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MODULE - 8

FASTENING & JOINING


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8.1 - IDENTIFY TYPES AND APPLICATIONS OF MECHANICAL FASTENING DEVICES.

8.1.1 - FASTENING

A fastener is a hardware device that mechanically joins or affixes two or more objects together. Fasteners can also be used to close a container such as a bag, a box, or an envelope; or they may involve keeping together the sides of an opening of flexible material, attaching a lid to a container. There are various types of hardware are mentioned below:

Nuts
Bolts/Screws
Studs
Washers
Rivets
Cotter Pin
Split Pin
Gaskets

8.1.2 - NUTS

A nut is a type of hardware fastener with a threaded hole. Nuts are almost always used opposite a mating bolt to fasten a stack of parts together.

TYPES OF NUTS

Acron (Cap nut)
Clip on Nut (j-nut or U nut)
Coupling Nut
Cross dowel nut
Flange Nut
Hex Nut
Insert Nut
Internal Wrenching Nut
Knurled Nut
Lock Nut
Lug Nut
PEM Nut,
Plate Nut
Rivet Nut
Slotted Nut

Square Nut
Self Lock Nut
Self Aligning Nut
Split Nut
Swage Nut
T-Nut
T-slot Nut (T-groove nut)
Weld Nut
Welded Nut
Well Nut
Wing Nut

WING NUTS

The tabs, or wings, on these nuts make them easy to adjust without a tool.
Wing nuts have two "wings," which make adjusting these nuts by hand easy. Wing nuts are convenient for projects that require frequent tightening or loosening.

SLOTTED NUTS (CASTLE NUT)

The shape of slotted nuts resembles a castle's tower, which is why they are sometimes referred to as castle nuts.
Slotted nuts, also known as castle nuts (due to their resemblance to a castle tower), are useful for projects where vibration is a concern. A pin fits through the slots on the nut and through a hole in the bolt to prevent movement.

SQUARE NUTS

Square nuts with flat tops, like these, are also known as machine screw square nuts.
Square nuts have a larger surface than hex nuts, which makes square nuts easier to grip with wrenches. Square nuts are sometimes welded to machinery.

LOCKNUTS

Locknuts provide resistance against vibration, which might cause a nut to come loose over time. There are several styles of locknuts, but they all prevent loosening from vibration. Lock nut, also known as a lock nut, locking nut, prevailing torque nut, stiff nut or elastic stop nut, is a nut that resists loosening under vibrations and torque.

TYPES OF LOCK NUT

Castle Nut,
Distorted thread locknut
- Centre lock nut
- Elliptical offset locknut
- Top lock nut

Interfering thread nut
- Tapered thread nut

Jam Nut
Jet Nut (K-nut)
Keps Nut (K nut, washer nut)
Nylock Plate Nut
Nylock (Polymer insert nut)
Serrated Face Nut
Serrated Flange Nut
Speed Nut (sheet metal nut, Tinnerman nut)
Split Beam Nut

CASTLE NUT

A castle nut, also called a Castellated Nut or slotted nut, is a type of nut with rounded extensions projecting past the nut's opening and with slots (notches) cut into one end. The name comes from the nut's resemblance to the crenellated parapet of a medieval castle. The bolt or axle has one or two holes drilled through its threaded end. The nut is torque properly and then, if the slot isn't aligned with the hole in the fastener, the nut is rotated to the nearest slot. The nut is then secured with a cotter pin or safety wire.

APPLICATION

Castle or Slotted nuts are used in conjunction with a cotter pin on drilled shank fasteners to prevent loosening. Castellated nuts are used in low-torque applications, such as holding a wheel in place

DISTORTED THREAD LOCK NUT

In a distorted thread locknut, there are certain threads, either at one end or in the middle of the nut, that are distorted that don't thread on to the bolt perfectly on purpose. These distorted threads on the nut are forced to thread onto a bolt. The distorted threads and the thread on the bolt are forced so tightly together that there is a great amount of friction between them.

Distorted thread lock nuts usually cannot be reused, because they will have new threads cut into them after being used the first time, and will lose their locking power. However, unlike Nylock bolts, they are good in high temperatures up to 1,400 degrees.

Note that a distorted nut cannot be made of a metal that is stronger than the bolt metal or its distorted threads will destroy the threads on a the bolt rather than lock to it. For example, never use a steel distorted thread lock nut on an aluminum bolt.

APPLICATION

A distorted thread lock nut is a type of locknut that uses a deformed section of thread to keep the nut from loosening from vibrations or rotation of the clamped item. They are broken down into three types: elliptical offset nuts, center lock nuts, and top lock nuts.

TYPES OF DISTORTED THREAD LOCK NUT

Center lock nut: Center lock nuts are similar to elliptical offset nuts, except that they are distorted in the middle of the nut. This allows the nut to be started from either side.

ELLIPTICAL OFFSET LOCKNUT

Elliptical offset nuts, also known as oval locknuts or non-slotted hex locknuts, is a nut that has been deformed at one end so that the threads no longer perfectly circular. The deformed end is usually shaped into an ellipse. The nut is easily started on the male fastener as the bottom portion is not deformed. As the male fastener reaches the deformed section it deforms the threads of the nut elastically back into a circle. This action increases the friction between the nut and the fastener greatly and creates the locking action. Due to the elastic nature of the deformation the nuts can be reused indefinitely.

Top lock nut: Top lock nuts are also similar to elliptical offset nuts, except that the whole thread on one end is not distorted. Instead only three small sections of the thread are deformed on one end.

INTERFERING THREAD NUT

An interfering thread nut is a type of locking that has an over-sized root diameter. This creates interference between the nut and the fastener, plastically deforming the threads on the fastener. Due to this deformation they are usually only used on permanent or semi-permanent installations. A variation of this nut is the tapered thread nut. It utilizes a tapered thread to achieve the interference. The nut goes on easily, because the thread diameter starts at a standard size; as the nut is further threaded on it begins to lock, much like a distorted thread locknut.

JET NUT (K-NUT)

A jet nut, also known as a K-nut, is a special type of hex locknut that is commonly used in the aerospace and automotive racing industries. It has a flange on one end of the nut, the hex is smaller than a standard sized hex nut, and it is shorter than a standard

Kay or **Jet Nut**, 8-32 Thread
300 x 300

JAM NUT

Jam nuts are any nut that is jammed up against another nut in order to lock in place the nuts' position on a bolt. A good jam lock is achieved this way: A first nut is screwed onto a bolt a little past its desired location. Then, a second nut is screwed onto the bolt next to the first nut. The second nut is held still with a wrench, and then the first nut is backed up with another wrench to press tightly against the second nut---achieving a locked position on the bolt and also backing the first nut into its desired position. On the bicycle, these are used on hubs and bottom brackets to lock nuts just loose enough to allow rings of bearings to move freely, but not rattle around.

APPLICATION

Jam nuts are used when the nuts need to be locked into place along a bolt without being pressed against another surface---they press on one another, instead. Jam nuts do not provide an unbreakable lock, but they are sufficient, sometimes necessary, and they are reusable.

KEPS NUT (K-NUT OR WASHER NUT)

A Keps nut, also called a K-nut or washer nut, is a nut with an attached, free-spinning washer. It is used to make assembly more convenient. Common washer types are star-type lock washers, conical, and flat washers.

NYLOCK PLATE NUT

A nylon pellet nut is very similar to a Nylock nut except that it uses one or smaller nylon inserts instead of a ring of nylon. They do not lock as strongly as Nylock nuts.
Nylock is a registered trade name of Forest Fasteners. The term "Nylock" has become a genericized trademark in Australia, referring to all types and brands of polymer insert locking nuts.

Nut (1/2-20 Thin Nylock S/S)
750 x 750

NYLOCK NUT (nylon insert lock nut, polymer insert lock nut or elastic stop nut)

It is a kind of nut that includes a nylon collar insert. The insert is placed at the end of the nut and its inner diameter (ID) is slightly smaller than the major diameter of the screw. The insert deforms elastically over the threads of the screw, but threads are not cut into the nylon. The nylon insert locks the nut in two ways. First, it forces the bottom face of the screw threads against the top face of the nut threads, increasing the friction between the two. Second, the nylon applies a compressive force against the screw itself. Nylock nuts retain their locking ability up to 250 °F (121 °C).

SERRATED FACE NUT

Serrated face nuts have serrations cut into one or both of their faces. A face with the serration is screwed onto a bolt until it presses against surface and the angle of the serrations because the face to bite into the surface it presses against, preventing loosening. Serrated face lock nuts won't work if locked against a washer---the washer will spin instead of putting up resistance against the threads.

A serrated-face nut
(flange
843 x 865

SERRATED FLANGE NUT:

It has a wide flange at one end that acts as an integrated, non- spinning washer. This serves to distribute the pressure of the nut over the part being secured, reducing the chance of damage to the part and making it less likely to loosen as a result of an uneven fastening surface.
The flange may be serrated to provide a locking action. The serrations are angled such that they keep the nut from rotating in the direction that would loosen the nut. Because of the serrations they cannot be used with a washer or on surfaces that cannot be scratched. Sometimes both faces of the nut are serrated, permitting either side to lock.

SERRATED FLANGE NUTS
178 x 118

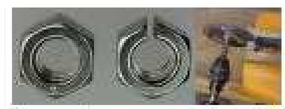
SPEED NUT (Sheet metal nut or Tinnerman nut)

A speed nut, also known as a sheet metal nut, is a type of lock nut with two sheet metal prongs that act as one thread.. They are made from spring steel. The fastener serves the functions of both a lock washer and a nut. As the fastener is tightened in the nut the prongs are drawn inward until they exert pressure on the root of the thread on the fastener. When the fastener is tightened, the base of the nut, which is arched, elastically deforms and applies a force to the fastener, which locks it from loosening under vibrations.

Speed Nut for Tormek and Jet
288 x 223

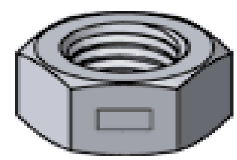
SPLIT BEAM NUT (split hex nut or slotted beam nut)

A split beam nut is a nut with one end that is split into two or more segments (though the segments continue to be threaded). There is a gap between the segments, and each segment is bent slightly inward. The segmented portion of the nut threads on last, and as it threads on, the segments are forced to expand back out to fit the diameter of the bolt. However, they are still pressing inward, providing enough friction to lock the nut into place on the bolt.



The **nut** was easy to **split**
600 x 217

TWO-WAY REVERSIBLE LOCK NUTS These lock nuts can be installed either side up. They are non-reusable as removal often damages the threads. All metal lock nuts are often used high temperature applications.

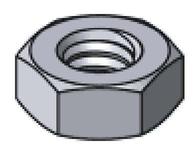


HEX NUTS

Hex nuts are used for many general-purpose projects. Because hex nuts work for many applications, they are one of the most common styles used. They have six sides, which is where the name "hex" comes from.

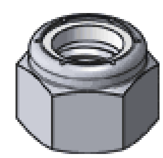
HEX MACHINE SCREW NUTS

Used for fastening to a bolt when mechanically joining materials together. This type refers to nuts used with smaller machine screw **sizes under 1/4.**



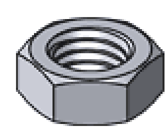
HEX LOCK NUTS NYLON INSERT

Used for fastening to a bolt when mechanically joining materials together. The bolt threads into the nylon material located at the top of the nut. This helps prevent loosening from vibration.

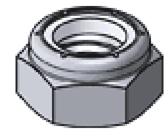


HEX JAM NUTS

A thinner version of a standard finish full hex nut

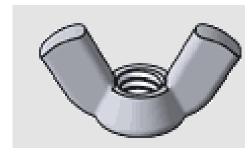


HEX JAM NYLON LOCK NUTS



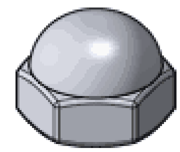
A thin pattern lock nut used for fastening to a bolt when mechanically joining materials together. The bolt threads into the nylon material located at the top of the nut. This helps prevent loosening from vibration.

WING NUT



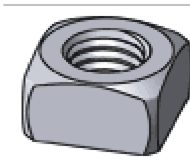
It is also known as butter fly nut. It can be turned by hand and normally used for assembly that needs to open repeatedly for example it is used in air cleaner assembly of vehicle.

CAP NUT



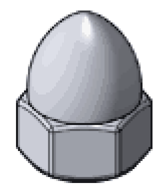
A nut with a finished top. Bolts must be in the proper length.

SQUARE NUTS



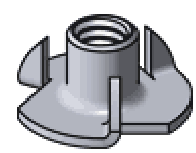
Square nuts, once very common, were mostly replaced by hex nuts. Can also be used in a channel or welded in place.

ACORN NUTS



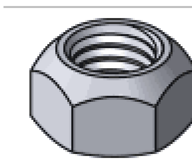
Acorn nuts are a high crown type of cap nut used for appearance.

T-NUTS



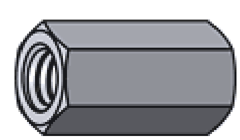
A type of nut used to fasten to wood, particle or composite materials, leaving a flush surface.

PREVAILING TORQUE LOCK NUTS



All metal lock nuts are non-reversible and often used high temperature applications. These nuts are non-reversible because removal often damages the threads.

