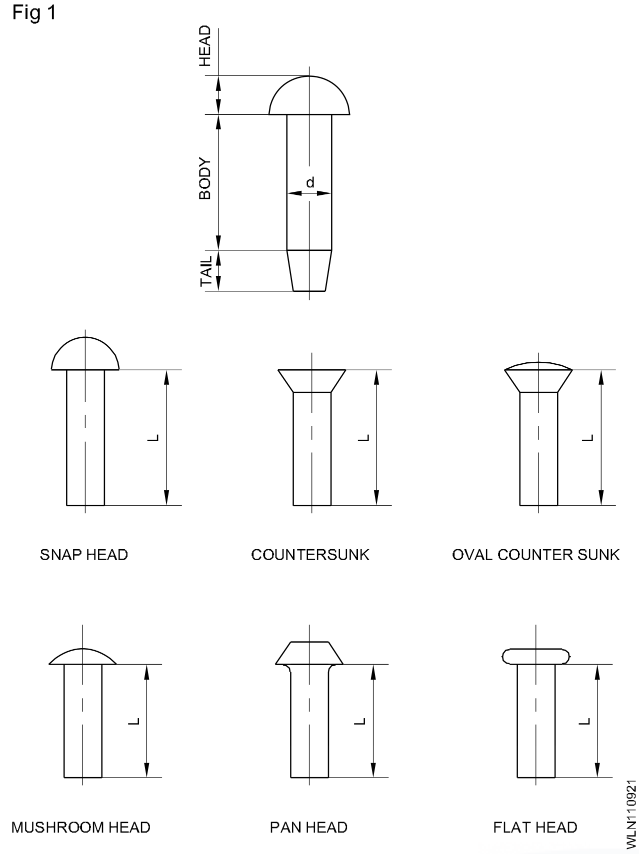
Rivet interference

The length required to form the head in riveting is called rivet interference.

When forming a round head (Fig 3) the interference X is given as

X = d X (1.3, -- 1.6)

Fig 1



where = rivet interference(mm)

d = rivet diameter (mm)

Therefore, the length of the rivet (L mm) to form a round head when the total thickness of the piled plates is T mm will be, as given below.

L = T + d (1.3 - 1.6)

When forming a flat head (Fig 4) the length of the rivet (L'mm) will be as given below.

L' = T + d (0.8 - 1.2)

When the appropriate values of the rivet diameter and the length for the plate thickness are found out, choose the rivets with the standard size close to the calculated values.

Fig 2

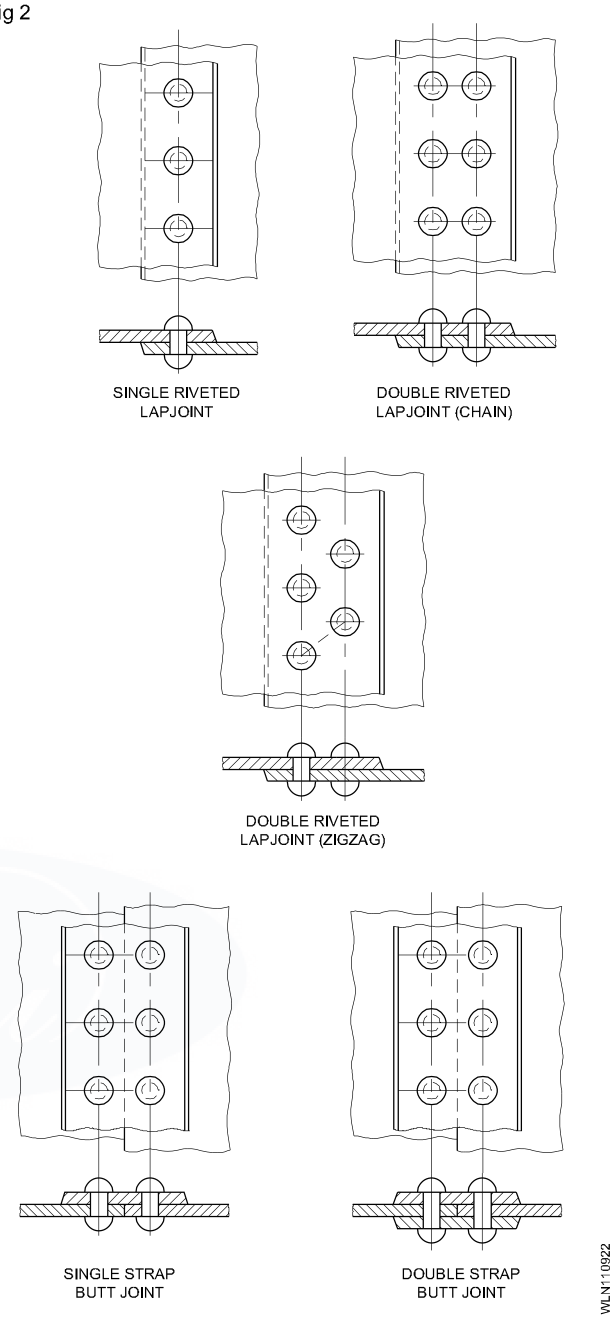


Fig 3

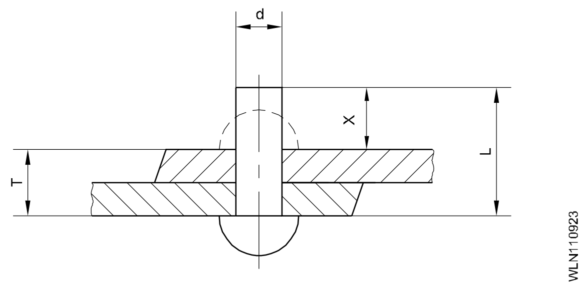
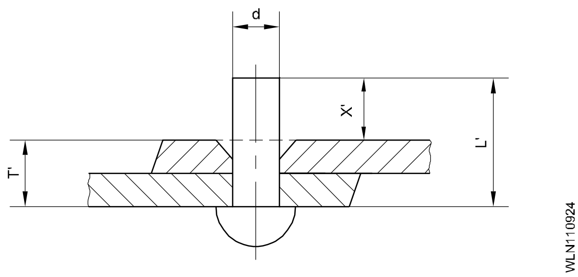


Fig 4



Soldering

Objectives: At the end of this lesson you shall be able to
- **define 'soldering'**
- **state the different types of soldering processes.**

Soldering method: There are different methods of joining metallic sheets. Soldering is one of them.

Soldering is the process by which metals are joined with the help of another alloy called solder without heating the base metal to be joined. The melting point of the solder is lower than that of the materials being joined.

The molten solder wets the base material which helps in binding the base metal to form a joint.

Soldering should not be done on joints subjected to heat and vibration and where more strength is required.

Soldering can be classified as soft soldering and hard soldering. Hard soldering is further divided as (a) brazing (b) sliver brazing.

The process of joining metals using tin and lead as a soldering alloy which melts below 420°C is known as soft soldering.

The process of joining metals using copper. zinc and tin alloy as filler material in which the base metal is heated above 420°C below 850°C is called brazing.

Silver brazing is similar to brazing except that the filler material used is a silver-copper alloy and the flux used is also different.

Soldering iron (soldering bit)

Objectives: At the end of this lesson you shall be able to
- **state the purpose of soldering iron**
- **describe constructional features of soldering iron**
- **state different types of copper bits and there uses.**

Soldering iron: The soldering iron is used to melt the solder and heat metal that are joined together.

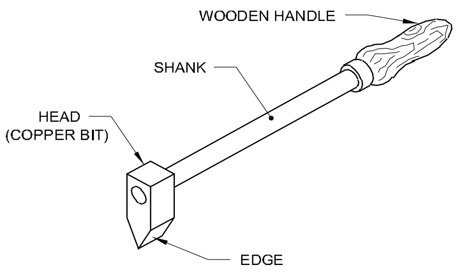
Soldering irons are normally made of copper or copper alloys. So they are also called as copper bits.

Copper is the preferred material for soldering bit because

- it is a very good conductor of heat
- it has affinity for tin lead alloy
- it is easy to maintain in serviceable condition
- it can be easily forged to the required shape.

A soldering iron has the following parts. (Fig 1)

Fig 1



SOLDERING IRON (HATCHET TYPE)

- Head (copper bit)
- Shank
- Wooden handle
- Edge

SOLDERING COPPER BIT

Type of soldering copper bits: There are 7 types of soldering copper bits in general use,

They are

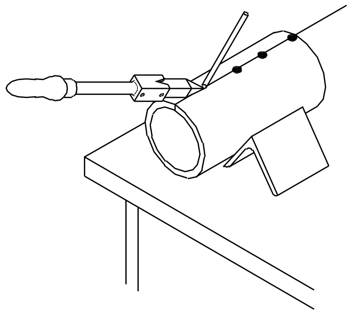
- The pointed soldering copper bit.
- The electric soldering copper bit.
- The gas heated soldering copper bit .
- Straight soldering copper bit.
- Hatchet soldering copper bit.
- Adjustable copper bit
- Handy soldering copper bit.

The bits of soldering irons are made in various shapes and sizes to suit the particular job. They should be large enough to carry adequate heat to avoid too frequent reheating and not too big to be awkward to manipulate.

Soldering bits are specified by the weight of the copper head. For general soldering process, the shape of the head is a square pyramid but for repetition, or awkward placed, other shapes are designated.

