Solders

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, antimony, copper, cadmium and zinc and are used for soldering heavy (thick) and light metals. Table shows different compositions of solder and their application.

In the composition of soft solder, tin is always stated first.

WARNING

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

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

Table 1

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,
3	Fine solder	70	30	they are used for copper water tanks, heaters and general electrical work.
4	Coarse solder	40	60	Used on galvanised 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 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.

Functions of the fluxes

1 Flues removes axides from the soldering surface it prevents corrosion

2 It forms a liquid cover over the workpiece 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 criterias 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 non-corrosive (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 fluxes

(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 forming zinc chloride and acts as a flux. So it cannot be used as a flux for sheet metals other than zinc iron or galvanised sheets. 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. (Fig 1)

Zinc chlorides are known as killed spirits. It is mainly used for soldering copper, brass and tin sheets.

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 or 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 paste or powder form.

Resin is 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 pewter.

Table 1

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 spirits	Resin	Commercial flux available
Copper	Killed spirits 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	
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		

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.

Melting characteristics of soft solders: The eutectic alloy of tin lead solder is a mixture of 63% tin and 37% lead. 63/37 solder melts at 183^{0}C and is the lowest melting point of all combinations in the alloy series as shown in Fig 2.

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.

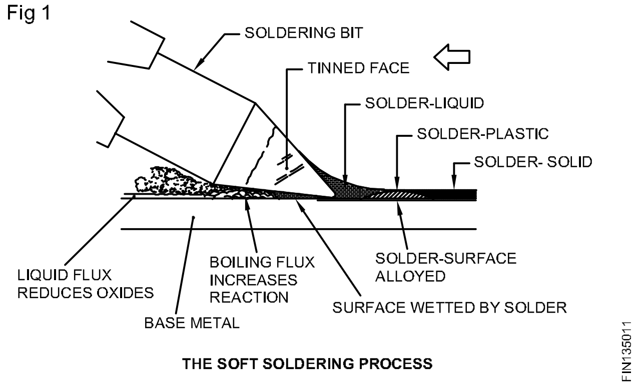
– Copper bit heating

– Soldering bit manipulation

– Cleaning after soldering

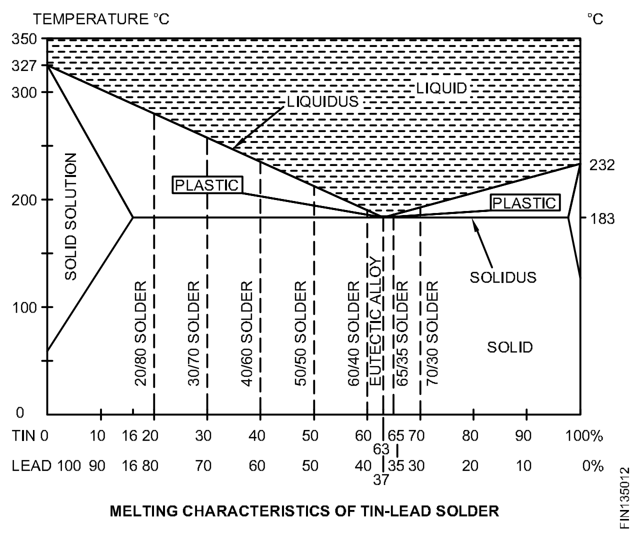
– Inspection of the seam.

Fig 1



THE SOFT SOLDERING PROCESS

Fig 2



MELTING CHARACTERISTICS OF TIN-LEAD SOLDER

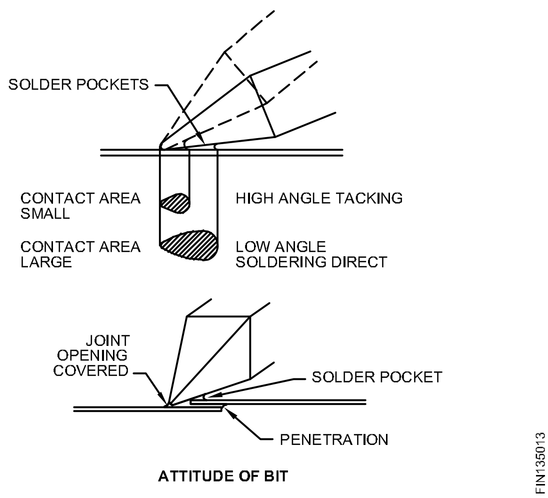
Attitude of the bit: The soldering iron bit should be placed in a position that enables sufficient heat and solder to flow into the joint.