COUPLING NUTS



Coupling nuts are long nuts used to connect pieces of threaded rod or other male threaded fasteners.

8.1.3 - BOLTS

Bolts are used to join pieces together either permanently or temporarily. Many steel structures, including buildings, are simply bolted together. A cylindrically shaped, threaded device used for fastening parts. Bolts usually have blunt ends and mate with a nut.

(HSFG)

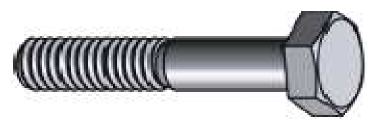
What are the advantages of using high strength friction grip (HSFG) bolts when compared with normal bolts?
HSFG bolts have the following advantages when compared with normal bolts :

i. The performance of preloaded HSFG bolts under fatigue loading is good because the prestressed bolts are subjected to reduced stress range during each loading cycle when compared with unloaded bolts.
ii. For structures adjacent to machinery which generate substantial vibration, preloading bolts can help to avoid the loosening of bolts.
iii. HSFG bolts are used in connections where any slight slip movement would render the integrity of the whole structures break down.
iv. Owing to its high tensile strength, it is commonly used in connections which require the taking up of high flexure and the tensile stress generated could be readily resisted by it high tensile strength.

TYPES OF BOLT

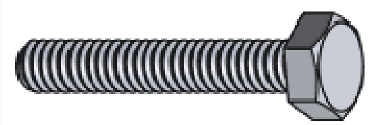
HEX BOLTS

Hex bolts, also known as hex cap screws or machine bolts. A standard bolt has a hex head and a smooth shoulder area beyond the standard amount of threading.
Shorter lengths are fully threaded.



FULL THREAD TAP BOLTS

Hex bolts, also known as hex cap screws or machine bolts.

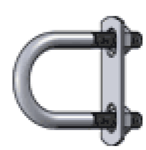


U-BOLTS

Bolts in U shape for attaching to pipe or other round surfaces. Also available with a square bend.

ROUND BEND (W/ 2 NUTS & STRAP)

Bolts in U shape for attaching to pipe or other round surfaces. Also available with a round bend

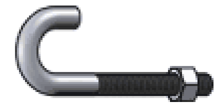


SQUARE BEND (W/ 2 NUTS & STRAP)

Bolts in U shape for attaching to pipe or other round surfaces. Also available with a square bend.

J-BOLTS (W/ NUTS)

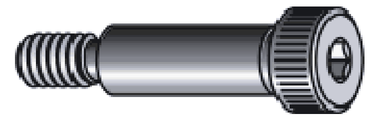
J shaped bolts are used for tie-downs or as an open eye bolt.



SHOULDER BOLTS

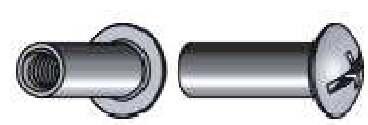
Shoulder bolts (also known as stripper bolts) are used to create a pivot point.

These shoulder bolts are tightened with a hex Allen wrench.



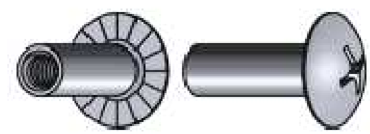
SEX BOLTS - COMBINATION TRUSS HEAD

Sex bolts (also known as barrel nuts and Chicago bolts) have a female thread and are used for through bolting applications where a head is desired on both sides of the joint.



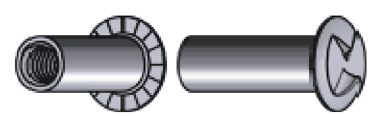
SEX BOLTS - PHILLIPS TRUSS HEAD SERRATED

Sex bolts (also known as barrel nuts and Chicago bolts) have a female thread and are used for through bolting applications where a head is desired on both sides of the joint.



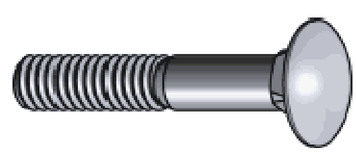
SEX BOLTS - ONE WAY TRUSS HEAD SERRATED

Sex bolts (also known as barrel nuts and Chicago bolts) have a female thread and are used for through bolting applications where a head is desired on both sides of the joint.



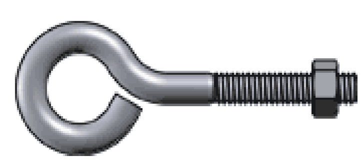
CARRIAGE & TIMBER BOLTS

A bolt mostly used in wood with a domed top and a square under the head. This pulls into the wood as the nut is tightened.



EYE BOLTS & EYE LAGS

Eye bolts and eye lags (eye bolts with wood thread) are available in several materials and styles.



WIRE EYE BOLTS (W/ NUTS)

Wire eye bolts (also referred to as bent or turned eye bolts) are used for light duty applications, and should not be used for angular loads.

FORGED EYE BOLTS (W/ NUTS)

Domestic drop forged eye bolts. Forged eye bolts are significantly stronger than wire eyes and are available in larger sizes. These bolts should not be used for angular loads.

FORGED MACHINERY EYE BOLT

Drop forged machinery eye bolts. Machinery eyes are fully threaded. Machinery eye bolts without a shoulder should not be used for angular loads.

WIRE EYE LAGS

Wire eye lags (also referred to as screw thread eye bolts, eye screws, or turned/bent eye lags) have a wood screw thread for use in wood or lag anchors. Like wire eye bolts, wire eye lags are intended for light duty applications and should not be used for angular load

ELEVATOR BOLTS

Elevator bolts are often used in conveyor systems. They have a large, flat head.

HANGER BOLTS

Hanger bolts have wood thread on one end and machine thread on the other end. Hanger bolts have wood thread on one end and machine thread on the other end. These bolts are frequently found in furniture.

LAG BOLTS

Often called a lag screw. Hex lag bolts are for fastening in wood. Available in a variety of materials.

8.1.4 - SCREW

A threaded cylindrical pin or rod with a head at one end, engaging a threaded hole and used either as a fastener or as a simple machine for applying power, as in a clamp, jack, etc. Compare bolt

MACHINE SCREW

CSK Head Machine Screw
Pan Head Machine Screw
Cheese Head Machine Screw
Raised Head Machine Screw

PHILLIPS HEAD SCREW

Raised Phillips Head Self Tapping Screw
CSK Phillips Head Machine Screw
Pan Phillips Head Machine Screw
CSK PHILLIPS Head Self Tapping Screw
Pan Phillips Head Self
Self Tapping Screw
CSK Head Self Tapping Screw
Pan Head Self Tapping Screw
Round Head Self Tapping Screw
Raised Head Self Tapping Screw
Cheese Head Self Tapping Screw

WOOD SCREW

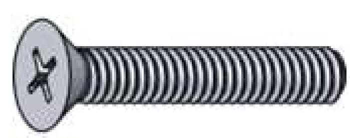
CSK Phillips Head Wood Screw

PHILLIPS PAN HEAD

A pan head screw protrudes above the surface of the material to be fastened.

FLAT HEAD SCREW

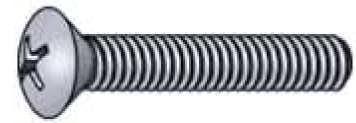
Flat head screws are countersunk into the material for a smooth surface area.



SLOTTED FLAT HEAD SCREW

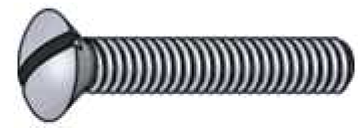
Slotted Flat head screws are countersunk into the material for a smooth surface area.

PHILLIPS OVAL HEAD



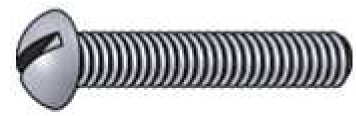
Oval head screws are similar to flat head, but have a slightly rounded top for a more finished look.

SLOTTED OVAL HEAD



Oval head screws are similar to flat head, but have a slightly rounded top for a more finished look.

SLOTTED ROUND HEAD

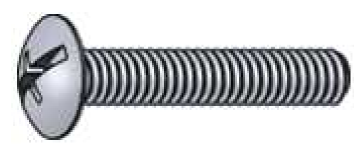


Round head protrudes above the surface of the material to be fastened.

COMBINATION ROUND HEAD

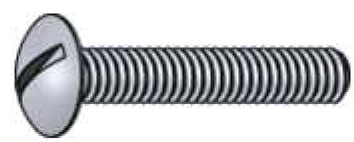
These are the same as round head except for the option of using either a slotted or Phillips screwdriver.

COMBINATION TRUSS HEAD



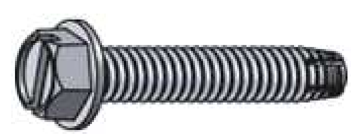
Protrudes above the surface to be fastened but with a low profile and a larger surface area under the head. Combination truss takes either a Phillips or slotted screwdriver.

SLOTTED TRUSS HEAD



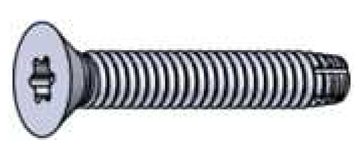
Slotted truss head protrudes above the surface to be fastened but with a low profile and a larger surface area under the head.

HEX SLOTTED WASHER HEAD THREAD CUTTING SCREW TYPE F



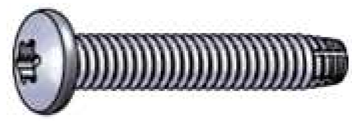
A hex head machine screw with a slotted and tapered point which is self tapping.

TORX FLAT HEAD THREAD CUTTING SCREW TYPE F



Also known as Trailer floor screws or Floor board screws these screws have a countersunk head and a self tapping point.

TORX PAN HEAD THREAD CUTTING SCREW TYPE F



These screws have a pan head and a self tapping point.

8.1.5 - WASHER

A washer is a thin plate (typically disk-shaped) with a hole (typically in the middle) that is normally used to distribute the load of a threaded fastener, such as a screw or nut. Other uses are as a spacer, spring (Belleville washer, wave washer), wear pad, preload indicating device, locking device, and to reduce vibration (rubber washer).

Washers usually have an outer diameter (OD) about twice the length of their inner diameter (ID).

Washers are usually metal or plastic. High quality bolted joints require hardened steel washers to prevent the loss of pre-load due to b brinelling after the torque is applied.

TYPES OF WASHER

- ⊞ Plain Washer
- ⊞ Lock Washer
- ⊞ Special Purpose Washer
- ⊞ Square Bend Washer
- ⊞ Shaft Lock Washer
- ⊞ Shim Washer
- ⊞ Taper Washer
- ⊞ Ape Washer
- ⊞ Tooth Lock Washer
- ⊞ Machined Washer
- ⊞ Disc Washer
- ⊞ Dust Cap Washer
- ⊞ Special Washer
- ⊞ Internal Lock Washer
- ⊞ Spring Washer
- ⊞ Square Washer
- ⊞ Wave Washer
- ⊞ Cup Washer
- ⊞ Tab Washer
- ⊞ Crank Washer
- ⊞ Oil Cups
- ⊞ Check Nut
- ⊞ Chain Tensioner
- ⊞ PTO Pins
- ⊞ Locking Collars
- ⊞ Special Sheet Metal Cup

PLAIN WASHER (FLAT WASHER)

It is a flat annulus or ring shape. These types of washers spread a load, and prevent damage to the surface being fixed, or provide some sort of insulation such as electrical. Additionally a plain washer may be used when the hole is a larger diameter than the fixing nut

PLAIN WASHER TYPES AND APPLICATION

SPHERICAL WASHER

Two-piece washer that compensates whenever a stud and clamping surface are not exactly perpendicular. The top washer has a convex spherical radius, while the bottom washer has a matching concave spherical radius.

- Spherical washers act like a ball and socket to compensate for slight misalignment.

- Use in pairs, or use the bottom with our spherical flange nuts.
- Carburized hardened steel.

ANCHOR PLATE (WALL WASHER)

It is a large plate or washer connected to a tie rod or bolt. Anchor plates are used on exterior walls of masonry buildings, for structural reinforcement. Being visible, many anchor plates are made in a style that is decorative

A FLANGE NUT

It is a nut with an integral fixed washer.

TORQUE WASHER

It is used in woodworking in combination with a carriage bolt. It has a square hole in the center where the carriage bolt square fits into. Teeth or prongs on the washer bite into the wood preventing the bolt from revolving freely when a nut is being tightened.

SPRING WASHERS

These types of washers have axial flexibility and are used to prevent fastening loosening due to vibrations; and locking washers which prevent fastening loosening by preventing unscrewing rotation of the fastening device; locking washers as usually also spring washers. The term washer is also often used for disc shaped devices used as grommets.

TYPES AND APPLICATION

- **BELLEVILLE WASHERS**

It is also known as a cupped spring washer or conical washer, has a slight conical shape, which provides an axial force when deformed.

- **CURVED DISC SPRING**

It is similar to a Belleville except the washer is curved in only one direction, therefore there are only four points of contact. Unlike Belleville washers, they only exert light pressures.

- **WAVE WASHERS**

These types have a "wave" in the axial direction, which provides spring pressure when compressed. Wave washers, of comparable size, do not produce as much force as Belleville washers. In Germany, they are used as a lock washer, however they are ineffective.