Point soldering copper bit: This is also called a square pointed soldering iron, The edge is shaped to an angle on four sides to from a pyramid. This is used for tacking and soldering. (Fig 2)

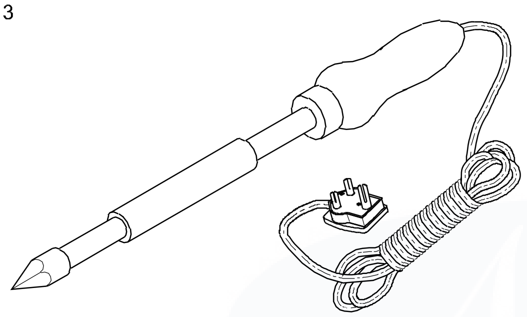
Fig 2



WLN110932

Electric soldering copper bit: The bit of the electric soldering iron is heated by an element. This type is preferred, if current is available because it maintains uniform heat. Electric soldering irons are available for different voltages and are usually supplied with a number of interchangeable tips. They can be made quite small and are generally used on electrical or radio assembly work (Fig 3)

Fig 3

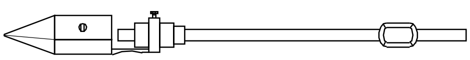


ELECTRIC COPPER SOLDERING

WLN110933

Gas heated soldering copper bit: A gas heated soldering copper bit is heated by a gas flame which ignites on the back of the head. High pressure gas is used and the bit is large enough to have a good heat storage capacity. Liquified petroleum gas (L.P.G) flame is used extensively for this purpose. Soldering kit normally includes many sizes and shapes of bits which can be used to make most kinds of soldering connections. (Fig 4)

Fig 4

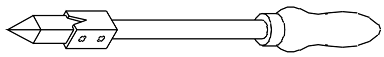


GAS HEATED SOLDERING COPPER BIT

WLN110934

Straight soldering copper bit: This type of soldering iron is suitable for soldering the inside bottom of a round job. (Fig 5)

Fig 5

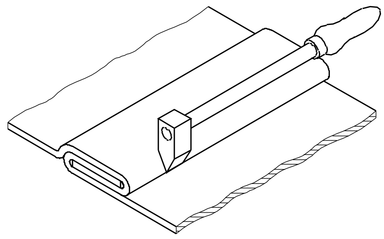


STRAIGHT SOLDERING COPPER WITH HANDLE

WLN110935

Hatchet soldering copper bit: This type of soldering iron is very much suitable for soldering on flat position hp or grooved joint outside round or square bottom. (Fig 6)

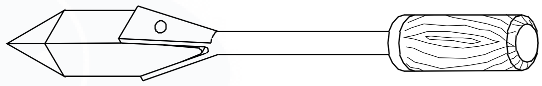
Fig 6



WLN110936

Adjustable soldering copper bit: This type of soldering iron is used for soldering where straight or Hatchet bit cannot be used for soldering. Adjustable soldering bit can be adjusted in any position for soldering. (Fig 7)

Fig 7

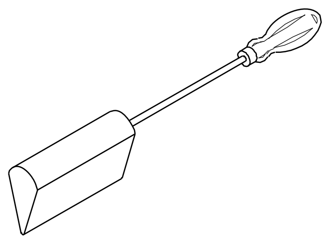


ADJUSTABLE SOLDERING BIT

WLN110937

Handy soldering copper bit: It is like a hatchet type but bigger in size than the hatchet. It is used for soldering heavy gauges of metal because additional heat will cause the metal to buckle. (Fig 8)

Fig 8



HANDY SOLDERING COPPER BIT

WLN110938

Solder

Objectives: At the end of this lesson you shall be able to
- **define a solder**
- **state the types of solders**
- **state the constituents of soft and hard solders.**

Solder is a bonding filler metal used in soldering process.

Pure metals or alloys are used as solders. Solders are applied in the form of wires, sticks ingots, rods, threads, tapes, formed sections, powder, pastes etc.

Types of solders

There are two types of solders.

- Soft solder
- Hard solder

Soft solders: Soft solders are alloys of tin and lead in varying proportions. They are called soft solders because of their comparatively low melting point. One distinguishes between soft solder whose melting points are 450°C and hard solders whose melting points lie above 450°C These are alloys of the materials tin, lead, anitimony, copper, cadmium and zinc and are used for soldering heavy (thick) metals. Table shows different compositions of solder and their application.

Warning

For cooking utensils, do not use solder containing lead. This could cause poisoning. Use pure tin only.

Hard solder: These are alloys of copper, tin, silver, zinc, cadmium and phosphorus and are used for soldering heavy metals.

Sl.No.	Types of solder	Tin	Lead	Application
1	Common solder	50	50	General sheet metal applications
2	Fine solder	60	40	Because of quick setting properties and higher strength, they are used for copper water electrical work.
3	Fine Solder	70	30	
4	Coarse solder	40	60	Used on glavanised iron sheets
5	Extra fine solder	66	34	Soldering brass, copper and jewellery
6	Eutectic alloy	63	37	Similar to fine solder

Soldering flux

Objectives: At the end of this lesson you shall be able to
- **state the functions of soldering fluxes**
- **state the criteria for the selection of fluxes**
- **distinguish between corrosive and non-corrosive fluxes**
- **state the different types of fluxes and their applications.**

All metal rust to some extent, when exposed to the atmosphere because of oxidation. The layer of the rust must be removed before soldering. For this, a chemical compound applied to the joint is called flux.

Function of the fluxes:

1 Fluxes remove oxides from the soldering surface. It prevents corrosion.

2 It forms a liquid cover over the work piece and prevents further oxidation.

3 It helps molten solder to flow easily in the required place by lowering the surface tension of the molten solder.

Selection of flux: The following criteria's are important for selecting a flux.

- Working temperature of the solder
- Soldering process
- Material to be joined

Different types of fluxes: Flux can be classified as (1) Inorganic or corrosive (Active) & (2) Organic or noncorrosive (Passive.)

Inorganic fluxes are acidic and chemically active and remove oxides by chemically dissolving them. They are applied by brush directly on to the surface to be soldered and should be washed immediately after the soldering operation is completed.

organic fluxes are chemically inactive. These fluxes coat the surface of the metals to be joined and exclude the air from the surface, to avoid further oxidation. They are applied only to the metal surfaces which have been previously cleaned, by mechanical abrasion. They are in the form of lump, powder, paste or liquid.

Different types of of fluxes

A A Inorganic fluxes

1 Hydrochloric acid: Concentrated hydrochloric acid is a liquid which fumes when it comes into contact with air. After mixing with water 2 or 3 times the quantity of the acid, it is used as dilute hydrochloric acid. Hydrochloric acid combines with zinc farming zinc chloride and acts as a flux. So it cannot be used as a flux for sheet metals other than zinc iron or galvanised sheet this is also known as muriatic acid.

2 Zinc chloride: Zinc chloride is produced by adding small pieces of clean zinc to hydrochloric acid. It gives off hydrogen gas and heat after a vigorous bubbling action, thus producing zinc chloride. The zinc chloride is prepared in heat resisting glass beakers in small quantities.(Fig1)

3 **Ammonium chloride or Sal-Ammoniac:** It is a solid white crystalline substance used when soldering copper, brass, iron and steel. It is used in the form of powder mixed with water. It is also used as a cleaning agent in dipping solution.

4 **Phosphoric acid:** It is mainly used as flux for stainless steel. It is extremely reactive. It is stored in plastic containers because it attacks glass.

B Organic fluxes

1 **Resin:** it is an amber coloured substance extracted from pine tree sap. It is available in paster or powder form.

Resin used for soldering copper, brass, bronze, tin plate, cadmium, nickel, silver and some alloys of these metals. This is used extensively for electrical soldering work.

2 **Tallow:** It is a form of animal fat. It is used when soldering lead, brass and copper.

The following Table shows the nature and type of flux used in soldering.

Metal to be soldered	Inorganic flux	Organic flux	Remarks
Aluminium Aluminium-bronze			Commercially prepared flux and solder required
Brass	Killed spirits Sal ammoniac	Resin Tallow	Commercial flux available
Cadmium	Killed sprits	Resin	commercial flux available
Copper	Killed sprits sal-ammoniac	Resin	Commercial flux available
Gold		Resin	
Lead	Killed Spirits	Tallow Resin	
Monel			Commercial flux required
Nickel	Killed spirits	Resin	commercial flux available
Silver		Resin	commercial flux available
Stainless steel	Phosphoric acid		commercial flux available
Steel	Killed spirits		
Tin	Killed spirits		commercial flux available
Tin -bronze	Killed spirits	Resin	
Tin-lead			
Tin-zinc	Killed spirits	Resin	
zinc	Muriatic acid		

Portable hand forge with blower

Objectives: At the end of this lesson you shall be able to
- **state the purpose of hand forge**
- **describe the constructional feature of hand forge**
- **state the fuel used in hand forge.**

Hand forge: It is used for heating the soldering bit.

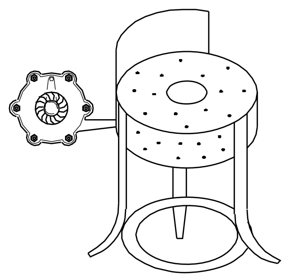
It is made of mild steel plates and angles. It is generally round in shape, the hand blower is attached to it for air supply.

A perforated plate is fixed at the bottom to remove burnt residuals.

The fuel zone is built up with fire bricks and coated with the mixture of clay and sand, providing space at the centre for fuel, (Fig 1)

The fuel used for firing is mainly charcoal. The charcoal is prepared from hard wood.

Fig 1



HAND FORGE

Dipping solution

Objectives: At the end of this lesson you shall be able to
- **state the use of the dipping solution**
- **state the constituents of the dipping solution.**

It is used to dissolve oxides from solder coated faces of the copper bit before applying it to the workpiece.