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.

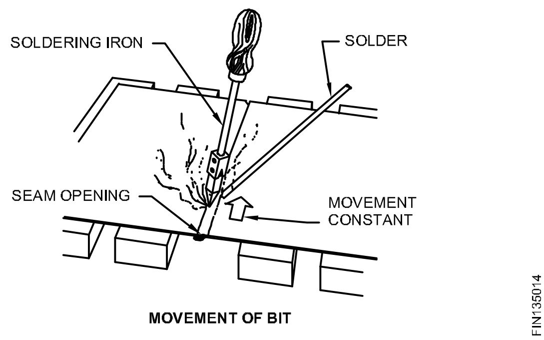
Fig 3



ATTITUDE OF BIT

The pattern of the bit movement ensures successful heating of the solder deposited, when the point of the bit covering the joint opening penetrate through the lap as shown in figure 4

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 surfaces.

– 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 seams is specified often. Leaks, detected by the tests are corrected by re-cleaning, re-fluxing and re-soldering of the faulty area in the soldered seam.

Process of soft soldering and hard soldering

Objectives: At the end of this exercise you shall be able to
- **define 'soldering'**
- **state the different types of soldering processes**
- **state the different types of solder and their applications**
- **state the different types of soldering bits and their uses.**

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

Soldering is the process by which metallic materials are joined with the help of another liquified metal (solder). The melting point of the solder is lower than that of the materials being joined.

The solder wets the base material without melting it.

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

Soldering can be classed as soft soldering and hard soldering.

The process of joining metals using tin lead solders which melt below 420°C is known as soft soldering.

The process of joining metals using hard solders consisting of copper, zinc, cadmium and silver which melt above 600° is known as hard soldering

Brazing is a hard soldering process used to join copper brass and most ferrous metals.

The bonding filler metal usually consists of copper and zinc alloys. Silver brazing or silver soldering is a process used to join steel, copper, bronze and brass and precious metals like gold and silver.

The bonding filler metal consists of silver, copper and zinc tin alloys.

Factors considered while soldering

Objectives: At the end of this exercise you shall be able to
- **follow the conditions for proper define 'soldering'**
- **state the different types of soldering processes.**

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 folds these conditions, you could get a good solder joint.

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

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

Successful soldering

Objective : At the end of this lesson you shall be able to
- **follow the hints for successful soldering.**

Hints for successful soldering

You should always wear safety glasses to avoid possible injury to the eyes.

Sheet metal must be cleaned with a file, wire brush, steel wool strip, or emery cloth.

Be sure that the pieces to be soldered fit closely together, for a strong joint.

Soldering flux must be applied by a swab or brush only to the surfaces on which molten solder is to be applied.

Hold the pieces to be soldered firmly to prevent their movement.

Hold the soldering iron in one hand, placing its widest tinned face flat against the surface to be soldered.

When soldering iron is held incorrectly, the point of the soldering iron touches only a portion of the area to be soldered, this is referred to as "skimming" the joint and results in a weak joint.

Apply the wire solder beneath the edge of the iron and nearest to the work. Move the soldering iron slowly along the work making sure that the solder melts, spreads and penetrates properly.

Solder as much surfaces as possible without re-heating the soldering iron or changing to another iron.

A temperature capable of merely melting the solder is not sufficient enough, heat must be transmitted by the soldering iron to the workpiece to quickly raise the temperature of the metals to the solder melting temperature.

It is this step in soldering that beginners often fail to understand and remember.

A soldering iron that is too small, often causes difficulty.

Do not breathe any smoke from the sal ammoniac block as it is a toxic gas and is dangerous.

Sweating of sweat soldering

Objective : At the end of this lesson you shall be able to
- **explain the process of sweating.**

Sweating or Sweat soldering is a process, in which two or more surfaces are soldered one on the top of the other without allowing the solder to be seen after assembly.