- **A SPLIT WASHER**

It is a ring split at one point and bent into a helical shape. This causes the washer to exert a spring force between the fastener's head and the substrate. While this is supposed to act as a locking device

- **A TOOTHED LOCK WASHER (SERRATED WASHER OR STAR WASHER)**

It has serrations that extend radially inward and/or outward to bite into the bearing surface. This type of washer is effective as a lock washer when used with a soft substrate, such as aluminum or plastic. There are four types:

  - **INTERNAL**

The internal style has the serrations along the inner diameter of the washer, which makes them more aesthetically pleasing

  - **EXTERNAL**

The external style has the serrations around the outer diameter, which provides better holding power, because of the greater surface area

  - **COMBINATION**

The combination style has serrations about both diameters, for maximum holding power

  - **COUNTERSUNK**

The countersunk style is designed to be used with flat-head screws.

TAPPER

SPRING/LOCKING/ CUPPED SPRING/CONICAL/WASHER: has a slight conical shape, which provides an axial force when deformed.

WAVE WASHERS have a "wave" in the axial direction, which provides spring pressure when compressed. Wave washers, of comparable size, do not produce as much force as Belleville washers. In Germany, they are used as a lock washer, however they are ineffective.

SPLIT WASHER is a ring split at one point and bent into a helical shape. This causes the washer to exert a spring force between the fastener's head and the substrate. While this is supposed to act as a locking device, it is ineffective.

TOOTHED LOCK WASHER/ SERRATED WASHER/ STAR WASHER: has serrations that extend radially inward and/or outward to bite into the bearing surface. This type of washer is effective as a lock washer when used with a soft substrate, such as aluminum or plastic. There are four types: internal, external, combination, and countersunk. The internal style has the serrations along the inner diameter of the washer, which makes them more aesthetically pleasing. The external style has the serrations around the outer diameter, which provides better holding power, because of the greater surface area. The combination style has serrations about both diameters, for maximum holding power. The countersunk style is designed to be used with flat-head screws.

Plate Washer

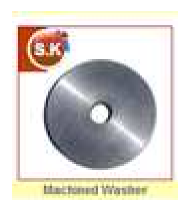
Square Bend Washer

Shaft Lock Washer

Shim Washer

Ape Washer

Machined Washer



Disc Washer

Dust Cap Washer

Internal Lock washer

Square Washer

Check Nut Washer

Square Bend Washer

8.1.6 - RIVET

A rivet is a permanent mechanical fastener. Before being installed a rivet consists of a smooth cylindrical shaft with a head on one end. The end opposite the head is called the buck-tail. On installation the rivet is placed in a punched or pre-drilled hole, and the tail is upset, or bucked (i.e. deformed), so that it expands to about 1.5 times the original shaft diameter, holding the rivet in place. To distinguish between the two ends of the rivet, the original head is called the factory head and the deformed end is called the shop head or buck-tail.

TYPES OF RIVETS

Solid
Semi tubular rivets
Blind rivets
Drive rivet
Flush rivet
Friction lock rivet
Self pierce rivet

SOLID RIVET

Solid rivets are one of the oldest and most reliable types of fasteners, Solid rivets consist simply of a shaft and head which are deformed with a hammer or rivet gun. The use of a rivet compression or crimping tool can also be used to deform this type of rivet; this tool is mainly used on rivets close to the edge of the fastened material, since the tool is limited by the depth of its frame. A rivet compression tool does not require two people and is generally the most foolproof way to install solid rivets.

APPLICATION

Solid rivets are used in applications where reliability and safety count. A typical application for solid rivets can be found within the structural parts of:

Aircraft.

Hundreds of thousands of solid rivets are used to assemble the frame of a modern aircraft.
Bridges:
Crane
Building Frame
A countersink may be used in many tools, such as drills, drill presses, milling machines, and lathes

SEMI-TUBULAR RIVETS (TUBULAR RIVETS)

Semi-tubular rivets (also known as tubular rivets) are similar to solid rivets, except they have a partial hole (opposite the head) at the tip. The purpose of this hole is to reduce the amount of force needed for application by rolling the tubular portion outward. The force needed to apply a semitubular rivet is about 1/4 of the amount needed to apply a solid rivet. Tubular rivets can also be used as pivot points (a joint where movement is preferred) since the swelling of the rivet is only at the tail. Solid rivets expand radially and generally fill the hole limiting movement. The type of equipment used to apply semi-tubular rivets range from prototyping tools (less than $50) to fully automated systems. Typical installation tools (from lowest to highest price) are hand set, manual squeezer, pneumatic squeezer, kick press, impact riveter, and finally PLC-controlled robotics. The most common machine is the impact riveter and the most common use of semitubular rivets is in lighting, brakes, ladders, binders, HVAC duct work, mechanical products, and electronics. They are offered from 1/16-inch (1.6 mm) to 3/8-inch (9.5 mm) in diameter (other sizes are considered highly special) and can be up to 8 inches (203 mm) long. A wide variety of materials and platings are available, most common base metals are steel, brass, copper, stainless, aluminum and most common platings are zinc, nickel, brass, tin. All tubular rivets are waxed to facilitate proper assembly. The finished look of a tubular rivet will have a head on one side, with a rolled over and exposed shallow blind hole on the other. Semi-tubular rivets are the fastest way to rivet in mass production but require

BLIND RIVETS

Blind rivets are tubular and are supplied with a mandrel through the center. The rivet assembly is inserted into a hole drilled through the parts to be joined and a specially designed tool is used to draw the mandrel into the rivet. This expands the blind end of the rivet and then the mandrel snaps off. (A POP rivet is a brand name for blind rivets sold by Emhart Teknologies.) These types of blind rivets have non-locking mandrels and are avoided for critical structural joints because the mandrels may fall out, due to vibration or other reasons, leaving a hollow rivet that will have a significantly lower load carrying capability than solid rivets. Furthermore, because of the mandrel they are more prone to failure from corrosion and vibration. Unlike solid rivets, blind rivets can be inserted and fully installed in a joint from only one side of a part or structure, "blind" to the opposite side.[2]

Prior to the adoption of blind rivets, installation of a solid rivet typically required two assemblers: one person with a rivet hammer on one side and a second person with a bucking bar on the other side. Seeking an alternative, inventors such as Carl Cherry and Lou Huck experimented with other techniques for expanding solid rivets. The blind rivet was developed by the United Shoe Machinery Corporation.[3]

Due to this feature, blind rivets are mainly used when access to the joint is only available from one side. The rivet is placed in a pre-drilled hole and is set by pulling the mandrel head into the rivet body, expanding the rivet body and causing it to flare against the reverse side. As the head of the mandrel reaches the face of the blind side material, the pulling force is resisted, and at a predetermined force, the mandrel will snap at its break point, also called "Blind Setting". A tight joint formed by the rivet body remains, the head of the mandrel remains encapsulated at the blind side, although variations of this are available, and the mandrel stem is ejected.

Most blind rivets have limited use on aircraft and are never used for structural repairs. However, they are useful for temporarily lining up holes. In addition, some "home built" aircraft use blind rivets. They are available in flat head, countersunk head, and modified flush head with standard diameters of 1/8, 5/32 and 3/16 inch. Blind rivets are made from soft aluminum alloy, steel (including stainless steel), copper, and Monel.

The rivet body is normally manufactured using one of three methods:

DRIVE RIVET

A drive rivet is a form of blind rivet that has a short mandrel protruding from the head that is driven in with a hammer to flare out the end inserted in the hole. This is commonly used to rivet wood panels into place since the hole does not need to be drilled all the way through the panel, producing an aesthetically pleasing appearance. They can also be used with plastic, metal, and other materials and require no special setting tool other than a hammer and possibly a backing block (steel or some other dense material) placed behind the location of the rivet while hammering it into place. Drive rivets have less clamping force than most other rivets.

FLUSH RIVET

A flush rivet is used primarily on external metal surfaces where good appearance and the elimination of unnecessary aerodynamic drag are important. A flush rivet takes advantage of a countersink hole, they are also commonly referred to as countersunk rivets. Countersunk or flush rivets are used extensively on the exterior of aircraft for aerodynamic reasons. Additional post-installation machining may be performed to perfect the airflow.

FRICTION - LOCK RIVET

One early form of blind rivet that was the first to be widely used for aircraft construction and repair was the Cherry friction-lock rivet. Originally, Cherry friction-locks were available in two styles, hollow shank pull-through and self-plugging types. The pull-through type is no longer common, however, the self -plugging Cherry friction-lock rivet is still used for repairing light aircraft.

Cherry friction-lock rivets are available in two head styles, universal and 100 degree countersunk. Furthermore, they are usually supplied in three standard diameters, 1/8, 5/32 and 3/16 inch.

A friction-lock rivet cannot replace a solid shank rivet, size for size. When a friction-lock is used to replace a solid shank rivet, it must be at least one size larger in diameter. the reason behind this is that friction-lock rivet loses considerable strength if its center stem falls out due to vibrations or damage.

Rivet alloys, their shear strengths and condition in which they are driven.

SELF PIERCE RIVET

Self-pierce riveting (SPR) is a process of joining two or more materials using an engineered rivet. Unlike solid, blind and semi-tubular rivets, self-pierce rivets do not require a drilled or punched hole.

SPRs are cold forged to a semi-tubular shape and contain a partial hole to the opposite end of the head. The end geometry of the rivet has a chamfered poke which aids the piercing of the materials being joined, a hydraulic or electric servo rivet setter drives the rivet into the material and an upsetting die provides a cavity for the displaced bottom sheet material to flow.

The self-pierce rivet fully pierces the top sheet material(s) but only partially pierces the bottom sheet. As the tail end of the rivet does not break through the bottom sheet it provides a water or gas tight joint. With the influence of the upsetting die, the tail end of the rivet flares and interlocks into the bottom sheet forming a low profile button.

Rivets need to be harder than the materials being joined, they are heat treated to various levels of hardness depending on the materials ductility and hardness. Rivets come in a range of diameters and lengths depending on the materials being joined, head styles are either flush countersunk or pan heads.

Depending on the rivet setter configuration, i.e. hydraulic, servo, stroke, nose-to-die gap, feed system etc., cycle times can be as quick as one second. Rivets are typically fed to the rivet setter nose from tape and come in cassette or spool form for continuous production.

Riveting systems can be manual or automated depending on the application requirements, all systems are very flexible in terms of product design and ease of integration into a manufacturing process.

SPR joins a range of dissimilar materials such as steel, aluminum, plastics, composites and pre-coated or pre-painted materials. Benefits include low energy demands, no heat, fumes, sparks or waste and very repeatable quality.

Such rivets come with rounded (universal) or 100° countersunk heads. Typical materials for aircraft rivets are aluminium alloys (2017, 2024, 2117, 7050, 5056, 55000, V-65), titanium, and nickel-based alloys (e.g. Monel). Some aluminum alloy rivets are too hard to buck and must be softened by annealing prior to being bucked. "Ice box" aluminum alloy rivets harden with age, and must likewise be annealed and then kept at sub-freezing temperatures (hence the name "ice box") to slow the age-hardening process. Steel rivets can be found in static structures such as bridges, cranes, and building frames.

The setting of these fasteners requires access to both sides of a structure. Solid rivets are driven using a hydraulically, pneumatically, or electromagnetically driven squeezing tool or even a handheld hammer. Applications in which only one side is accessible require the use of blind rivets.

RIVET TYPES

Solid
Snap or Round
Flat
Tubular (POP)

BLIND RIVETS (open or closed end)

They are used for blind fastening where there is no access to the opposite side of the work.

BULB -TITE RIVETS

The Bulb - Tite rivet body folds into three separate legs forming a large blind-side head. This large bearing head evenly distributes the Bulb-Tite's clamp force in soft, thin or brittle materials while providing high pull-through resistance. The Bulb-tite's wide grip range enables a single Bulb-Tite to work in a greater variation of thicknesses.

BUTTONHEAD RIVETS (open end, blind / pop rivets / break-stem rivets)

They are used for blind fastening where there is no access to the opposite side of the work. These have a low profile head diameter which is about twice the rivet body diameter, providing adequate bearing surface.

CLOSED END RIVETS

These are moisture resistant due to the closed end and tight seal. They also have greater shear strength. Sizes are 1/8 to1/4" diameter.

EXTRA-LONG / METRIC RIVETS

We provide metric blind rivets according to DIN7337 standards in 3mm, 4mm and 5mm diameters. Standard material is Aluminum/Steel. Stainless Steel 304 and 316 alloys are available upon special request. All dimensions for Metric Series are given in millimeters. Additional diameters of 4.8mm, 6mm and 6.4mm available on special request.

LARGE FLANGE RIVETS

Provide greater bearing surface for fastening soft and brittle facing materials and oversize facing holes. Multi-Grip Rivets have extended grip range capacity. They reduce the inventory of sizes needed to keep on hand.

MEGA-GRIP RIVETS

The Mega-Grip rivet is a high strength structural blind rivet offering several advantages over conventional blind rivets. Mega-Grip's wide grip range enables a single Mega-Grip to replace up to five different lengths of standard rivets. High shear strength is achieved by Mega-Grip's flush break self plugging mandrel. Mega-Grip rivets are hole-filling, resulting in tighter joints and improved sealing for weather resistance. Mega-Grip rivets are installed via standard rivet tools and do not require special nose tips.