It is made of

1 Dissolving sal-ammoniac powder in water.

2 Dilute zinc-chloride with water,

3 Adding commercial flux with zinc chloride or ammonium chloride as active ingredients to water.

A mixture of approximately one part of active component and four parts of water is satisfactory as the acidity of the solution should not be strong.

Safety precautions in soldering

Objectives: At the end of this lesson you shall be able to
- **follow safety precautions in soldering to avoid injuries/acccidents.**

Safety precautions followed while soldering

1 Wear safety glasses to protect your eyes from solder splattering and flux.

2 Be careful while storing hot soldering irons after use to avoid burns.

3 Wash your hands thoroughly after using soft solder because it is poisonous.

4 Tin the soldering iron in a well ventilated area to exhaust fumes coming out while soldering.

5 Wear safety goggles when using acids for cleaning.

6 When making acid solution, always pour acid into water slowly.

7 Never pour water into the acid.

8 All inorganic fluxes are poisonous.

9 Wear goggles and gloves while handling corrosive flux.

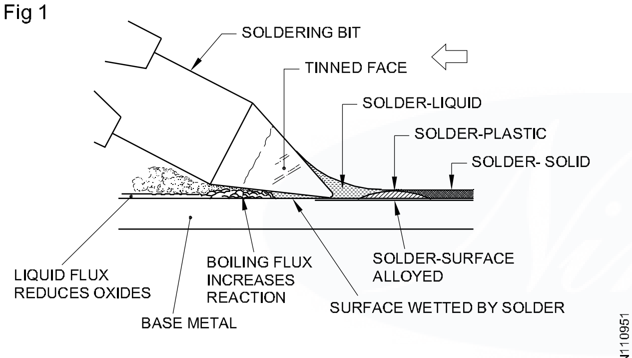
Soft soldering

Objectives: At the end of this lesson you shall be able to
- **explain soft soldering process**
- **state the melting characteristics of soft solders**
- **state the essential features of the soldering technique**
- **explain the importance of the attitude of the bit**
- **state the importance of movement of the bit in soldering**
- **state the characteristics of the soldered seams to be observed while inspection.**

Soft soldering involves the process.

- Preparing the workpiece.
- Select the correct soft solder.
- Preparing the soldering iron.
- Select and apply suitable flux.
- heat the soldering iron bit and the workpiece to the correct temperature.
- manipulating the soldering iron on the workpiece skillfully as shown in Fig 1.
- Complete the job to a satisfactory standard.

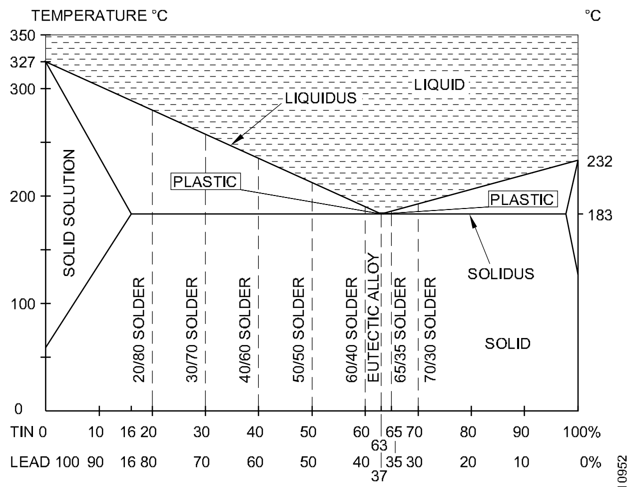
Fig 1



THE SOFT SOLDERING PROCESS

Melting characteristics of soft solders: The eutectic alloy of tins lead solder is a mixture of 63% tin and 37% lead. 63/37 solder melts at 183°C and is the lowest melting point of alloy series as shown in Fig 2.

Fig 2



MELTING CHARACTERISTICS OF TIN-LEAD SOLDER

Soldering Techniques: The following features are essential to do soldering.

- Correct joint design
- Preparation of the joint
- Selection of the solder
- Selection and preparation of the soldering iron.
- Copper bit heating
- Soldering bit manipulation
- Cleaning after soldering
- Inspection of the seam.

Attitude of the bit: The soldering iron bit should be placed in a position that enables sufficient heat and solder to flow into the joint.

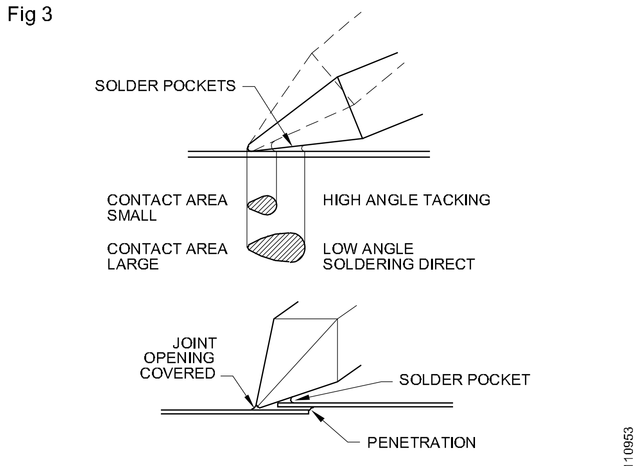
The angle between a working face of the bit and the joint surface should be filled with a pocket of solder. (Fig 3)

Any variation of this angle will control the amount of heat and solder which is transferred onto the lapped surfaces.

Contact between the molten solder and the joint opening is essential for the penetration of the solder into the joint as shown in figure.

Successful use of the soldering iron is influenced by the attitude of the bit and the movement of the bit on the workpiece.

Fig 3

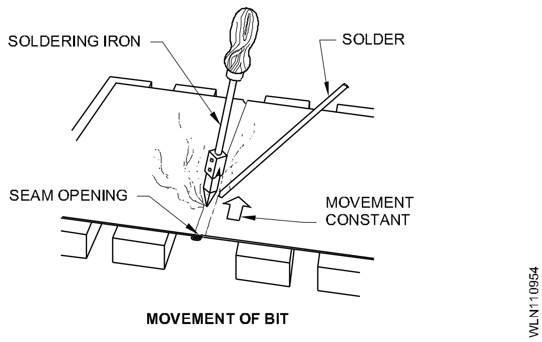


ATTITUDE OF BIT

Movement of the bit: The bit movement along the line of the seam, must be constant and consistent with a smooth flow of solder. When sweating wide overlaps, in addition to the progressive movement along the seam, it is required to move the bit back and forth across the seam. (Fig 4)

The pattern of the bit movement ensures successful heating of the solder deposited, when the point of the bit covering the joint opening penetrates through the lap as shown in figure.

Fig 4



MOVEMENT OF BIT

Flux residues and stains should be removed from the seam, to keep clean dry surfaces for paint finishes.

Inspection of the seam: A soldered seam should have the following characteristics.

- The solder has penetrated the lapped surface.
- The joint gap is sealed with a neat smooth fillet of the solder.
- The upper surfaces of the seam must be smooth, thin coating of solder, with tidy solder margins with uniform width.

Visual inspection is good to rectify the faults of the solder. However, physical testing for air or water tight seam is specified often. Leaks, detected by the tests are corrected by re-cleaning, re-fluxing and re-soldering of the faulty joint in the soldered seam.

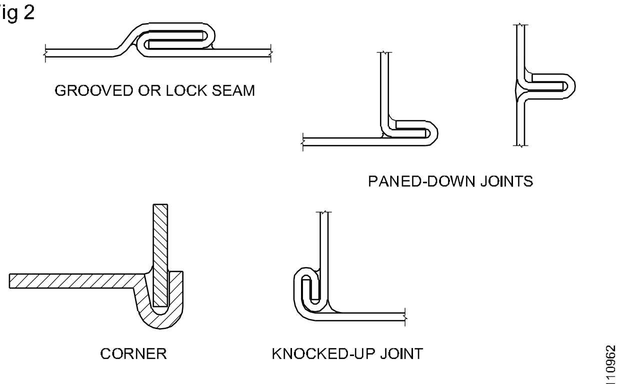
Soldered joint

Objectives: At the end of this lesson you shall be able to
- **state the types of the soldered joints**
- **state the points to be considered for correct joint design.**

Types of soldered joints: Sheet metal components are joined together by soldered joints. In many cases, the edges are joined by sheet metal mechanical joints and then soldered to make the joint stronger and leak proof.

Fig 1 shows soldered lap joints.

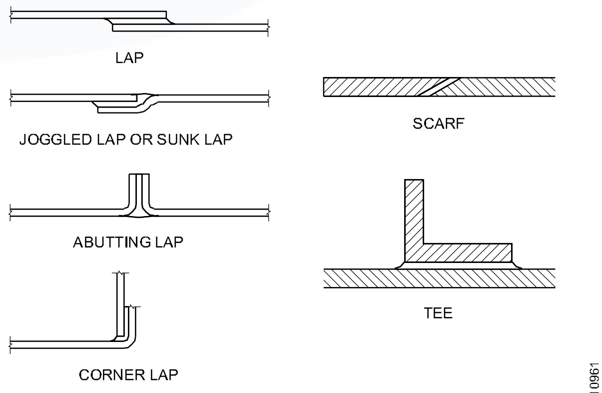
Fig 2



SOLDERED FOLDED SEAMS

Fig 2 shows soldered seams.