In sweating, metal surfaces to be joined are tinned first, then placed on above the other and heated together. While heating, the solder melts and flows to join the overlapped surfaces.

Sweating process is applied in body repairing works in which the damaged surface is sweat soldered with a piece of metal called patch. This process is also applied in rectifying leakages of water tanks and fuel tanks.

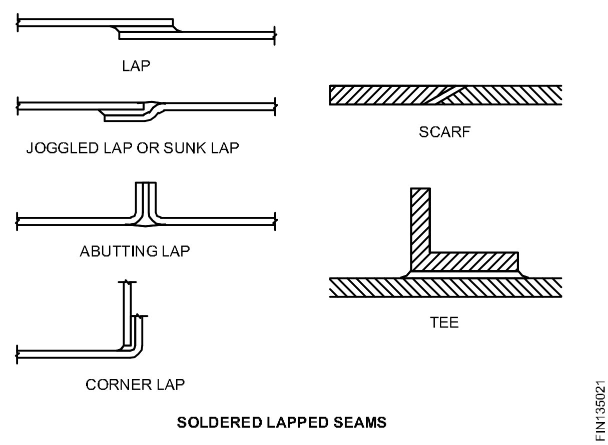
Soldered Joint

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.

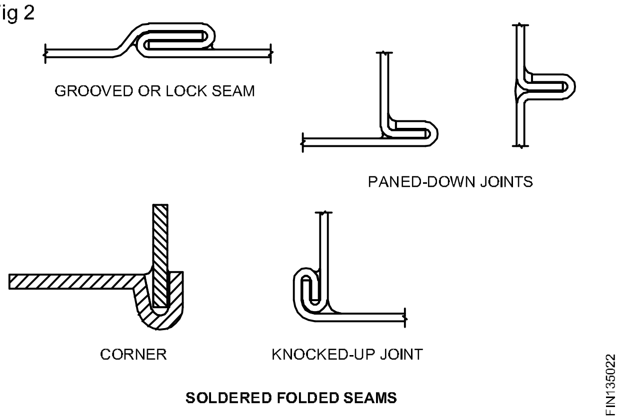
Fig 1



SOLDERED LAPPED SEAMS

Fig 2 shows soldered seams.

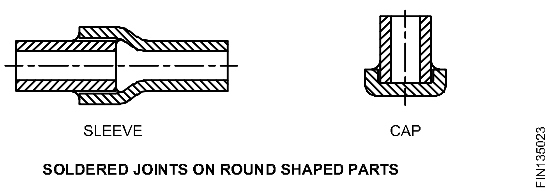
Fig 2



SOLDERED FOLDED SEAMS

Fig 3 shows soldered joint on round shaped parts.

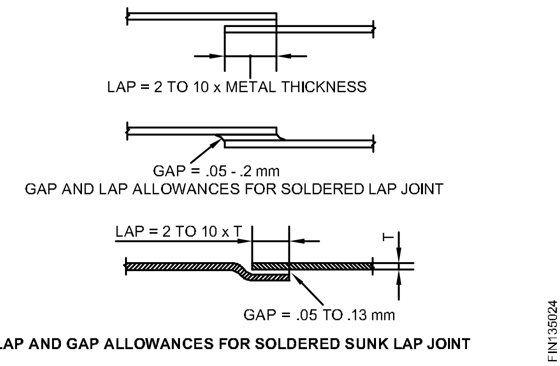
Fig 3



SOLDERED JOINTS ON ROUND SHAPED PARTS

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

Fig 4



LAP AND GAP ALLOWANCES FOR SOLDERED SUNK LAP JOINT

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

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 molten solder 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.

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.

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

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

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.

Fluxes types and description

Objectives : At the end of this lesson you shall be able to
- **explain flux and its function**
- **describe the types of fluxes and their storage.**

Flux is a fusible (easily melted) chemical compound to be applied before and during welding to prevent unwanted chemical action during welding and thus making the welding operation easier.

The fuctions of fluxes : To dissolve oxides and to prevent impurities and other inclusions that could affect the weld quality.

Fluxes help the flow of filler metal into very small gap between the metals being joined.