MULTI GRIP RIVETS

Rivets have a wider grip range than standard blind rivets and several other advantages. The "bulbing" action of a multigrip blind rivet ensures complete hole fill even in oversized, irregular or misaligned holes, provides high clamp-up and high shear strength and ensures positive stem (mandrel) retention, plugging the end of the rivet body and providing a vibration and weather-proof seal. Due to the Multi-Grip blind rivets extended grip range capacity, Multi Grip Rivets reduce the inventory of sizes needed to keep on hand. We stock aluminum-steel Multi grip rivets. PolyGrip multi-grip rivets feature a wide grip range, enabling a single PolyGrip to replace up to three different lengths of standard blind rivets. PolyGrip rivets expand radially, filling the application hole, resulting in tighter joints and improved sealing. The PolyGrip's locked mandrel core creates a weather resistant fastener. Improved material support is provided by the PolyGrip's larger blindside head formation. Large flange head style available upon request.

OPEN END RIVETS

These are the standard design and are available in a wide variety of sizes and materials, for most any application.

PLASTIC RIVETS:

Precision Molded, all nylon. Secure lock feature prevents pull-out. Used for fastening plastic to plastic, plastic to metal or fiberglass.

RIVET DESIGN AND SELECTION:

1. Rivet shear and tensile strength: The rivet selected and the number of rivets used in the application should equal or exceed the joint strength requirements. Typical ultimate shear and tensile strengths are listed in the catalog. Testing is recommended before final selection and use in product.

2. Rivet body material: Should be compatible with the materials to be joined to resist galvanic corrosion which may result in reduction of joint strength. If dissimilar materials are widely separated on the galvanic chart, it is advisable to separate them with a dielectric material such as paint or other coating.

3. Rivet Grip Range: Select the rivet grip range which includes the total thickness of materials to be joined. Please note that the rivet barrel length is not the grip range.

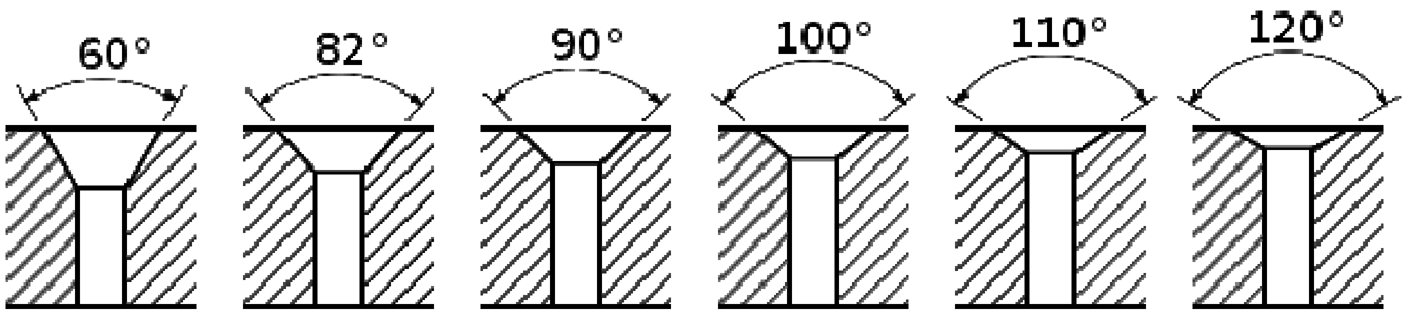
4. Rivet Hole Size: Recommended hole sizes are listed for each rivet. An undersize hole will not allow insertion of the rivet body; an oversize hole will reduce shear and tensile strengths, and may cause improper rivet setting, all of which promote joint failure.

5. Rivet Head Style: Various head types are offered to accommodate different assembly needs. The most popular is the buttonhead, whose lower-profile head is twice the diameter of the rivet body. This provides adequate bearing surface for nearly all applications. The large flange rivet provides greater bearing surface for fastening soft or brittle facing materials. The countersunk rivet is available for applications where a flush appearance is required. And the closed-end is ideal for roofing, marine, electric or electronics applications.

8.1.7 - COUNTER SUNK

A **countersink** is a conical hole cut into a manufactured object, or the cutter used to cut such a hole. A common usage is to allow the head of a countersunk bolt or screw, when placed in the hole, to sit flush with or below the surface of the surrounding material. (By comparison, a counterbore makes a flat-bottomed hole that might be used with a hex-headed capscrew.) A countersink may also be used to remove the burr left from a drilling or tapping operation thereby improving the finish of the product and removing any hazardous sharp edges.

The basic geometry of a countersink (cutter) inherently can be applied to the plunging applications described above (axial feed only) and also to other milling applications (sideways traversal). Therefore countersinks overlap in form, function, and sometimes name with chamfering endmills (endmills with angled tips). Regardless of the name given to the cutter, the surface being generated may be a conical chamfer (plunging applications) or a beveled corner for the intersection of two planes (traversing applications).



Cross-sections of countersunk holes of various chamfer angles

TYPES

MACHINING

A countersink may be used in many tools, such as drills, drill presses, milling machines, and lathes.

CROSS-HOLE COUNTERSINK CUTTER

Side and end view of a cross-hole deburrer

A cross-hole countersink is a cone-shaped tool with a cutting edge provided by a hole that goes through the side of the cone. The intersection of the hole and cone form the cutting edge on the tool. The cone is not truly symmetrical as it is essential that the cone retreats away from the cutting edge as the tool rotates. If this does not occur the cutting edge will lack clearance and rub rather than bite into the material. This clearance is referred to as cutting relief.

These tools are best used as deburring tools, where the burr from a previous machining operation needs to be removed for cosmetic and safety reasons, however they may be used in softer materials (such as wood or plastic) to create a countersunk hole for a screw.

FLUTED COUNTERSINK CUTTER

Side and end view of a 4 fluted countersink

The fluted countersink cutter is used to provide a heavy chamfer in the entrance to a drilled hole. This may be required to allow the correct seating for a countersunk-head screw or to provide the lead in for a second machining operation such as tapping. Countersink cutters are manufactured with six common angles, which are 60°, 82°, 90°, 100°, 110°, or 120°, with the two most common of those being 82° and 90°. Countersunk-head screws that follow the Unified Thread Standard very often have an 82° angle, and screws that follow the ISO standard very often have a 90° angle. Throughout the aerospace industry, countersunk fasteners typically have an angle of 100°. The ideal countersink angle for holes tapped with 60° threads, when no countersunk fastener head will sit in the countersunk area, is often 60°; but often another angle is used if that is the cutter that is at hand, and the difference usually doesn't matter.

BACK COUNTERSINK

A back countersink, also known as an inserted countersink, is a two piece countersink used on tough to reach areas. One component is a rod that is inserted into the existing hole in the workpieces; the other component is the cutter, which is attached to the rod after it is in position.[1]

SPEEDS, FEEDS, AND AVOIDING CHATTER

It can often be difficult to avoid chatter when cutting with countersink cutters. As usual in machining, the shorter and more rigid the setup, the better. Better-quality fluted countersink cutters sometimes have the flutes (or at least one flute) at an irregular pitching. This variation in pitching reduces the chance of the cutting edges setting up a harmonic action and leaving an undulated surface. This surface ripple is also dependent on the surface speed of the cutting edges, material type, and applied pressure (or feed rate); once started it is hard to remove. Too light a feed tends to increase chatter risk. As in many other machining operations, an appropriate response to the chatter may be to decrease speed and increase feed.

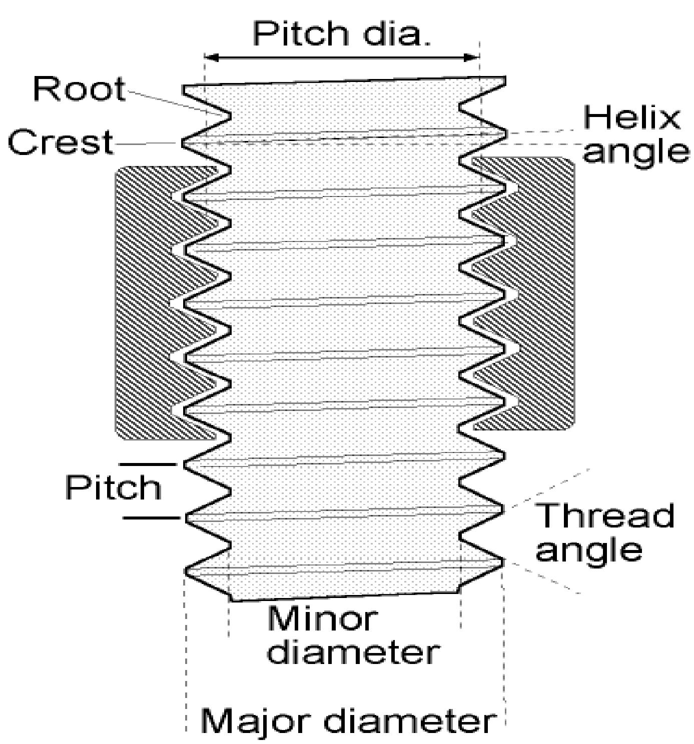
FORM COUNTERSINKING

Form countersinking, also known as dimpling, is a countersink that is formed into sheet metal to increase the strength of a structure as the countersinks of multiple pieces nest together. There are two processes for producing formed countersinks: coin dimpling and modified radius dimpling.[2]

8.2 - IDENTIFY TYPES AND APPLICATIONS OF SCREW THREADS

8.2.1 - SCREW THREAD

- A thread is a continuous helical ridge formed on the inside (nut) or outside (screw) of a cylinder.
- This ridge is called the **crest**.
- Between each crest is a space, called the **root**.
- Threads are set at an angle to the axis of the bolt or nut. This slope is called the **helix angle**.
- The angle must be sloped, either upward to the right (for right-hand threaded screws) or upward to the left (for left-hand threaded screws).
- The thread forms a "V" shape between crests. The angle of this "V" is called the **thread angle.**
- **Thread pitch** is the distance from the crest of one thread to another crest measured along the length of the thread. Pitch is best measured using a thread pitch gauge.
- The **pitch diameter** is the diameter of the thread at a point where the width across the thread and the width across the groove between threads, are equal.
- The **major diameter** is the outer diameter at the top of the thread crests.
- The **minor diameter** is the inner diameter of thread roots.