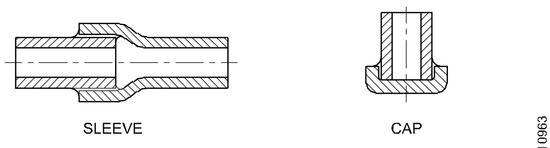
Fig 1



SOLDERED LAPPED SEAMS

Fig 3 shows soldered joint on round shaped parts.

Fig 3



SOLDERED JOINTS ON ROUND SHAPED PARTS

Correct joint design: Sheet metal joints with overlapping surfaces are ideal for joining or sealing with solder. Close fitting of lapped surfaces are essential for the flow of mobilized solder in into the joint by capillary action.

Joint design suitable for silver brazing or soldering mainly depends on the type of assembly and its intended use following conditions.

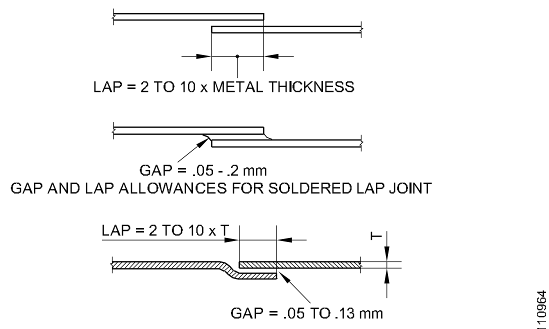
Maximum strength can be achieved by observing the following conditions.

- A suitable filler alloy must be used. Component metal is of major consideration.
- Joint clearances should be minimum. Close fitting surfaces helps capillary flow and gaps between 0.05 and 0.13 mm should be used.
- The solder must contact lapped surface sufficiently. Lap width is commonly made 2 to 10 times the component metal thickness. In case of unequal thickness, the lap size is based on the thinner materials.
- Workpieces must be firmly supported. It is essential to prevent the movement for the control of the solder application, alignment and accuracy of the component assembly.

Sheet metal joints both lapped and folded, are suitable for silver soldering application as shown in Fig 4.

Silver solder effects the union of lapped joints and seals the seam openings of the interlocking folded joints.

Fig 4



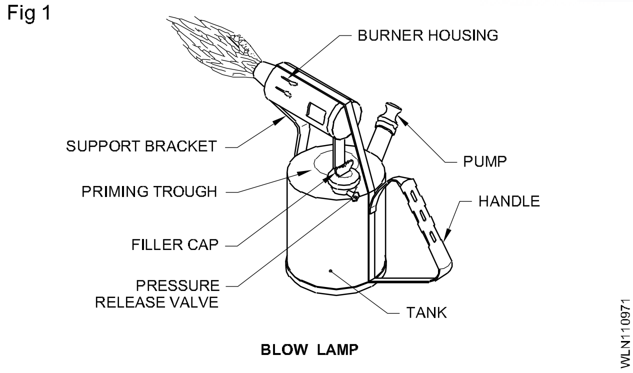
LAP AND GAP ALLOWANCES FOR SOLDERED SUNK LAP JOINT

Blow lamp

Objectives: At the end of this lesson you shall be able to
- **state the constructional feature of blow lamp**
- **identify the parts of blow lamp**
- **describe the operation of blow lamp.**

In blow lamp (Fig 1) the kerosene is pressurized to pass through pre-heated tubes, thus becoming vaporised. The kerosene vapour continues through a jet to mix with a air and when ignited directed through a nozzle, producing a forceful flame.

Fig 1



BLOW LAMP

The flame within the housing provides the heat to maintain vaporisation of the kerosene. The free flame at the nozzle outlet is used to heat the soldering bit.

Blow lamp is a portable heating appliance used as a direct source of heat for soldering irons or other parts to be soldered. Fig 1 shows parts of blow lamp.

It has an tank made of brass, filler cap is fitted at its top to fill kerosene. A pressure relief valve is connected to the tank to switch ON/OFF and control the flame.

Priming trough is provided for filling methylated spirit for lighting the blow lamp. Set of nozzle is provided to direct the kerosene vapour to produce forceful flame. Burner housing is mounted on support brackets on which soldering iron is placed for heating as shown in figure.

Pump is provided to pressurise the kerosene in the tank.

Factors considered while soldering

Objectives: At the end of this lesson you shall be able to
- **state the constructional feature of blow lamp**
- **identify the parts of blow lamp**
- **describe the operation of blow lamp.**

Soldering is joining two metal parts with a solder, i.e., a third metal that has a lower melting point.

Before soldering the following conditions must be met.

1 The metal must be clean.

2 The correct soldering device must be used and it must be in good condition.

3 The correct solder and flux or soldering agent must be chosen.

4 Proper amount of heat must be applied. If you follow these conditions, you could get a good solder joint.

Cleanliness: Solder will never stick to a dirty, oil or oxide coated surface. Beginners often ignore this simple point. If the metal is dirty, clean it with a liquid cleaner. If it is black annealed sheet remove the oxide with an abrasive cloth, and clean it until the surface is bright.

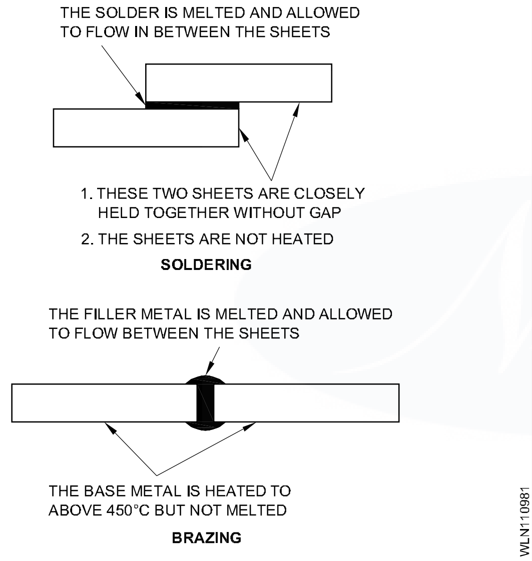
A bright metal, such as copper, can be coated with oxide even though you cannot see it. This oxide can be removed with any fine abrasive.

Soft soldering, brazing and silver brazing

Objectives: At the end of this lesson you shall be able to
- **explain soft soldering and hard soldering**
- **describe the method of soft soldering, brazing and sliver brazing**
- **describe the difference between brazing and soldering**
- **explain the various methods of brazing**
- **explain the problems in brazing and the remedies.**

Soldering and brazing: The soldering and brazing processes differ from welding in the sense that there is no direct melting of the base metal(s) being welded. In brazing or soldering, the filler alloy flows between two closely adjacent surfaces by capillary action.fig.1

Fig 1



Soft soldering: The filler metals used in soldering have a melting point below **427°C**

The alloys used for soft soldering are:

- tin-lead (for general purpose soldering)
- tin-lead-antimony
- tin-lead-cadmium,

The process is referred to as 'soft soldering'. The heat required for 'soft soldering' is supplied by a soldering iron, whose copper tip is heated either by a forge or electrically.

Composition of soft solder

Usually soft solder is an alloy of lead and tin in different ratios depending on the base metals soldered and the purpose of soldering.

Soft solders are available in different shapes and forms such as stick, bar, paste, tape or wire etc.

Types of fluxes

Corrosive: In this type the solution contains inorganic substances hydrochloric acid like zinc chloride, ammonium chloride, hydrochloric acid. This type of flux leaves a corrosive deposit on the base metal surface which must be throughly washed off after soldering. This type of flux is not used on electrical works or where the joints cannot be effectively washed.

Non-corrosive: These are fluxes based on resin. These leave a non-corrosive residue. They are used on electrical works, instruments like pressure gauges, and parts where washing is difficult.

Suitable fluxes for various materials

Steel - zinc chloride

Zinc and galvanized iron - hydrochloric acid

Tin - Zinc chloride

Lead - tallow resin

Brass, copper, brass - Zinc chloride, resin.

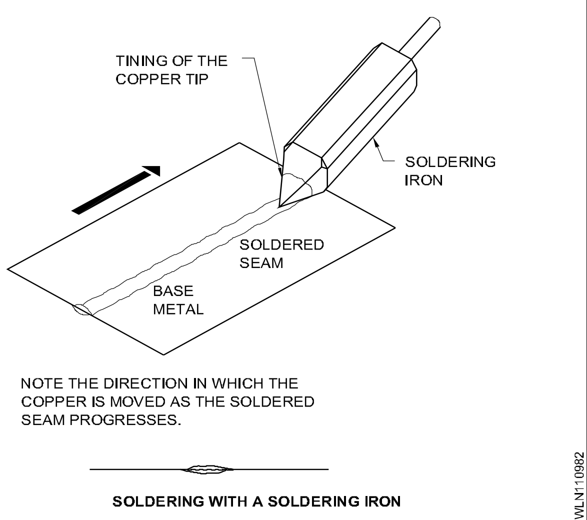
Basic operations in soldering

The parts to be soldered are fitted closely.

Paint, rust, dirt or thick oxides are removed by filing scraping or by using emery paper or steel wool.