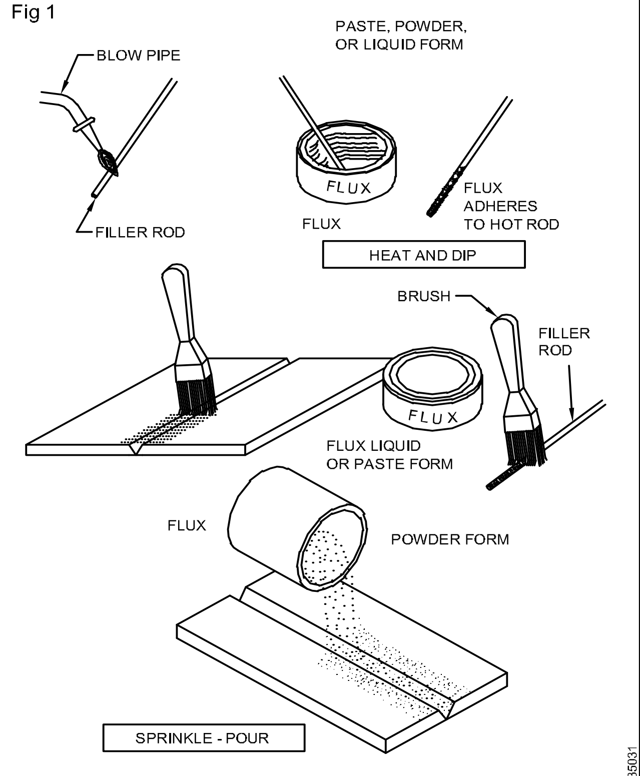
Fluxes act as cleaning agents to dissolve and remove and clean the metal for welding from dirt and other impurities.

Fluxes are available in the form of paste, powder and liquid.

The method of application of flux is shown in Fig. 1
Storing of fluxes; where the flux is in the form of a coating on the filler rod, protect carefully at all times against damage and dampness. Fig 2.

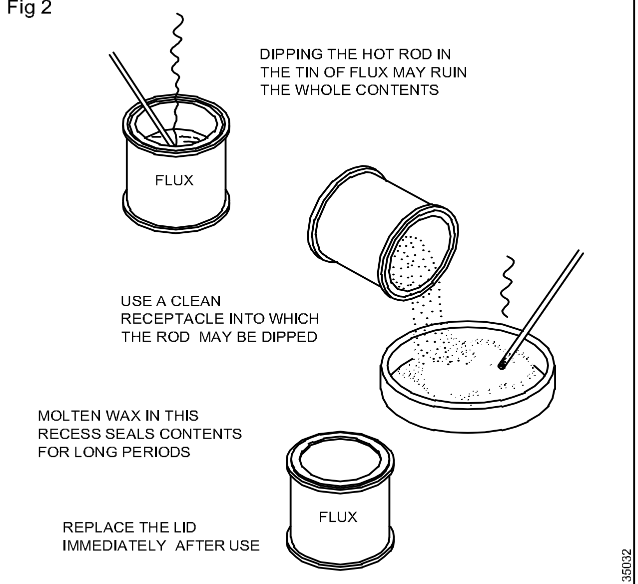
Seal flux tin lids when storing especially for long periods (Fig 2)

Fig 1



METHOD OF APPLICATION

Fig 2



METHOD OF STORING FLUX

Though the inner reducing envelope of an oxy-acetylene flame offers protection to the weld metal, it is necessary to use a flux in most cases.Fluxes used during welding not protect the weldment from oxidation but also from a slag which floats up and allows clean weld metal, to be deposited. After the completion of welding, flux residues should be cleaned.

Removal of flux residues: After welding or brazing is over, it is essential to remove the flux residues. Fluxes in general are chemically active. Therefore, flux residues, if not properly removed, may lead to corrosion of parent metal and weld deposit.