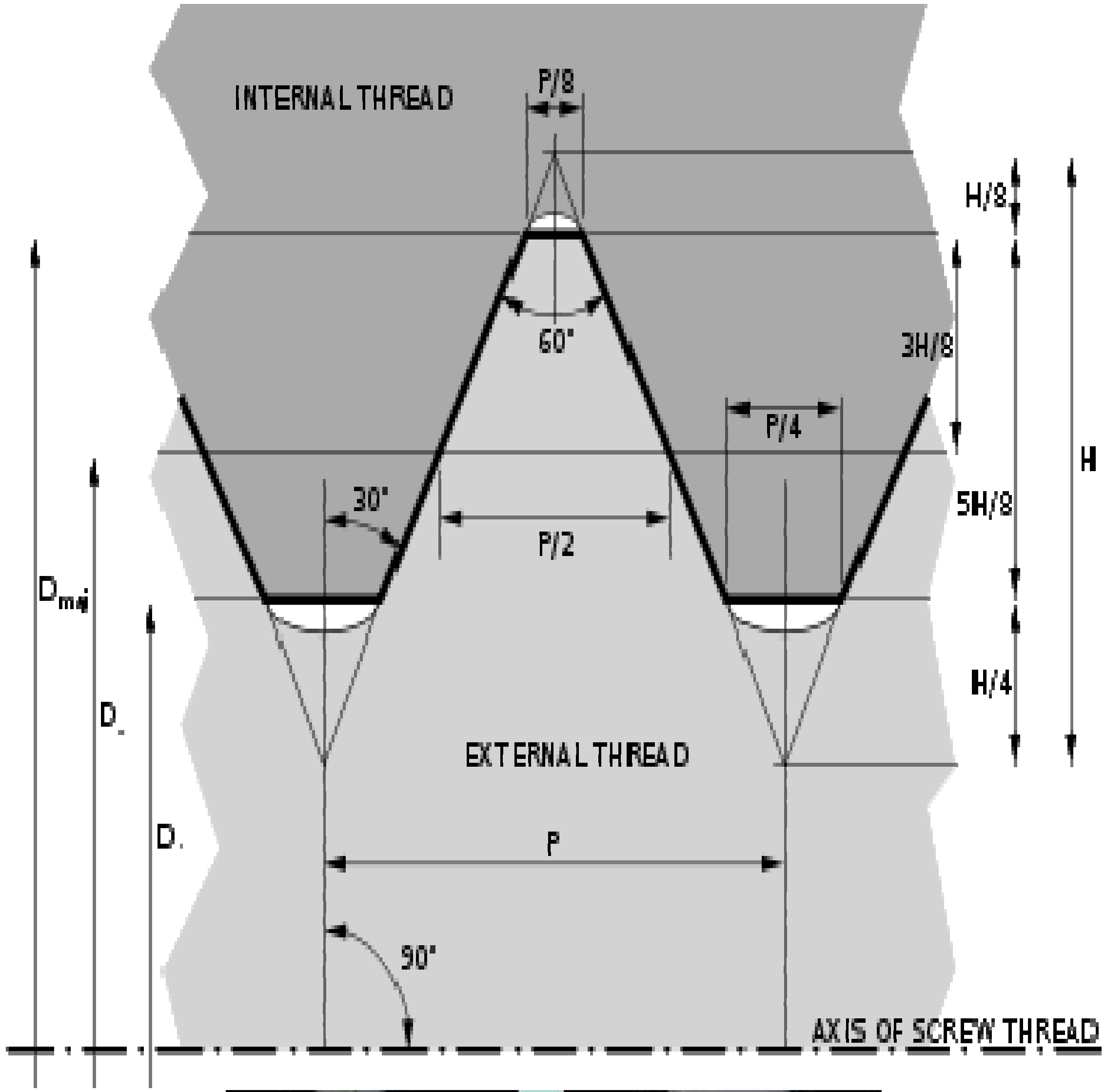
GENDER

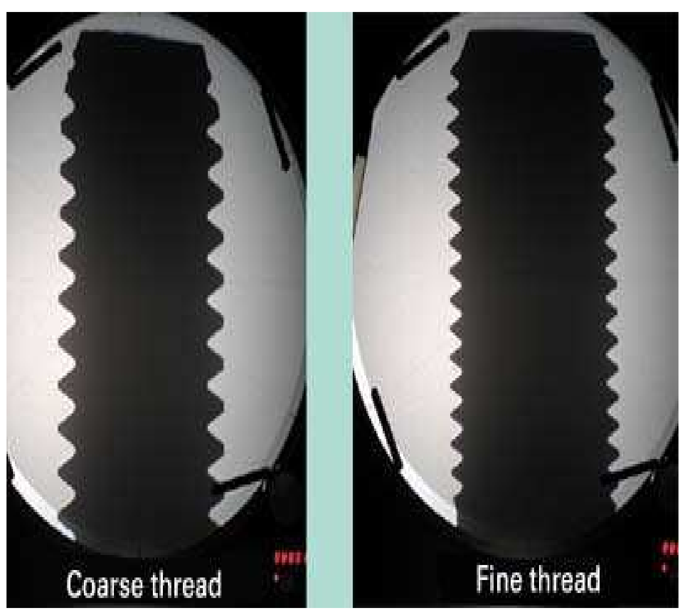
- Every matched pair of threads, *external* and *internal*, can be described as *male* and *female*. For example, a screw has male threads, while its matching hole (whether in nut or substrate) has female threads. This property is called *gender*.
- For external threads (bolts), a right-hand thread slopes up to the right, but the internal right-hand thread slopes up to the left.
- For external left-hand threads, the threads slope up to the left, while the internal left-hand threads slope up to the right.
- The right-hand screw tightens clockwise (to the right).
- The left-hand screw tightens counter-clockwise (to the left).
- It is also common to use "M" before the bolt size, such as M6 for a 6mm bolt.
- The wrench size for the head of the bolt or nut is not used to determine the size of the thread. For example, the common socket head cap screw in a 6mm x 1mm thread uses a 5mm hex wrench, yet the thread is not called a 5mm.

8.2.2 - TYPES OF SCREW THREADS

ISO METRIC SCREW THREADS

- The ISO metric screw threads are the world-wide most commonly used type of general purpose screw thread. They were one of the first international standards agreed when the International Organization for Standardization was set up in 1947.
- ISO metric threads consist of a symmetric V-shaped thread. In the plane of the thread axis, the flanks of the V have an angle of 60° to each other. The outermost 1/8 and the innermost 1/4 of the height *H* of the V-shape are cut off from the profile. Each thread is characterized by its major diameter *D* and its pitch *P*.
- In an external (male) thread (e.g., on a bolt), the major diameter D_{maj} and the minor diameter D_{min} define *maximum* dimensions of the thread. This means that the external thread must end flat at D_{maj}, but can be rounded out below the minor diameter D_{min}. Conversely, in an internal (female) thread (e.g., in a nut), the major and minor diameters are *minimum* dimensions; therefore the thread profile must end flat at D_{min} but may be rounded out beyond D_{maj}.
- There are three kinds of ISO metric threads:
  - Iso metric Coarse Thread
  - Iso Metric Fine Thread
  - Iso metric Extra Fine Thread


INTERNAL THREAD
P/8
H/8
60°
3H/8
P/4
H
30°
P/2
5H/8
Dmaj
H/4
D
EXTERNAL THREAD
D
P
90°
AXIS OF SCREW THREAD


Coarse thread
Fine thread

BRITISH STANDARD SCREW THREADS

a) BSW SCREW THREADS

- The British Standard Whitworth (BSW) thread is used in many types of engineering throughout the world, although its use is now being superseded by Iso Metric system.
- BSW threads also consist of a V-shaped thread. In the plane of the thread axis, the flanks of the V have an angle of 55° to each other.
- 1/6 of the outermost and innermost of the height h of the V-shape is cut off from the profile
- the threads are rounded equally at crests and roots by circular arcs ending tangentially with the flanks
- Following formulae are used for calculation:

Pitch (p) in inch= 1/tpi, where tpi is threads per inch

Basic Radius (r) = 0.1373 p

Basic depth of thread (h) = 0.64 p

b) BSF SCREW THREADS

- The British Standard Fine (BSF) screw thread has the same shape and thread angle as the BSW, but has a finer thread pitch and smaller thread depth. This is more like the modern "mechanical" screw and was used for fine machinery and for steel bolts.
- Many motorcar and motorcycle manufacturers commonly used a lot of BSF threads.
- The calculation formulae will remain same as for BSW screw threads. i.e

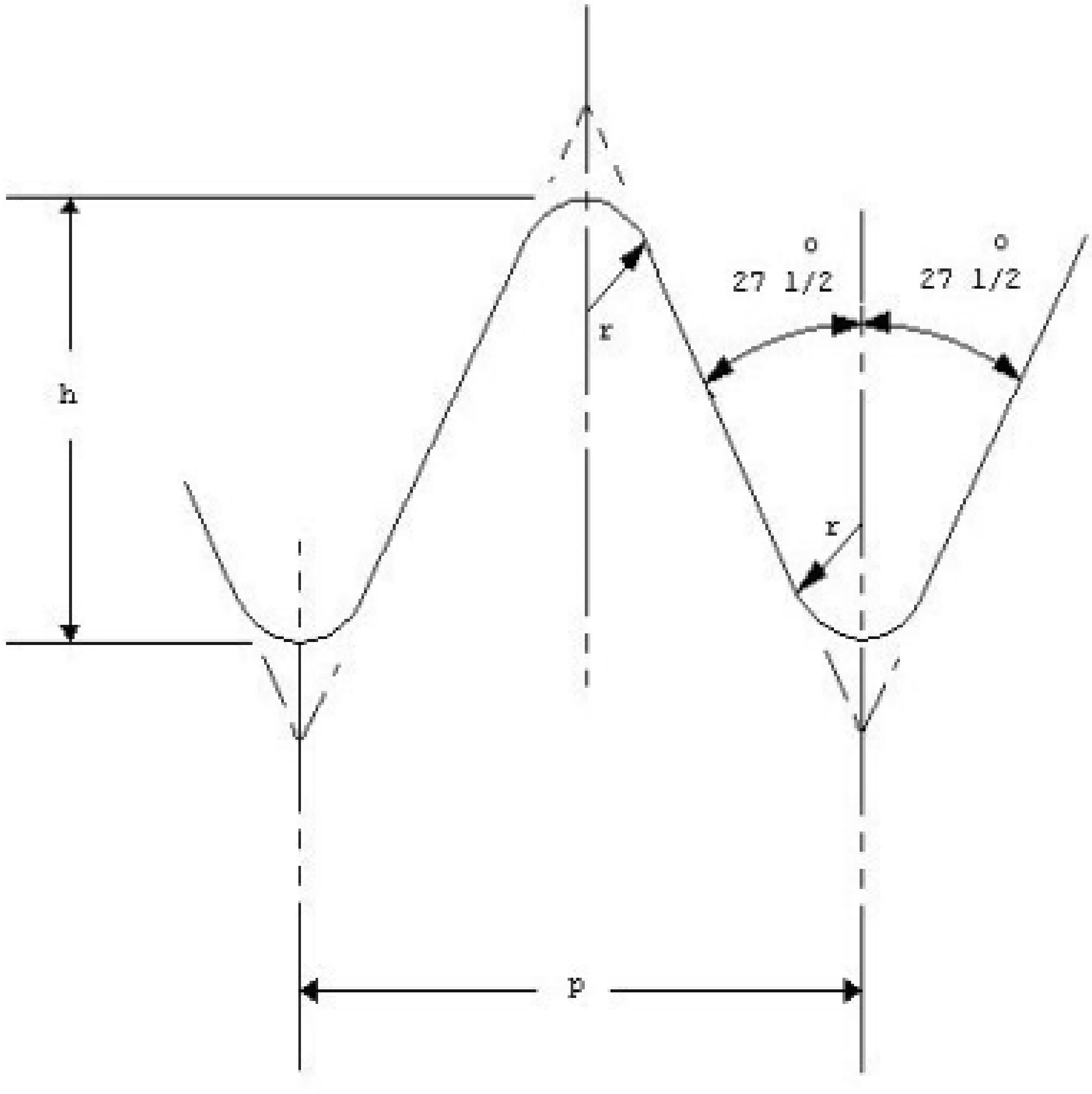
Pitch (p) in inch= 1/tpi, where tpi is threads per inch

Basic Radius (r) = 0.1373 p

Basic depth of thread (h) = 0.64 p

c) BSP SCREW THREADS

- This thread needs a gasket or seal to be gas/liquid tight.
- It was widely used for interconnecting and sealing pipe ends.
- These threads are normally right-hand. For left-hand threads, the letters "LH" are appended.
- The calculation formulae will remain same as for BSW and BSF screw threads.

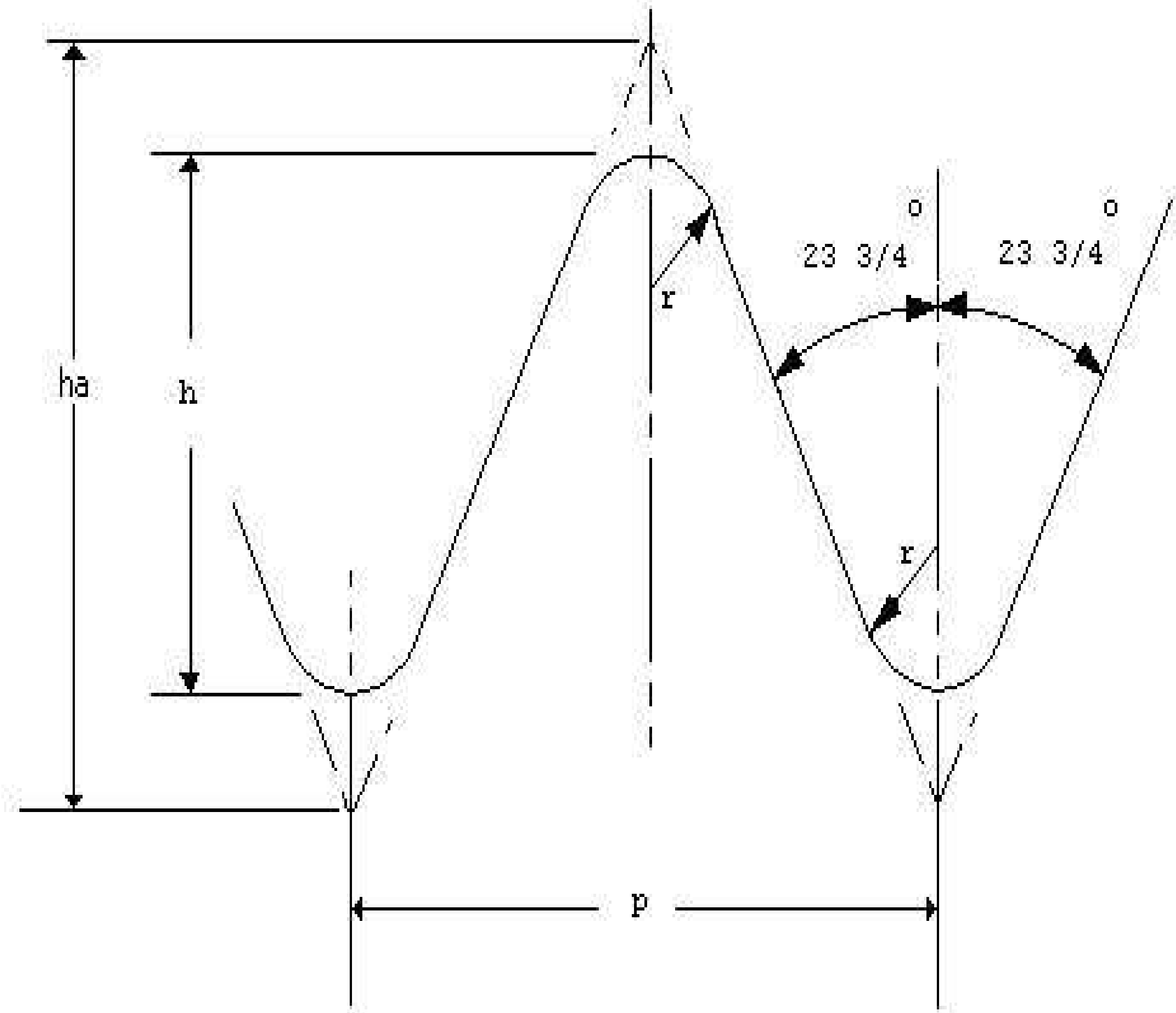


BA SCREW THREADS

- British Association or BA screw threads are a largely obsolete set of small screw threads. They were, and to some extent still are, used for miniature instruments and modeling. The British Standards Institution recommended the use of BA sizes in place of the smaller BSW and BSF screws (those below 1/4").
- BA threads also consist of a V-shaped thread. In the plane of the thread axis, the flanks of the V have an angle of 47.5° to each other.
- The calculation formulae for BA screw threads are as under:

Pitch (p) in inch= 1/tpi, where tpi is threads per inch
or p in mm= $(0.9)^n$, where n is designated number of screw
Basic Radius (r) = 0.1808 p

Basic depth of thread (h) = 0.6 p
Angular depth of thread (ha) = 1.13 p



UNIFIED THREADS STANDARD

- The Unified Thread Standard (UTS) defines a standard thread form and series along with allowances, tolerances, and designations for screw threads commonly used in the United States and Canada. It has the same 60° profile as the ISO metric screw thread used in the rest of the world, but the characteristic dimensions of each UTS thread (outer diameter and pitch) were chosen as an inch fraction rather than a round millimeter value. The UTS is currently controlled by ASME/ANSI in the United States.
- UTS threads consist of a symmetric V-shaped thread. In the plane of the thread axis, the flanks of the V have an angle of 60° to each other. The outermost 0.125 and the innermost 0.25 of the height *H* of the V-shape are cut off from the profile.
- Like Iso metric screw threads, major and minor diameters in UTS also play an important role. In an external (male) thread (e.g., on a bolt), the major diameter D_{maj} and the minor diameter D_{min} define *maximum* dimensions of the thread. This means that the external thread must end flat at D_{maj}, but can be rounded out below the minor diameter D_{min}. Conversely, in an internal (female) thread (e.g., in a nut), the major and minor diameters are *minimum* dimensions; therefore the thread profile must end flat at D_{min} but may be rounded out beyond D_{maj}.

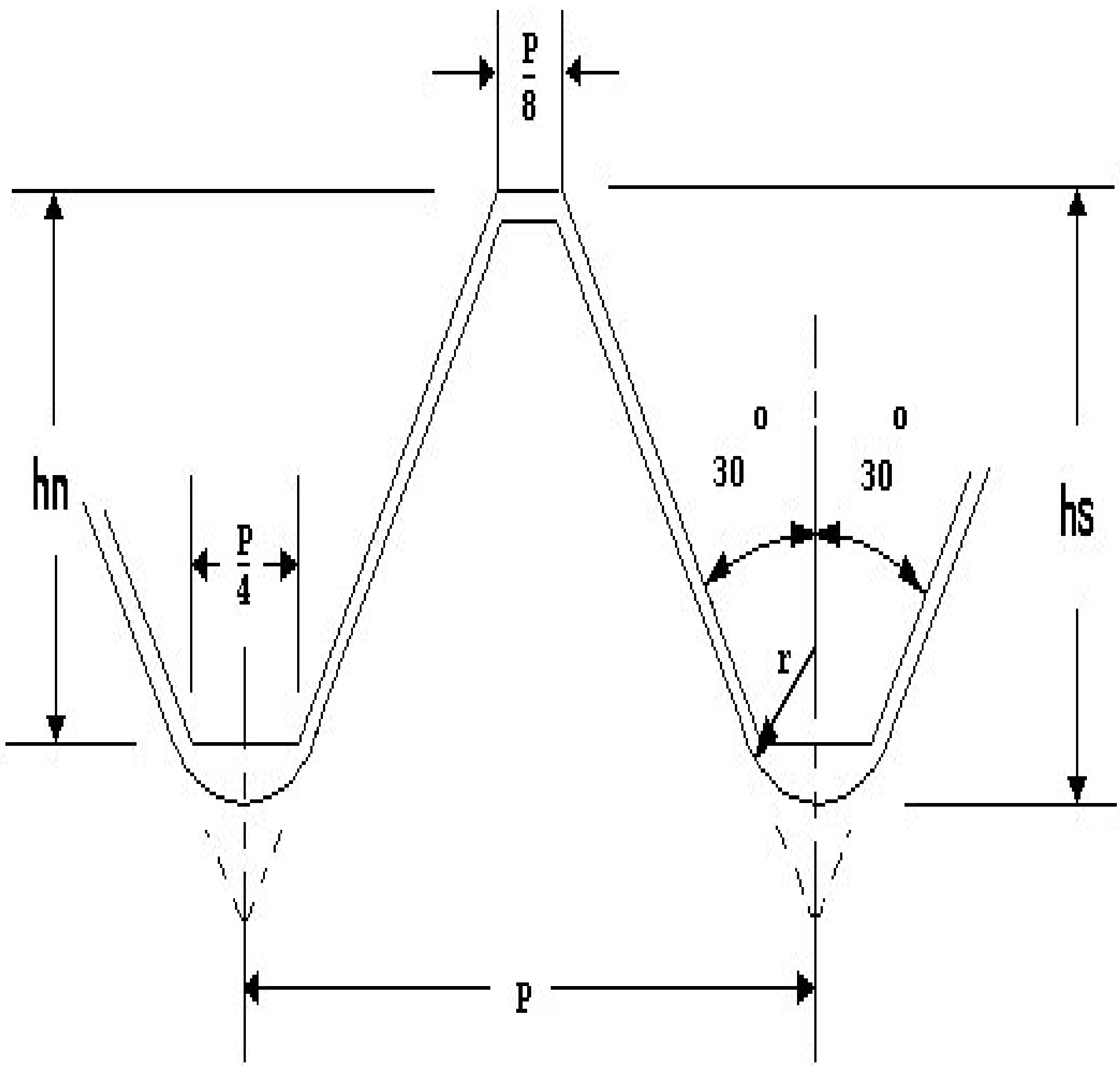
- The two types of UTS threads are:
    - Unified National Fine (UNF) Thread
    - Unified National Coarse (UNC) Thread
- The basic profile of both UNF and UNC is same. The calculation formulae for these threads are as under:

  Pitch (p) in inch= 1/tpi, where tpi is threads per inch

  Basic radius (r) = 0.1443 p

  Basic height of internal thread (hn) = 0.54 p

  Basic height of external thread (hs) = 0.61 p



ACME SCREW THREADS

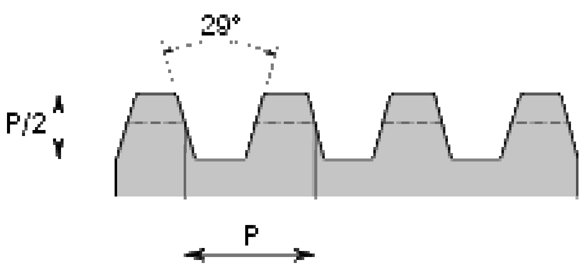
- The Acme thread form has a 29° thread angle with a thread height half of the pitch. The apex and valley are flat.
- The tooth shape has a wider base which means it is stronger (thus the screw can carry a greater load) than a similarly sized square thread.
- Long-length Acme threads are used for controlled movements on machine tools, testing machines, jacks, aircraft flaps, and conveyors.
- Short-length threads are used on valve stems, hose connectors, bonnets on pressure cylinders, steering mechanisms, and camera lens movement.
- The calculation formulae for these threads are as under:

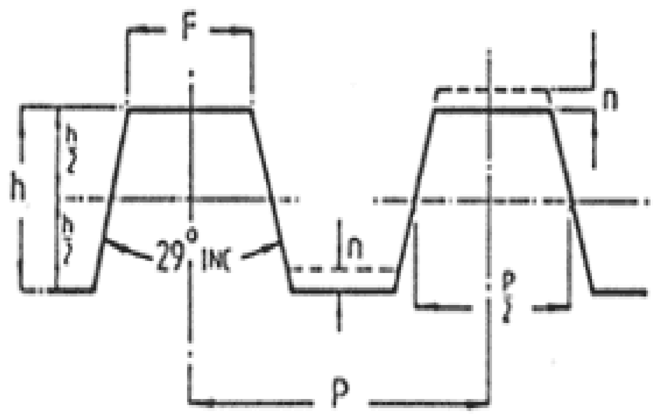
$h = 0.5\ p$

$F = 0.371\ p$

Nut clearance, $n = 0.005''$ (for 11 tpi and finer)

$n = 0.010''$ (for 10 tpi and coarser)





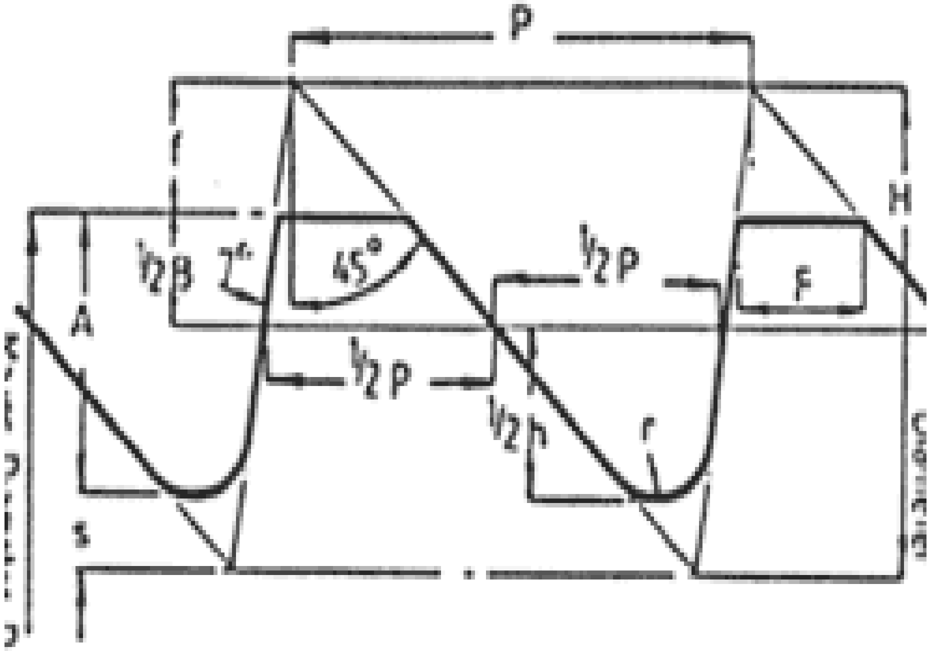
BUTTRESS SCREW THREADS

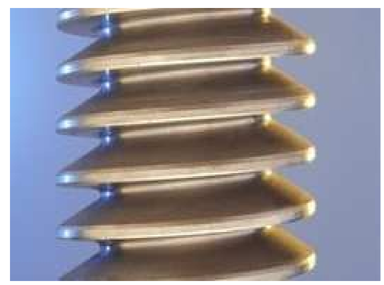
- The **buttress thread form** refers to two different thread profiles. One is a type of leadscrew and the other is a type of hydraulic sealing thread form. The leadscrew type is often used in machinery and the sealing type is often used in oil fields.
- The leadscrew type buttress thread form is designed to handle extremely high axial thrust in one direction. The load-bearing thread face is perpendicular to the screw axis or at a slight slant (usually no greater than 7°). The other face is slanted at 45°.
- This thread form also is easy to machine on a thread milling machine.
- The sealing type buttress thread is a pipe thread form designed to provide a tight hydraulic seal. The thread form is similar to that of Acme thread.

- The calculation formulae for these threads are as under:

H = 0.891 p	A = 0.506 p
B = 0.4 p	F = 0.275 p
f = 0.245 p	h = 0.611 p
s = 0.139 p	r = 0.12 p

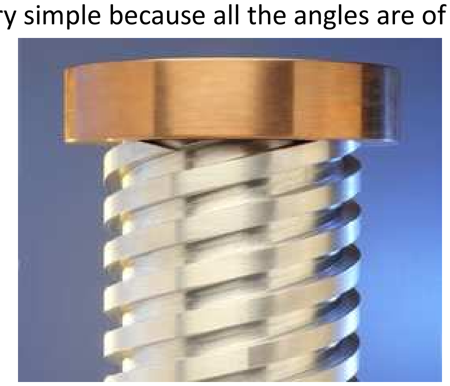
- Due to their asymmetrical shape buttress threads are suitable for resisting single direction axial loads.
- Buttress threads are often used as drive thread in hydraulic presses like spindle presses, in lifting systems and lifting tools or for chucks in turning and milling centres.