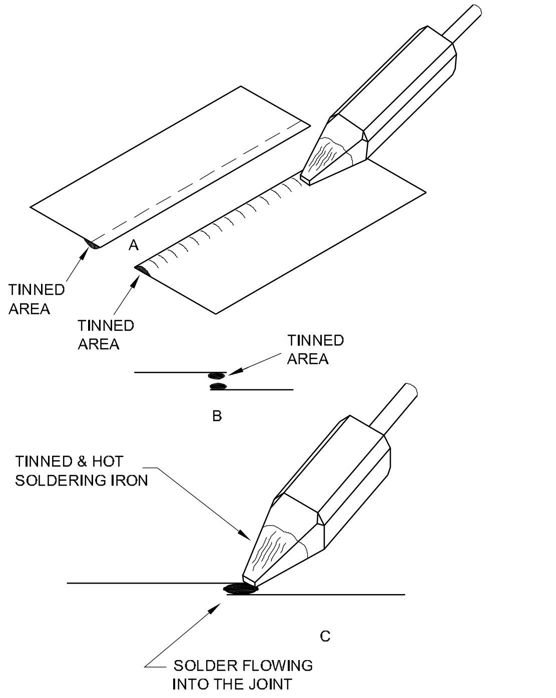
The surfaces to be soldered are coated with flux to remove the films of oxide. (Fig 2)

Fig 2



The solder is applied with a copper soldering bit. (Figs 3a, b and c) The joining takes place due to "sweating' of the bit the hot and tinned copper tip of the soldering iron.

Fig 3



The two sheets to be soldered are adhering to each other due to sweating and bonding of the tinned area.

The excess solder present on the surfaces is removed and the joint is allowed to cool.

Brazing: Brazing is a metal joining process which is done at a temperature of above 450°C as compared to soldering which is done at below 450°C

So brazing is a process in which the following steps are followed.

- Clean the area of the joint thoroughly by wire brushing, emerging and by chemical solutions for removing oil, grease, paints etc.
- Fit the joints tightly using proper clamping. (Maximum gap permitted between the two joining surfaces is only 0.08 mm)
- Apply the flux in paste form (for brazing iron and steel a mixture of 75% borax powder with 25% boric acid (liquid form) to form a paste is used). Usually the brazing flux contains chlorides, fluorides, borax, borates, flurodorates, boric acid, wetting agents and water. So suitable flux combination is selected based on metal being used.

Brazing is employed where a ductile joints is required.

Brazing filler rods/ metals melt at temperature from 860°C to 950°C and are used to braze iron and its alloys.

Brazing fluxes: Fused borax is the general purpose flux for most metals.

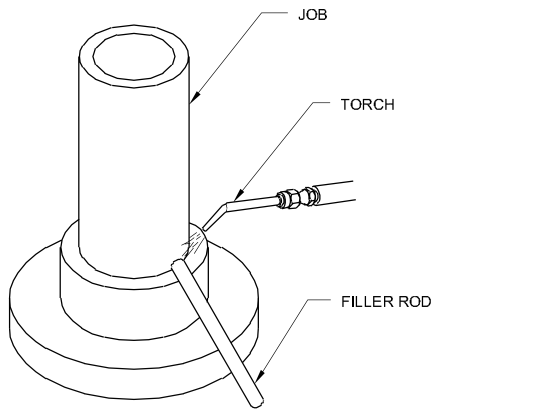
It is applied on the joint in the form of a paste made by mixing up with water.

If brazing is to be done at a lower temperature, fluorides of alkali materials are commonly used. These fluxes will remove refractory oxides of aluminium, chromium, silicon and beryllium.

Various methods of brazing

Torch brazing: The base metal is heated to the required temperature by the application of the oxy-acetylene flame. (Fig 4)

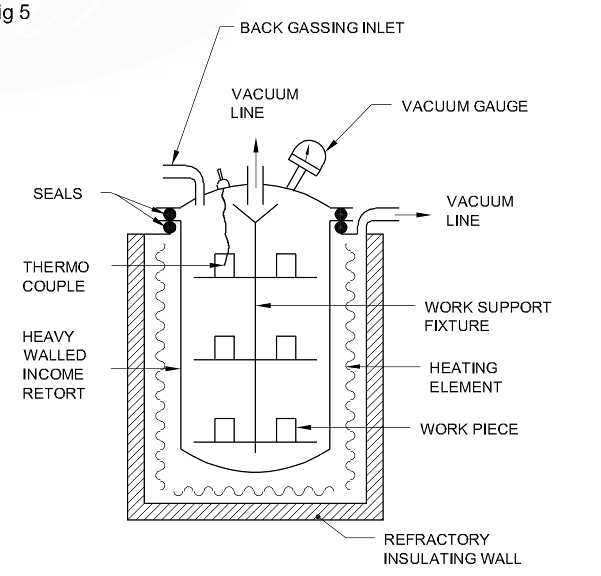
Fig 4



TORCH BRAZING

Furnace brazing: The parts to be brazed are aligned with the brazing material placed in the joint. The assembly is kept in the furnace. The temperature is controlled to provide uniform heating. (Fig 5)

Fig 5

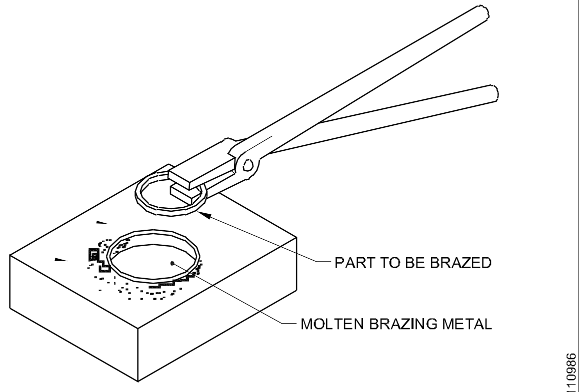


VACUUM FURNACE FOR BRAZING

Dip brazing: The parts to be brazed are submerged in a molten metal or chemical bath (Fig 6) of brazing filler metal.

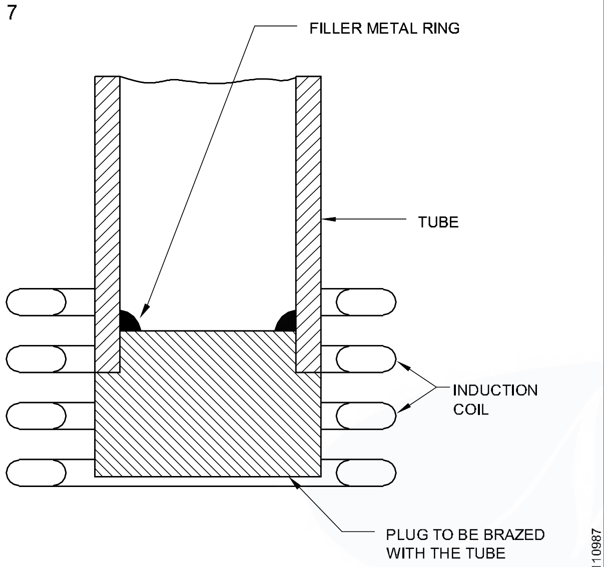
Induction brazing: The parts to be brazed are heated to the melting point of the brazing material by means of a high frequency electric current. This is done by encircling the joint with a water cooled induction coil (Fig 7).

Fig 6



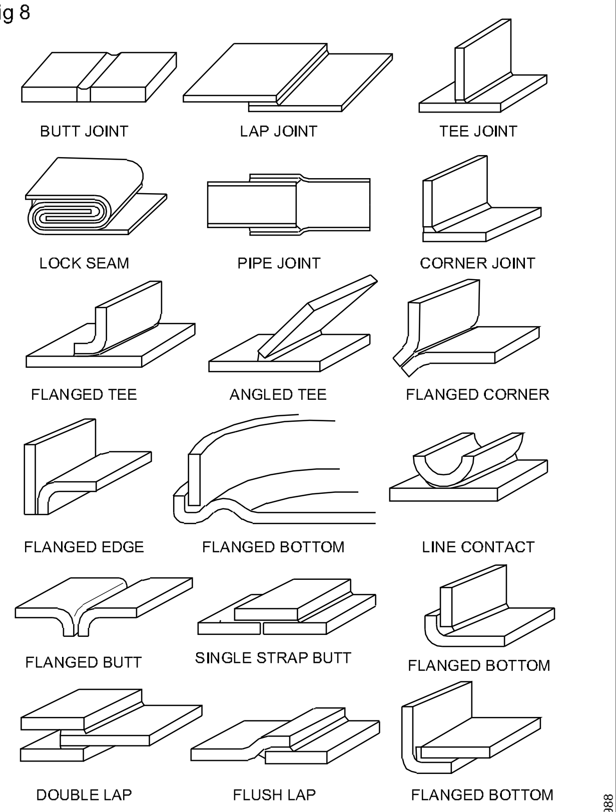
DIP BRAZING PROCESS

Fig 7



INDUCTION BRAZING

Fig 8



SUGGESTED JOINT DESIGNS FOR SOLDERED AND BRAZED JOINTS

Conditions to obtain satisfactory brazed or soldered joint

Wet the base metal.

Spread the filler metal and make contact with the joint surfaces. The solder will be drawn into the joint by capillary action.

Suggested joint designs for soldering and brazing are shown in Fig 8

Advantages of brazing

The completed joint requires little or no finishing.

The relatively low temperature at which the joint made minimizes distortion.

There is no flash or weld spatter.

The brazing technique does not require as much skill as the technique for fusion welding.

The process can be easily mechanised.

The process is economical owing to the above advantages.

Disadvantages of brazing

If the joint is exposed to corrosive media, the filler metal used may not have the required corrosive resistance.

All the brazing alloys loose strength at an elevated temperature

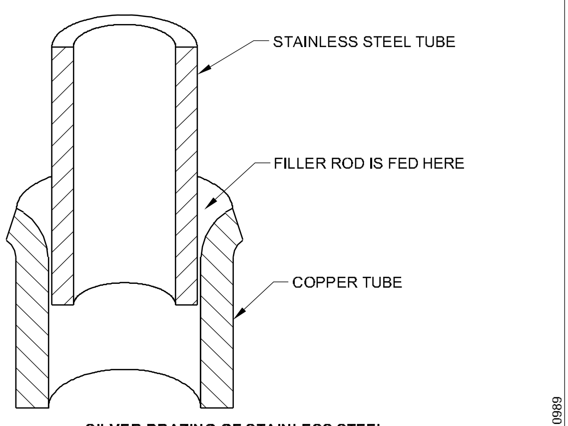
The colour of the brazing alloy which ranges from silver white to copper red may not match the base metal very closely.