Some hints for removal of flux residues are given below:

- **Aluminium and aluminium alloys-** As soon as possible after welding, wash the joints in warm water and brush vigorously. when conditions allow, follow up by a rapid dip in a 5 percent solution of nitric acid; wash again,using hot water to assist drying.
- When containers, such as fuel tanks, have been welded and parts are inaccessible for the hot water scrubbing method, use a solution of nitric and hydrofluoric acids.To each 5.0 litres of water add 400 ml of nitric acid (specific gravity 1.42) followed by 33ml of hydrofluoric acid (40 percent strength). The solution used at room temperature will generally completely remove the flux residue in 10 minutes, producing a clean uniformly etched surface, free from stains. Following this treatment the parts should be rinsed with cold water and finished with a hot water rinse. The time of immersion in hot water should not exceed three minutes, otherwise staining may result; after this washing with hot water the parts should be dried. It is essential when using this treatment that rubber gloves be worn by the operator and the acid solution should preferably be contained in an aluminium vessel.
- **Magnesium alloys**-Wash in water followed quickly by standard chromating. Acid chromate bath is recommended.
- **Copper and brass**- Wash in boiling water followed by brushing.Where possible, a 2 percent solution of nitric or sulphuric acid is preferred to help in removing the glassy slag, followed by a hot water wash.
- **Stainless steel**- Treat in boiling 5 percent caustic soda soultion, followed by washing in hot water. Alternatively, use a de-scaling solution of equal volume of hydrochloric acid and water to which is added 5 percent of the total volume of nitric acid with 0.2 percent of total volume of a suitable restrainer.
- **Cast iron**- Residues may be removed easily by a chipping hammer or wire brush.
- **Silver brazing** -The flux residue can be easily removed by soaking brazed components in hot water, followed by wire brushing. In difficult cases the work piece should be immersed in 5 to 10 percent sulphuric acid solution for a period of 2 to 5 minutes, followed by hot water rinsing and wire brushing.

Types of spelters and fluxes used in brazing

Objectives: At the end of this lesson you shall be able to
- **state the types of spelter and flux used in brazing**
- **state the composition of spelter and its melting point.**

Brazing is essentially similar to soldering but it gives a much stronger joint than soldering. The principal differences is the use of a harder filler material, commercially known as spelter which fuses at some temperature above red heat, but below the melting temperature of the parts to be joined. Filler materials used in this process may be divided into two classes. Copper base alloys and silver base alloys. There are a number of different alloys in each class, but brass (Copper and Zinc) sometimes with upto 20% tin are mostly used mainly for brazing the ferrous metals. Silver alloys (Silver and Copper or Silver and Copper and Zinc) having a melting point range of 600 to 850^{0}C are suitable for brazing any metals capable of being brazed. They are giving a clean finish and a strong ductile joint. Spelters are commonly made according to the thickness of sheets.

After brazing, the joint must be hammered to check the leakages and to remove flux. Mostly and commonly used flux is "Borax" for ferrous and non-ferrous metals. It removes rust and prevents atmospheric effect, when brazing operation is going on.

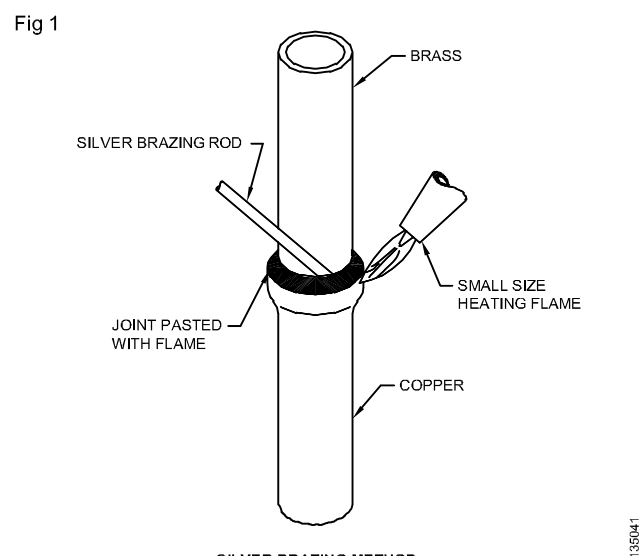
COMPOSITION OF SPELTER AND MELTING POINTS

Sl. No.	Types of spelters	Common metals	Copper %	Zinc %	Silver %	Melting temperatures	Uses
1	Copper + Zinc Base spelter	Common	60	40	NIL	850^{0}C	Hard brazing on copper sheets and non-ferrous
2	-do-	Ferrous metals	80	20	NIL	600^{0}C	Brass sheet thick
3	-do-	brass	30	70	NIL	400^{0}C	Brass sheet thin
4	Silver solder	Gold	10	10	80%	350^{0}C	It is used for gold ornaments brazing

Silver brazing of copper pipes by gas

Objectives: At the end of this lesson you shall be able to
- **explain the term silver brazing**
- **state the various applications of silver brazing.**

Silver brazing (Fig 1)



SILVER BRAZING METHOD

A low temperature brazing method.