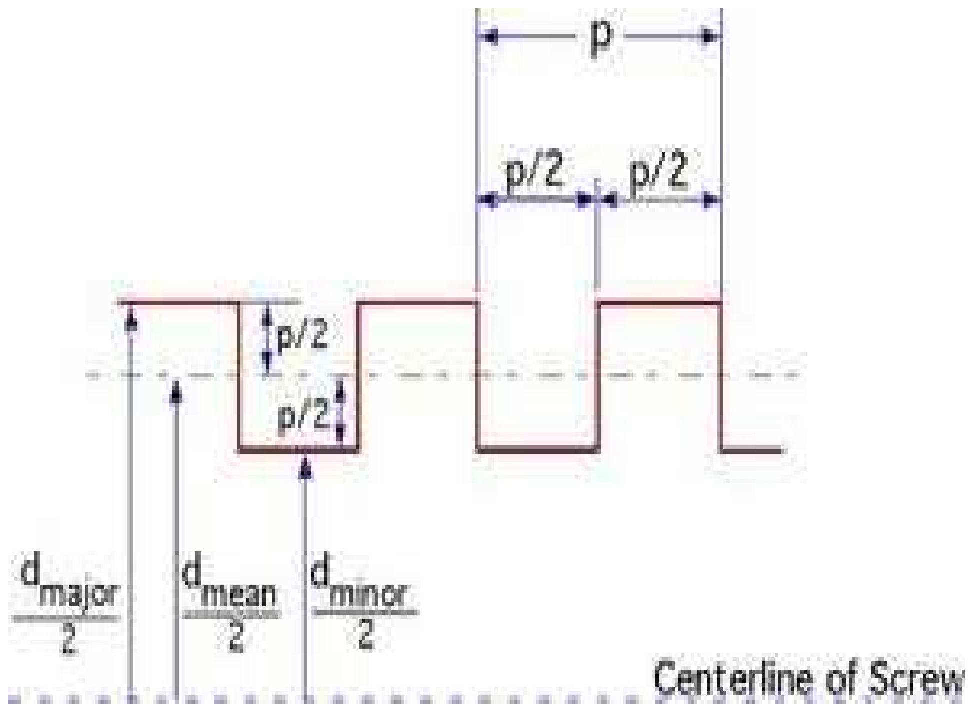




SQUARE SCREW THREADS

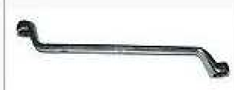
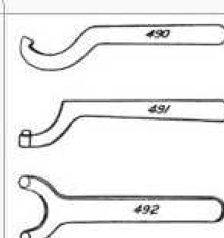
- The square thread is the most efficient conventional power screw form. It gets its name from the square cross-section of the thread. It is the most difficult form to machine.
- The crests are at 90° angles from the flanks.
- Due to the lack of a thread angle there is no radial pressure, or bursting pressure on the nut. This also increases the nut life.
- Square threads or flat threads are used for high load transmissions, avoiding additional radial loads.
- The calculation for square thread is very simple because all the angles are of 90^0.

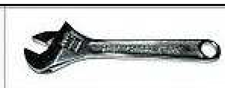
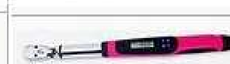
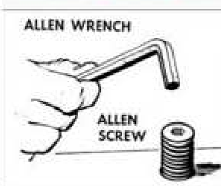



p
p/2
p/2
p/2
p/2
$\frac{d_{major}}{2}$
$\frac{d_{mean}}{2}$
$\frac{d_{minor}}{2}$
Centerline of Screw

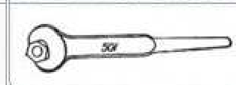
	Fastening & Joining	**Module No.**	8.03
		Prepared by	Hammad Mateen
Course	Certificate in Engineering Skills	**Duration**	60 - Mins
Teaching Aid			
Topic	Identify types and applications of spanners		

8.3 - IDENTIFY TYPES AND APPLICATIONS OF SPANNERS

British name	Description	
ring spanner	A one-piece wrench with an enclosed opening that grips the faces of the bolt or nut. The recess is generally a six-point or twelve-point opening for use with nuts or bolt heads with a hexagonal shape. The twelve-point fits onto the fastening at twice as many angles, an advantage where swing is limited. Eight-point wrenches are also made for square-shaped nuts and bolt heads. Ring spanners are often double-ended and usually with offset handles to improve access to the nut or bolt.	
box spanner / tube spanner	A tube with six-sided sockets on both ends. It is turned with a short length of rod (tommy bar or T bar) inserted through two holes in the middle of the tube.	
combination spanner	A double-ended tool with one end being like an open-end wrench or open-ended spanner, and the other end being like a box-end wrench or ring spanner. Both ends generally fit the same size of bolt.	
open-ended spanner	A one-piece wrench with a U-shaped opening that grips two opposite faces of the bolt or nut. This wrench is often double-ended, with a different-sized opening at each end. The ends are generally oriented at an angle of around 15 degrees to the longitudinal axis of the handle. This allows a greater range of movement in enclosed spaces by flipping the wrench over.	
crow's-foot spanner	A wrench that is used for gripping the nuts on the ends of tubes. It is similar to a box-end wrench but, instead of encircling the nut completely, it has a narrow opening just wide enough to allow the wrench to fit over the tube, and thick jaws to increase the contact area with the nut. This allows for maximum contact on plumbing nuts, which are typically softer metals and therefore more prone to damage from open-ended wrenches.	
ratcheting ring spanner	A type of ring spanner, or box wrench, whose end section ratchets. Ratcheting can be reversed by flipping over the wrench, or by activating a reversing lever on the wrench. This type of wrench combines compact design of a box wrench, with the utility and quickness of use of a ratchet wrench. A variety of ratcheting mechanisms are used, from simple pawls to more complex captured rollers, with the latter being more compact, smoother, but also more expensive to manufacture.	
?	Similar in concept to a socket wrench. A Saltus wrench features a socket permanently affixed to a handle. Sockets are not interchangeable as with a socket wrench. The socket often rotates around the handle to allow the user to access a fastener from a variety of angles. Commonly a Saltus wrench is part of a double-ended wrench, with an open-end type head on the opposite side from the socket head.	
pin spanner / C spanner / hook spanner	A wrench with one or several pins or hooks, designed to drive spanner head screws, threaded collars and retainer rings, shafts, and so on. Note the difference in the American and British senses of the word "spanner".	
slogging spanner flogging spanner	This is a specialized thick, short, stocky wrench with a block end to the handle specifically designed for use with a hammer, enabling one to impart great force. Used commonly with large fasteners, especially a nut and stud which both have index marks: the nut is screwed hand-tight, then further tightened with the striking wrench a known number of index marks calculated from the elasticity of the bolt or stud, thus giving precise torque (preload). Striking wrenches also provide shock and high force used to release large and/or stuck nuts and bolts; and when space does not allow room for a large wrench.	

adjustable spanner shifting spanner	A type of wrench with a movable jaw that adapts the tool to different sized objects.	
shifter	The most common type of adjustable wrench in use today. The adjustable end wrench differs from the monkey wrench in that the gripping faces of the jaws are displaced to a (typically) 15 degree angle relative to the tool's handle, a design feature that facilitates the wrench's use in close quarters. The modern adjustable end wrench was first developed by Johansson (with Bahco)[3] or by the Crescent Tool and Horseshoe Company, and is often referred to as a "Crescent wrench", regardless of the actual manufacturer.	
gas grips	An old type of adjustable end wrench with a straight handle and smooth jaws whose gripping faces are perpendicular to the handle.	
Stillson wrench or Stillsons	A tool that is similar in design and appearance to a monkey wrench, but with self-tightening properties and hardened, serrated jaws that securely grip soft iron pipe and pipe fittings. Sometimes known by the original patent holder's brand name as a *Stillson wrench*.	
socket wrench	A hollow cylinder that fits over one end of a nut or bolt head. It may include a handle, if it does not then it is often just referred to as a socket and is usually used with various drive tools to make it a wrench or spanner such as a ratchet handle, a tee bar (sliding tommy bar) bar or a knuckle bar (single axis pivot). It generally has a six-point, eight-point or twelve-point recess, may be shallow or deep, and may have a built-in universal joint. (The photo shows both ratchet and sockets.)	 
jointed nut spinner flex head nut spinner	This tool is a long non-ratcheting bar that allows the user to impart considerable torque to fasteners, especially in cases where corrosion has resulted in a difficult-to-loosen part.	
?	A type of socket designed to fit some of the same drive handles as the regular socket but non-cylindrical in shape. The ends are the same as those found on the open-end, box-end, or the flare-nut wrenches. These sockets use for use where space restrictions preclude the use of a regular socket. Their principal use is with torque wrenches.	
ratchet handle	It contains a one-way mechanism which allows the socket to be turned without removing it from the nut or bolt simply by cycling the handle backward and forward. (The photo shows both ratchet and sockets.)	
speed handle crank handle speed brace	A crank-shaped handle that drives a socket. The socket-driving analog of the brace used to drive a drill bit. Used instead of a ratchet in a few contexts when it can save substantial time and effort—that is, when there is a lot of turning to be done (many fasteners), ample room to swing the handle, ample access to the fastener heads, etc. Used occasionally in automotive repair or job shop work.	
torque wrench	A socket wrench drive tool that is employed to impart a precise amount of torque to a fastener, essential in many cases during the assembly of precision mechanisms.	
torque wrench	A socket wrench drive tool that is employed to impart a precise amount of torque to a fastener, essential in many cases during the assembly of precision mechanisms.	
Allen key	A wrench used to turn screw or bolt heads designed with a hexagonal socket (recess) to receive the wrench. The wrenches come in two common forms: L-shaped and T-handles. The L-shaped wrenches are formed from hexagonal wire stock, while the T-handles are the same hex wire stock with a metal or plastic handle attached to the end. There are also indexable-driver-bits that can be used in indexable screwdrivers.	
?	Another wrench designed for internal socket-head screws and bolts. The cross-section resembles a square-toothed gear. Not a common design, it is chiefly used on small set screws.	
Torx key	An internal socket-head screw design. The cross-section resembles a star. Commonly used in automobiles, automated equipment, and computer components as it is resistant to wrench cam-out and so suitable for use in the types of powered tools used in production-line assembly.	
?	A broad type of wrenches that use electricity or compressed air to power the wrench.	

Rattle gun	A compressed air (pneumatic) powered wrench commonly used in car garages and workshops to tighten and remove wheel nuts. Includes a mechanism to provide repeating pulsed force, good for loosening stuck fasteners and also for overcoming stiction when tightening, to assure consistent tightness.	
?	A formerly common type of wrench that was popular with mechanics, factory workers, and farmers for maintenance, repair and operations tasks in the days when fasteners often had square rather than hex heads. The wrench's shape suggests the open mouth of an alligator.	
cone spanner	A special thin open-end wrench used to fit narrow wrench flats of adjustable bearings, typically on a hub of a bicycle wheel. Called a "cone" wrench as it fits wrench flats of traditional "cup and cone" bearings, but also used with some other adjustable hub bearings. The wrench is very thin so has little strength; to compensate, cone wrenches typically have a large head. Most bicycle front hubs use a 13 mm; most rears use 15 mm.	
?	A double-handled wrench for turning the dies used in threading operations (cutting the male threads such as on a bolt).	
?	A small, square-head socket wrench used on drum tuning lugs and fasteners.	
?	A tool commonly used to open bungs on large 55-gallon drums.	
?	The hose connection has a threaded collar with a protruding pin. From the handle of the wrench an arc has at its end a loop to engage the pin.	
?	This is a pentagonal (five-sided) box wrench. Avoiding a hex shape for the lug makes the valve tamper-resistant: with the opposite faces nonparallel, unauthorized opening of the hydrant is less likely, because the would-be opener lacks a suitable tool. See also "curb key" on this page.	
?	This is a wrench for opening and closing valves on municipal water pipes (often at the curb, hence the name). It can be similar to a fire hydrant key, because both may have the pentagon drive for tamper resistance.	
?	A T-handle wrench with two pins and clearance for the spike—allows removal and insertion of spikes in shoes.	
?	A flat wrench with a circular hole and two inward protruding pins to engage slots in the nut. This type of nut is used on bicycles to secure the front fork pivot bearing to the headpiece of the frame.	
wheel brace	A socket wrench used to turn lug nuts on automobile wheels.	
Oil filter wrench or chain wrench	A type of wrench for removing cylindrical oil filters. It may be either a strap-type wrench or a socket.	
Multigrips or multigrip pliers	A tool to screw (rotate with force) various pipes during plumbing.	

rigger-jigger	A spanner used in attaching riggers to rowing boats with offset to allow users fingers to keep grip when flush with boat. 10 mm at one end, 13 mm at the other.	
?	A self-tightening wrench mounted at the end of a torque tube with a transverse handle at the opposite end. Used to tighten tubing connections to washstand valves in ceramic sinks—the nuts are often located deep in recesses. The self-tightening head may be flipped over to loosen connections.	
nipple wrench or spoke key	A wrench with a clearance slot for a wire wheel spoke such as a bicycle wheel and a drive head for the adjustment nipple nut. The handle is offset to make the wrench more convenient to grip, and the handle is short to fit between spokes, allowing the wrench to turn 360 degrees without being removed.	
podging spanner podger	A steel erecting tool which consists of a normal wrench at one end and a spike at the other, used for lining up bolt holes (typically when mating two pipe flanges).	
	A self-tightening wrench that engages the teeth of a chain drive sprocket, and used typically to remove thread-on sprockets. Similar to a strap wrench, but uses positive engagement rather than friction, and so needs to grab only one end of the chain.	
strap wrench chain wrench	A self-tightening wrench with either a chain or strap of metal, leather, or rubber attached to a handle, used to grip and turn smooth cylindrical objects (such as automotive oil filters). It relies entirely on friction between the strap or chain and the object to be manipulated. Similar to a pipe wrench, but uses a chain similar to a drive chain or strap, instead of an adjustable jaw. The links of the chain have extended pegs which fit into grooves in the front of the handle, with one end of the chain attached permanently to the handle. This is used in situations where pipe wrenches can't maintain a proper grip on an object such as a wet or oily pipe. Larger versions of chain wrenches are sometimes known as "bull tongs" and are used with large diameter pipe such as is used deep wells.	
tap wrench	A double-handled wrench for turning the square drive on taps used in threading operations (cutting the female threads such as within a nut) or a precision reamer.	
?	A spanner of small to moderate size constructed similarly to an open ended wrench, but with a thinner cross section. Its purpose is to apply torque to the fasteners found on the valve trains of older engines, especially automobile engines, where the valve train required adjustment of the tappets (also known as lifters). Tappets, push rods, rocker arms and similar adjustable pieces are often equipped with locknuts which are thinner than standard nuts, due to space limitations. Frequently, the hex section of the adjustment is contiguous to the lock nut, thus requiring a thinner "tappet wrench" to be used.	
?	A socket wrench used to tune some stringed musical instruments.	
	A tool specifically for use with wing nuts, allowing the application of greater torque than is possible by hand. It is generally advised not to use such spanners for tightening the wing nut, but rather only for loosening. It is a "hand saver" more than anything else.	
?	An adjustable wrench with a small number (usually 2–4) of discrete sizes. This is sometimes used as an inexpensive substitute for a monkey wrench.	