Brazing: Problems and remedies

Problem	Remedy
Filler metal 'balls up', does not melt and flow into the joint.	Use more flux. Pickling or additional mechanical cleaning to remove oxides, oils, or other surface coatings must be done, Add fresh flux. Also check for contaminated pickling acid or 'dirty' grinder wheels that could spread impurities instead of removing them.
Filler metal melts but does not flow completely through joint.	Longer preheating period required. the base metal may not be hot enough. More thorough cleaning required. A wider or narrower joint gap should be provided. Joint must not be too tight or too loose. Also check for gaps or spaces where capillarity is interrupted. Apply more flux to both filler and base metal. Use a different flux compound. Improper flux may be breaking down due to too much heat. Eliminate this fault.
Filler metal runs out, instead of running into the joint.	Re-position (tilt) the joint so that gravity helps the filler metal to run into the joint. Making a small reservoir in the joint to start the capillary action will help. Feeding the filler metal into the joint from above rather than horizontally or from below is recommended.
Filler metal melts but will not flow.	Additional cleaning of filler metal to remove oxides is required. More flux on both filler and base metal is required.

Silver brazing: Silver brazing is also sometimes called silver soldering. It is one of the best methods used to connect/join parts which are to be leak proof and has to give maximum strength of the joint. It is a very useful and easy process for joining copper brass, bronze parts as well as for joining dissimilar metal tubes like copper to stainless steel tubes etc. The melting point of silver brazing alloy filler rods will be around 600 to 800°C which is always less than that of the base metals joined. Fig 9 shows silver brazing of stainless steel tube to be with a copper tube.

Fig 9



SILVER BRAZING OF STAINLESS STEEL TUBE WITH COPPER TUBE

The process is similar to other brazing processes. The points to be remembered while silver soldering are:

- The joint must be thoroughly cleaned both mechanically and chemically.
- Fit the joint closely/tightly without any gap and support the joint. (The maximum permissible gap between the parts to be silver brazing is 0.08mm).

Apply proper flux at the joint and on the filler rod.

Heat the joint to the brazing temperature depending on the composition of the silver brazing filler rod. The brazing temperature may vary from 600°C to 800°. Use an oxy-acetylene blow pipe for heating.

Apply the silver brazing filler rod coated with the pasty flux at the joint using leftward technique. Heat the filler rod to the "flow temperature" which is usually 10 to 15° more than its melting temperature. i.e, for the filler metal to flow easily into the joint and for getting the wetting and capillary action, it is necessary to heat the molten filler metal to 10 or 15° more than its melting temperature.

Allow the joint to cool without removing the support given to the joint.

Clean the joint throughly to remove all residual flux.

Fluxes used for silver brazing may be chlorides or borax made into a paste with water.

Brazing and braze welding; Both brazing and braze welding are metal joining processes which are performed at temperatures above 840°F (450°C) as compared to soldering which is performed temperatures below 840°F (450°C)

The American Welding society defines these processes as follows:

Brazing-" A group of welding processes which produces coalescence of materials by heating them o a suitable temperature and by using a filler metal having a liquids above 840°F (450°C) and below the solidus of the base metal . The filler metal is distributed between the closely fitted surfaces of the joint by capillary action" coalescence is a joining or uniting of materials.

Braze welding-" A welding process variation in which a filler metal, having a liquids above 840°F (450°C) and below the solidus of the base metal, is used. Unlike brazing, in braze welding the filler is not distributed in the joint by capillary action"

Brazing has been used for centuries. Blacksmiths, jewelers, armourers and other crafters used the process on large and small articles before recorded history. This joining method has grown steadily both in volume and popularity. It is an important industrial process, as well as jewelery making and repair process. The art of brazing has become more of a science as the knowledge of chemistry, physics and metallurgy has increased.

The usual terms Brazing and Braze welding imply the use of a nonferrous alloy. These nonferrous alloys consist of alloys of copper. tin, zinc, aluminum, beryllium, magnesium, silver, gold and others.

Brass is an alloy consisting chief of copper and zinc. Bronze is an alloy consisting chiefly of copper and tin. Most rods used in both brazing and braze welding on ferrous metals are brass alloys rather than bronze. The brands which are called bronze usually contain a small percent (about one percent) of tin.

Brazing and braze welding principles: Brazing is an adhesion process in which the metals being joined are heated but not melted: the brazing filler metal melts and flows at temperatures above 840°F (450°C). Adhesion is the molecular attraction exerted between surfaces.

A brazed joint is stronger than a soldered joint because of the strength of the alloys used. In some instances it is as strong as a welded joint. It is used where mechanical strength and leap roof joints are desired. Brazing and braze welding are superior to welding in some applications, since they do not affect the heat treatment of the original metals as much as welding.

Brazing and braze welding wrap the original metals less and it is possible to joint dissimilar metals. For example, steel tubing may be brazed to cast iron, copper tubing brazed to steel and tool steel brazed to low carbon steel.

Brazing is done on metals which fit together tightly. The metal is drawn into the joint by capillary action. (A liquid will be drawn between two tightly fitted surfaces. This drawing action is known as capillary action). Very thin layers of filler metal are used when brazing. The joints and the material being brazed must be specially designed for the purpose. When brazing, poor fit and alignment result in poor joints and in inefficient use of brazing filler metal.

In braze welding, joint designs used for oxyfuel gas or arc welding are satisfactory. When braze welding, thick layers of the brazing filler metal is used.

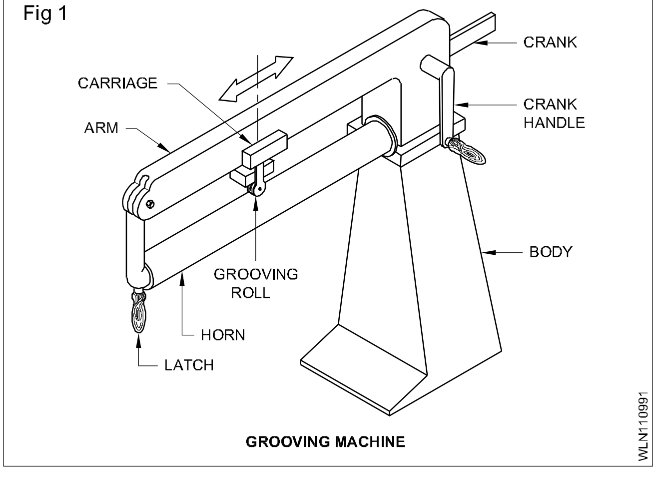
Seaming and Machine

Objectives: At the end of this lesson you shall be able to
- **explain the construction of the seam closing machine**
- **identify the parts of the seam closing machine**
- **state the uses of the seam closing machine.**

Grooved seam can also be closed or locked mechanically by means of the seam closing machine. This machine is also called "Seaming machine"

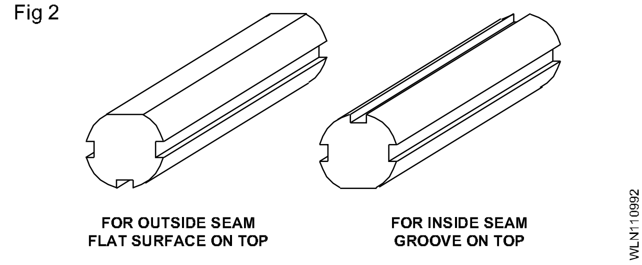
Parts shown in Fig 1 are Body, Arm, Pressure roller, Carriage, Crank handle, Latch and Crank rack.

Fig 1



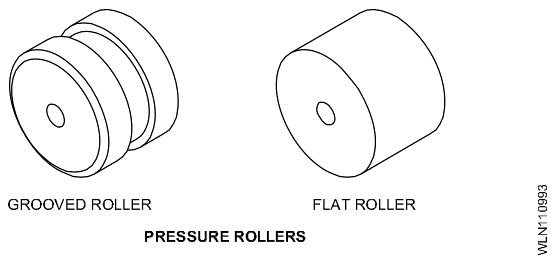
Horn: It contains grooves of various widths on throughout the length as shown in Fig 2.

Fig 2



Pressure roller: Two types of pressure rollers are available along with the machine. One is flat roller and the other is grooved one, Grooved roller is having grooves of 3 mm, 4 mm, 5 mm and 6 mm widths as shown in Fig 3.

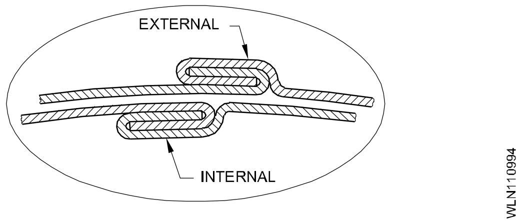
Fig 3



Latch: It holds the horn rigid by when pressure roller is functioning at the time of closing the seam.

Internal and External locks (Fig 4) can be made by adjusting the horn and changing the pressure rollers on the seam closing machine.