Also called by other names such as:- Silver soldering, Hard soldering.

Its temperature range is 600°C to 850°C.

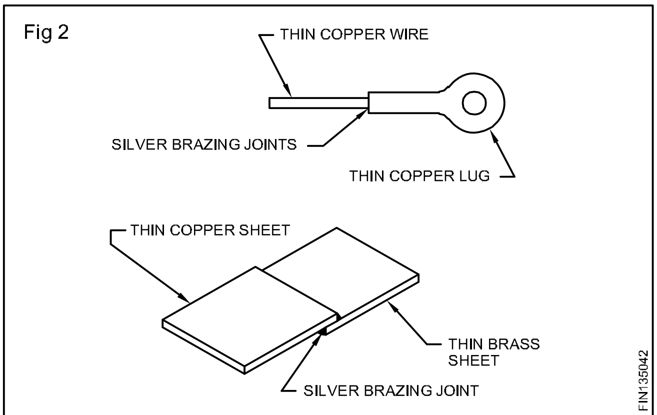
Silver-brazing filler rods are composed of copper and silver with a small percentage of Zinc, Cadmium and Nickel.

Silver content may vary from 40 to 60%.

Applications

This low temperature brazing alloy is suitable for the following.

Joining electrical parts requiring high electrical conductivity. (Fig 2)



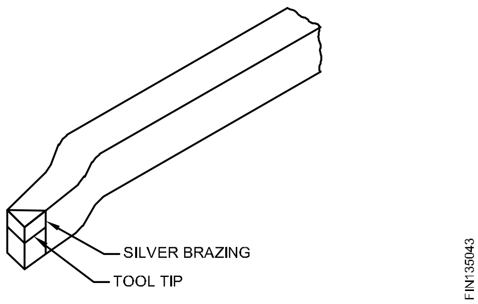
Food handling and processing equipment. (Stainless steel).

Economy in brazing operation requiring a low temperature, thin layer, quick and complete penetration.

Joining of thin sheets and close fitted joints in steel, copper, brass, bronze, nickel alloys and nickel-silver alloys.

Brazing tungsten carbide tips to ROCK DRILLS, MILLING CUTTERS, CUTTING and SHAPING TOOLS. (Fig 3)

Fig 3



Joining dissimilar metals and jewellery making works.

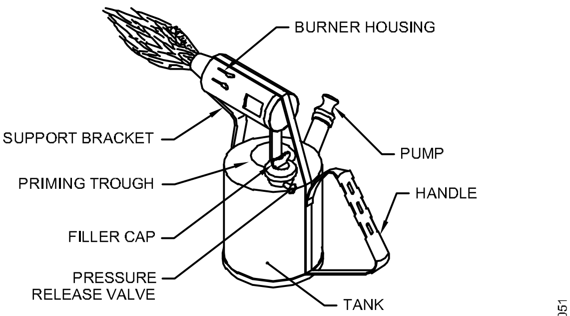
There is economy in the brazing operation as it requires only low temperature and a thin layer of deposition. There is quick and complete penetration in this method of joining.

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 mouth 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.

Portable hand forge with blower

Objectives: At the end of this lesson you shall be able to
- **state the purpsoe 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.

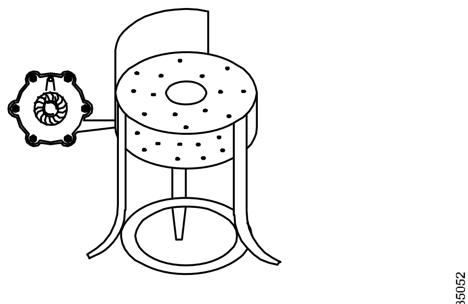
It is made of mild steel plates and angles. It is generally round in shape. the hand blower is attached to it for air supply.

A pefforated 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