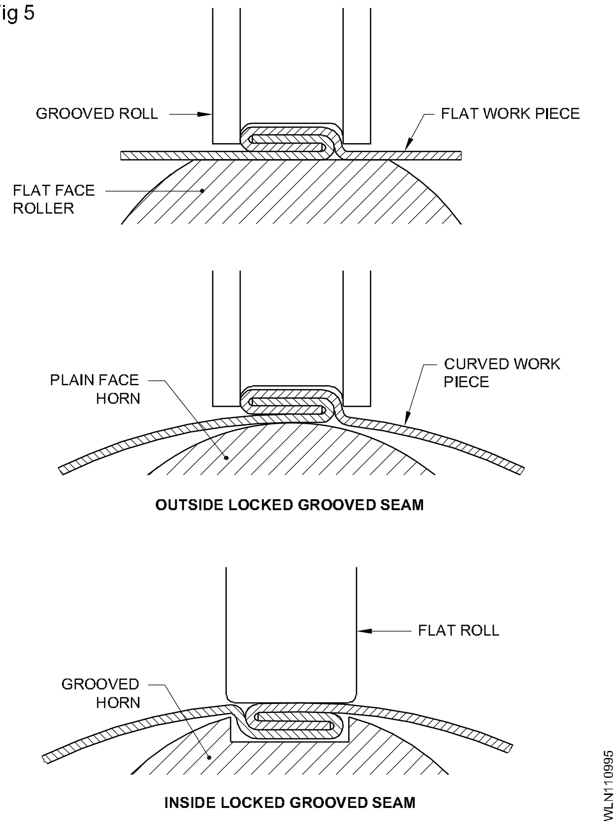
Fig 4



If the seam to be made on the outside of the object, adjust the flat or plain face of the horn on the upper side, and provide suitable grooved pressure roller in the carriage.

If the seam is to be made from inside of the object, adjust the suitable groove on the horn upper side and provide flat pressure roller in carriage as shown in Fig 5.

Fig 5



Scan the QR Code to view the video for this exercise

Basic Welding Joints and Nomenclature of butt and fillet weld

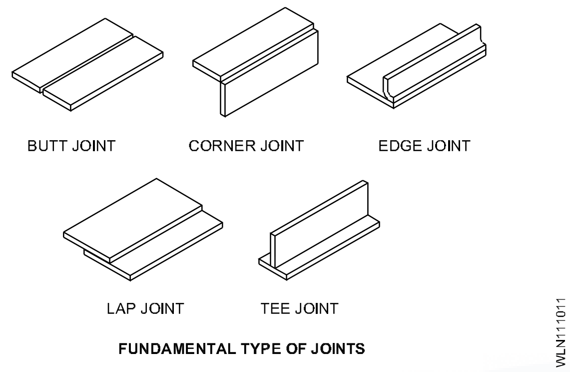
Objectives: At the end of this lesson you shall be able to
- **illustrate and name the basic welding joints.**
- **explain the nomenclature of butt and fillet welds.**

Basic welding joints (Fig. 1)

The various basic welding joints are shown in Fig. 1.

The above types mean the shape of the joint, that is, how the joining edges of the parts are placed together.

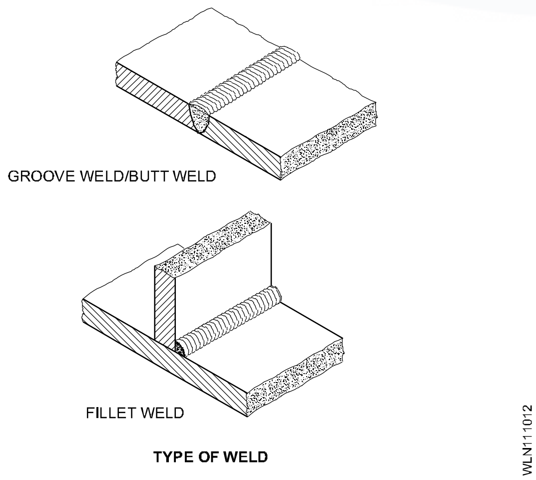
Fig 1



Types of weld: There are two types of weld. (Fig .2)

- Groove weld/butt weld
- Fillet weld
- Application of welding joints to the included

Fig 2



Nomenclature of butt nd fillet weld (Figs 3 and 4)

Root gap: It is the distance between the parts to be joined. (Fig 3)

Heat affected zone: Metallurgical properties have been changed by the welding heat adjacent to weld.

Leg length: The distance between the junction of the metals and the point where the weld metal touches the base metal 'toe' (Fig 5)

Fig 3

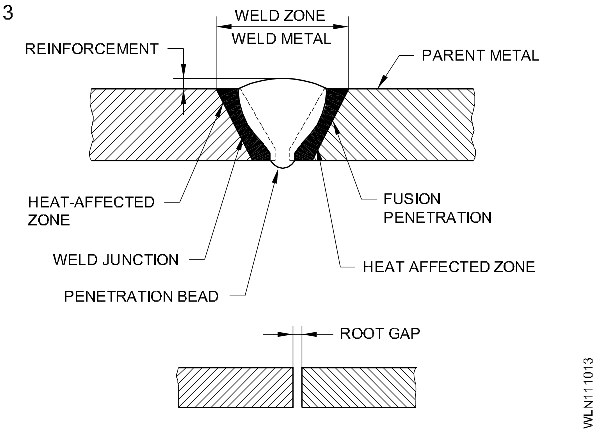


Fig 4

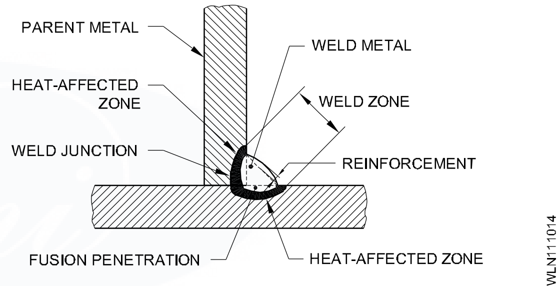
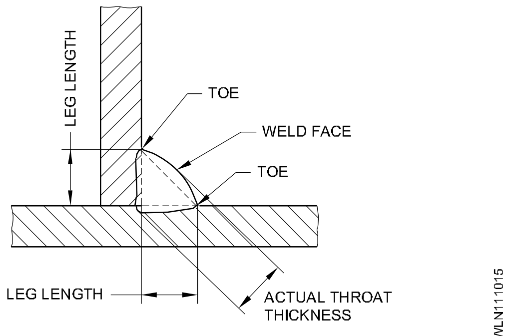


Fig 5

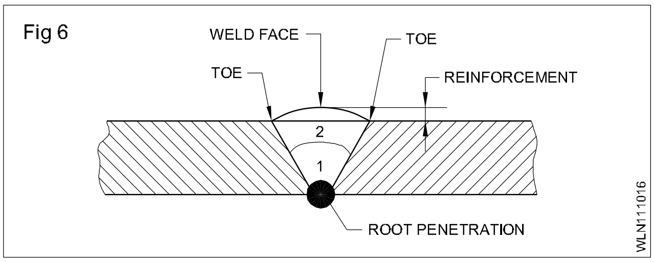


Parent metal: The material or the part to be welded.

Fusion penetration: The depth of fusion Zone in the parent metal. (Fig 3 and 4)

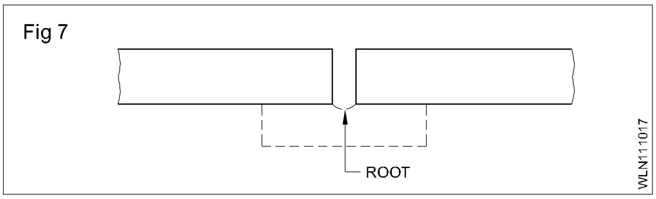
Reinforcement: Metal deposited on the surface of the parent metal of the excess metal over the line joining the two toes. (Fig 6)

Fig 6



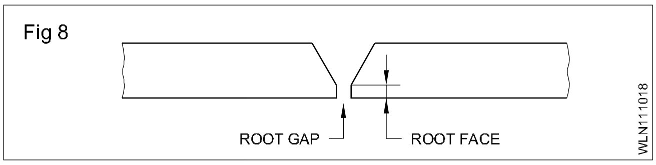
Root: The parts to be joined that are nearest together. (Fig 7)

Fig 7



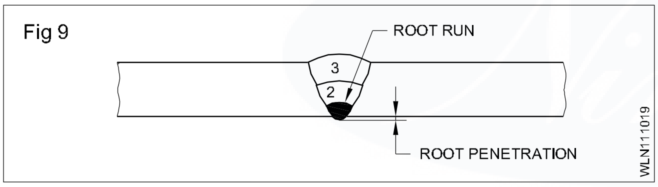
Root face: The surface formed by squaring off the root edge of the fusion face to avoid a sharp edge at the root. (Fig 8)

Fig 8



Root run: The first run deposited in the root of a joint (Fig 9)

Fig 9



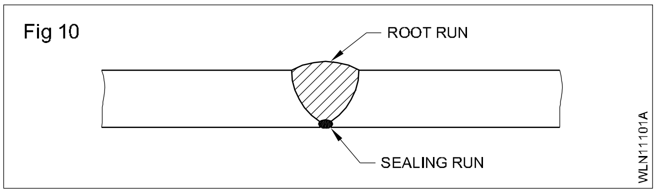
Root penetration: It is the projection of the root run at the bottom of the joint (Fig. 6 and 9)

Run: The metal deposited during one pass. Fig. 9.

The second run is marked as 2 which is deposited over the root run. The third run is marked as 3 which is deposited over the second run.

Sealing run: A small weld deposited on the root side of a butt or corner joint (after completion of the weld joint). (Fig 10)

Fig 10



Backing run: A small weld deposited on the root side of butt or corner joint (before welding the joint.) Fig. 6

Throat thickness: The distance between the junction of metals and the midpoint on the line joining the two toes. (Fig 5.)

Toe of weld: The point where the weld face joins the parent metal. (Fig 5&6.)

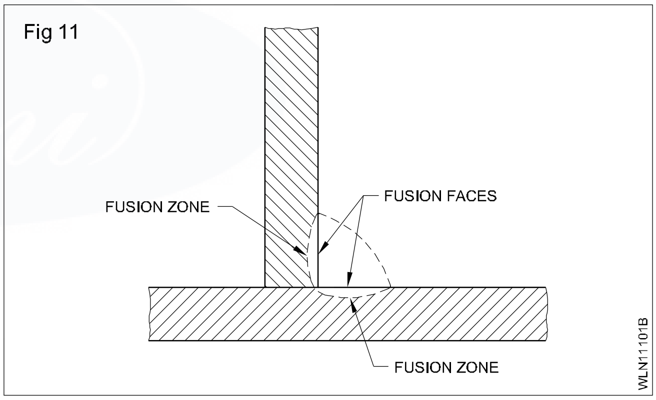
Weld face: The surface of a weld seen from the side from which the weld was made. (Fig 5&6.)

Weld Junction: The boundary between the fusion zone and the heat affected zone. (Fig 3&4)

Fusion face: The portion of a surface which is to be fused on making the weld. (Fig 11)

Fusion zone: The depth to which the parent metal has been fused. (Fig 11)

Fig 11



Material preparation method

Objectives: At the end of this lesson you shall be able to
- **state the necessity of preparing the materials to be welded**
- **state different methods used to cut mild steel sheets and plates to the required size before welding**
- **identify different tools and equipments used to prepare the mild steel sheets and plates.**

Necessity of materials preparation for welding: While fabricating (producing or making) different components/ parts by welding, different sizes of plates, sheets pipes, angles, channels with different dimensions are joined together to get the final objects. For example, a railway compartment, an aeroplane, an oil or water pipe line, a gate, a window grill, a stainless steel milk tank, etc. So these objects can be made to the required dimensions only by cutting them from the larger size sheets, plates, pipes etc, which are available in standard sizes, thickness, diameters and lengths in the market. Hence cutting and preparing the base metal to the required dimensions from the original material available in many stores is necessary before welding them.

Also the base metals before cutting them to size will have impurities like dirt, oil, paint, water and surface oxides, due to long storage.

These impurities will affect the welding and will create some defects in the welded joint. These defects will make the joint weak and it is possible that the welded joint will break, if the weld defects are present in the welded joints.

So in order to get a strong welded joint, it is necessary to clean the surfaces to be joined and remove the dirt, oil paint, water, surface oxide etc. from the joining surfaces before welding.

Different methods used to cut metals

1 By chiseling the sheets
2 By hack sawing
3 By shearing using hand lever shear
4 By using guillotine shear
5 By gas cutting

For thin sheets the first 4 methods are used. For thick materials method 2,4 and 5 are used.

Tools and equipments used to cut metals

1 Cold chisel
2 Hacksaw with frame
3 Hand lever shear
4 Guillotine shear
5 Oxy-acetylene cutting torch

The cut edges of the sheet or plate are to be filed to remove burrs and to make the edges to be square (at 90° angle) with each other. For ferrous metal plates, which are more than 3mm thick, the edges can be prepared by grinding them on a bench/pedestal grinding machine.

Edge preparation

Objectives: At the end of this lesson you shall be able to
- **explain the necessity of edge preparation**
- **describe the edge preparation for butt and fillet welds.**

Necessity of edge preparation: Joints are prepared to weld metals at less cost. The preparation of edges are also necessary prior to welding in order to obtain the required strength to the joint. The following factors are to be taken into consideration for the edge preparation.

- The welding process like SMAW, oxy-acetylene welds, $Co_{2,}$ electro-slag etc.
- The type of metal to be joined, (i.e) mild steel, stainless steel, alumininum, cast iron etc.
- The thickness of metal to be joined.
- The type of weld (groove and fillet weld)
- Economic factors

The square butt weld is the most economical to use, since this weld requires no chamfering, provided satisfactory strength is attained. The joints have to be beveled when the parts to be welded are thick so that the root of the joints have to be made accessible for welding in order to obtain the required strength.

In the interest of economy, bevel butt welds should be selected with minimum root opening and groove angles such that the amount of weld metal to be deposited is the smallest. “J” and “U” butt joints may be used to further minimise weld metal when the savings are sufficient to justify the more difficult and costly chamfering operations. The “J” joint is usually used in fillet welds.

A root gap is recommended since the spacing allows the shrinking weld to draw the plates freely together in the butt joint. Thus, it is possible to reduce weld cracking and minimise distortion and increase penetration, by providing a root gap for some welded joints.

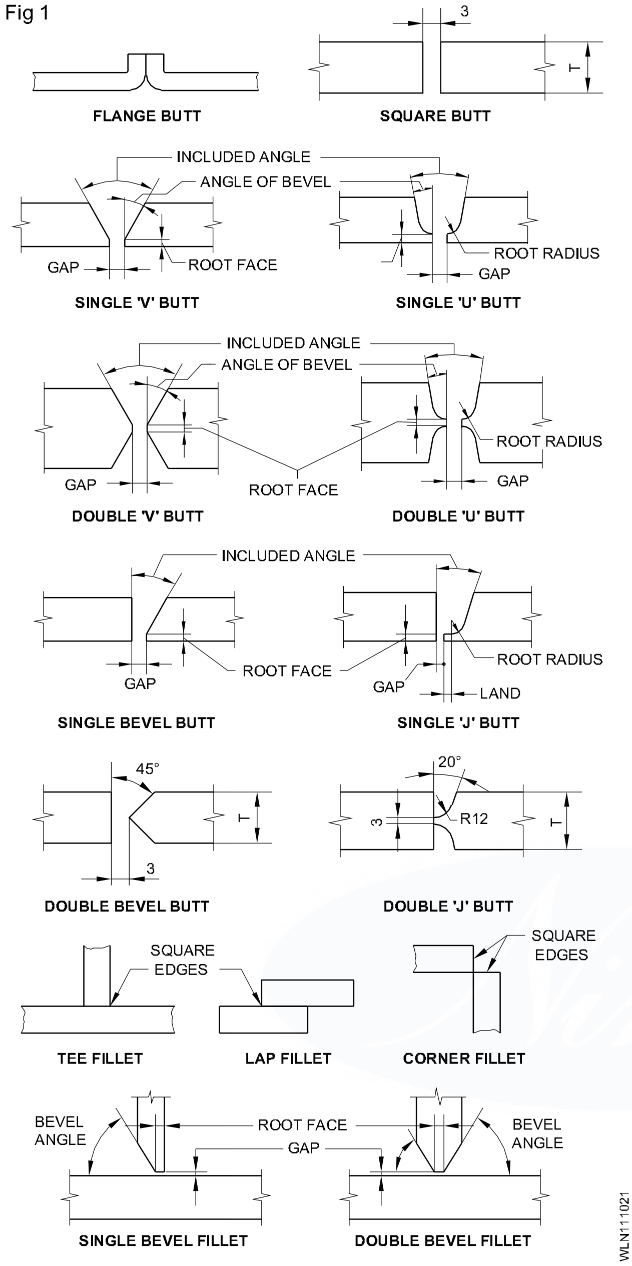
Method of edge preparation: The joining edges may be prepared for welding by any one of the methods mentioned below.

- Flame cutting
- Machine tool cutting
- Machine grinding or hand grinding
- Filing, chipping

Types of edge preparation and setup

Different preparation generally used in arc welding are shown in Fig 1 below.

Fig 1



Methods of cleaning the base metals before welding

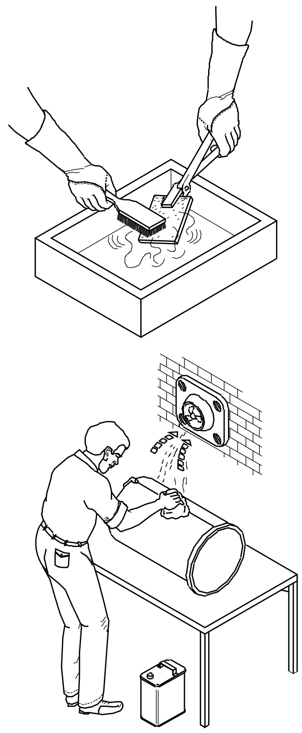
Objectives: At the end of this lesson you shall be able to
- **importance of cleaning**
- **describe the cleaning method**

Every joint must be cleaned before welding to obtain a sound weld.

Importance of cleaning: The basic requirement of any welding process is to clean the joining edges before welding. The joining edges of surface may have oil, paint, grease, rust, moisture, scale or any other foreign matter. If these contaminants are not removed the weld will become porous, brittle and weak. The success of welding depends largely on the conditions of the surface to be joined before welding. The oil, grease, paints and moisture of the sheets to be welded will give out gases while heated by arc or flame and these gases will get into the molten metal. They will come out of the metal when the molten metal cools to form the bead and create small pin holes on the surface of the bead. This is known as porosity and it weakens the joint.

Methods of cleaning: Chemical cleaning includes washing the joining surface with solvents of diluted hydrochloric acid to remove oil, grease, paint etc (Fig. 1)

Fig 1



Mechanical cleaning includes wire brushing, grinding, filing, sand blasting, scraping, machining or rubbing with emery paper. (Fig 2)

For cleaning ferrous metals a carbon steel wire brush is used. For cleaning stainless and non-ferrous metals, a stainless steel wire brush is used.

Fig 2