	Fastening & Joining	Module No.	8.04
		Prepared by	M.Ramzan
Course	Certificate in Engineering Skills	Duration	30 - Mins
Teaching Aid			
Topic	Identify riveted and bolt joints		

8.4 - IDENTIFY RIVETED AND BOLT JOINTS

8.4.1 - JOINTS

LAP JOINT

SINGLE & DOUBLE COVER PLATE BUTT JOINT.

RIVET: A **rivet** is a semi permanent mechanical fastener.

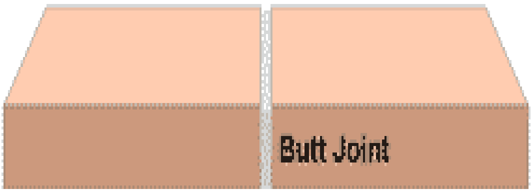
Before being installed, a rivet consists of a smooth cylindrical shaft with a head on one end. The end opposite the head is called the *buck-tail*

BOLT: A bolt is a temporary (usually) metal fastener, consisting of a cylindrical body that is threaded, with a larger head on one end. It can be inserted into an unthreaded hole up to the head, tighten with a nut on the other end.

8.4.2 - BUTT JOINT

A **butt joint** is a joinery technique in which two members are joined by simply butting them together.

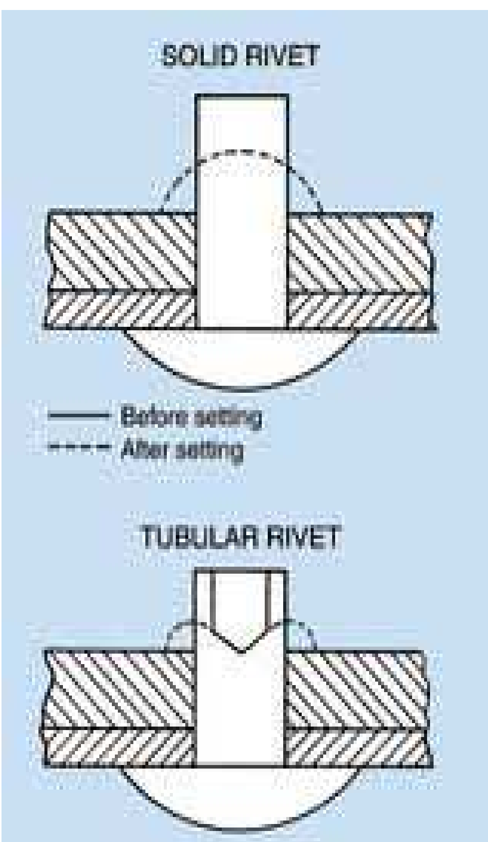
This type of joint is only applicable with welding but sometimes mechanical fastener may use.(special cases)

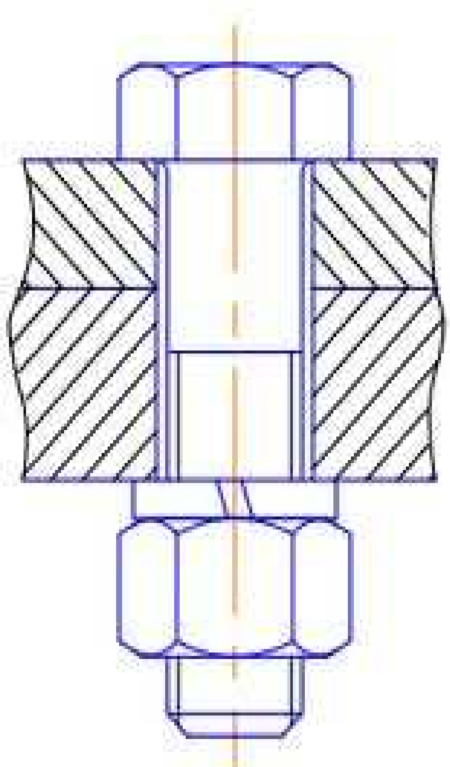


8.4.3 - LAP JOINT

A joint made between the surfaces of two partially overlapping objects.

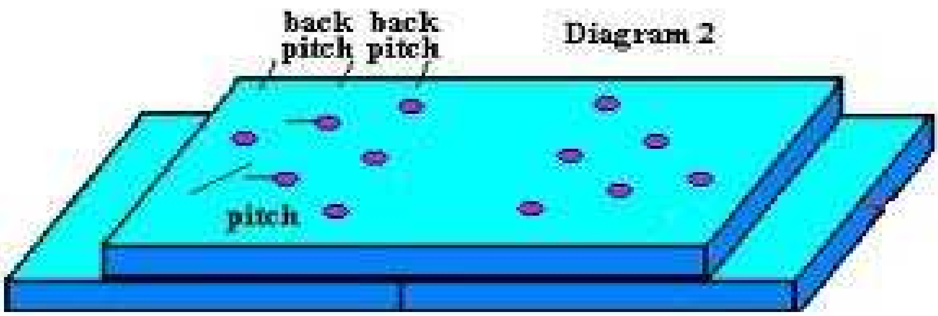
This type of joint is applicable for both riveted and bolted joints.





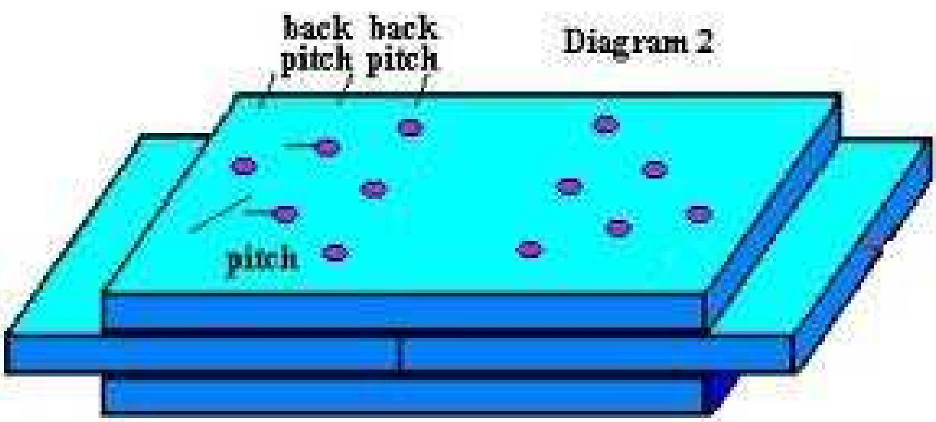
SINGLE LAP JOINT (single cover plate butt joint)

In this type of joint two plates are placed together as butt joint position and a cover plate placed on the plates then rivets or bolts are applied to fasten the plates.



DOUBLE LAP JOINT (double cover plate butt joint)

Same as above process the cover plates are placed on both sides of the job we need to join.

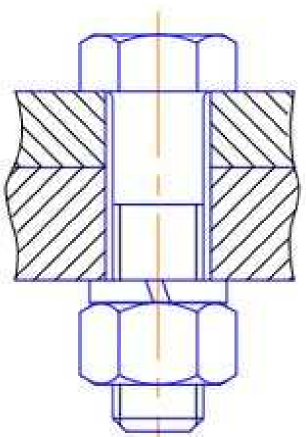


8.5 - IDENTIFY DEFECTS IN RIVETED AND BOLT JOINTS

8.5.1 - DEFECTS IN BOLTED JOINT

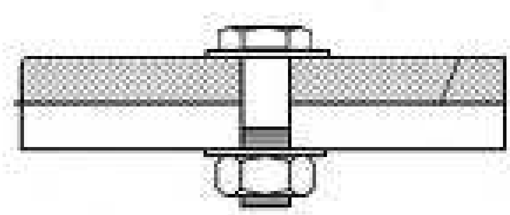
LACK OF FLAT OR TAPER WASHER

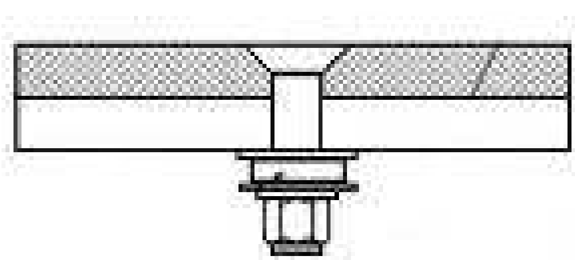
Washer should be use while fastening / assembling the job with bolts so that it prevents surface from damage.



INCORRECT BOLT/THREAD LENGTH

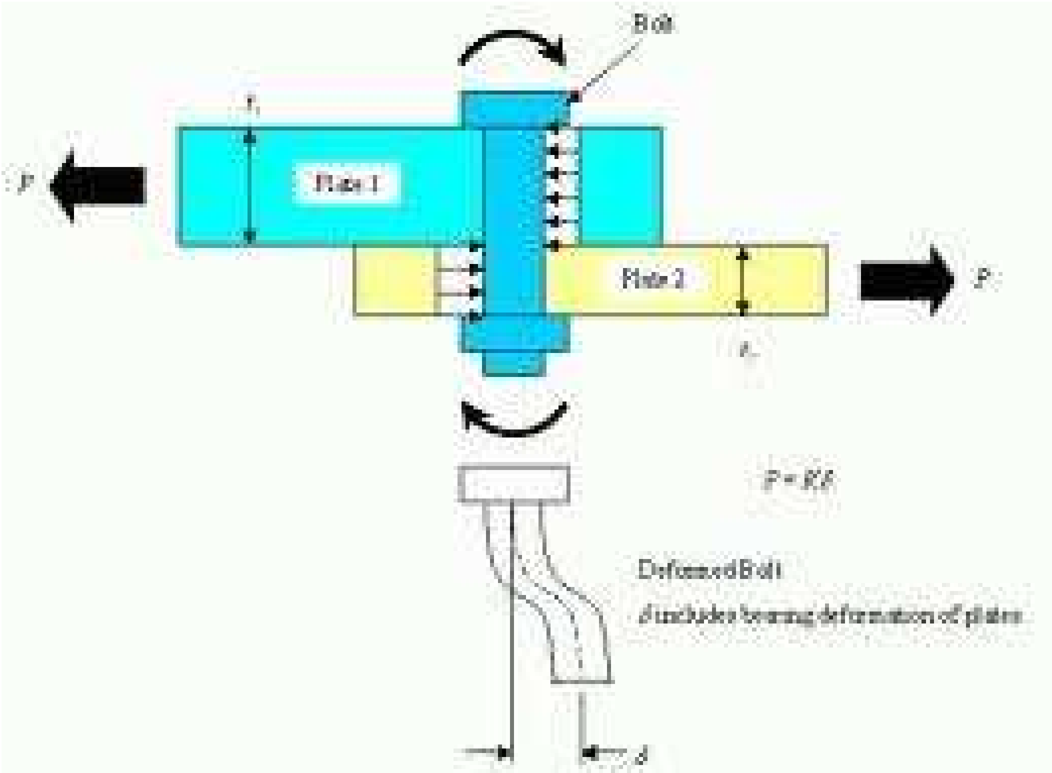
Always use correct length of bolts, the bolt length should not be more than two to five threads over the nut after tightening and the threaded length of the bolt should be as long as it should be at least three threads inside the hole.





HOLE DIAMETER TOO LARGE

The hole produced to use the bolt should be as per bolt diameter, the clearance between hole and bolt diameter should be as much as it can cover the offset location of holes on two or more objects. The larger clearance can damage the bolt upon application of load.



8.5.2 - DEFECTS IN RIVETED JOINT

RIVET LENGTH SHORT OR EXCESSIVE

Selection of correct length for rivet requires more attention so that the formation of buck-tail (apposite head) depends upon it.

The length of rivet is:

1.5 x diameter of rivet + pack thickness of sheet.

In case of short length the buck-tail will not formed properly and you cannot get the required strength or grip of the rivet

While due to larger length the buck-tail height will increased which can disturb other parts or may required more force to produce.

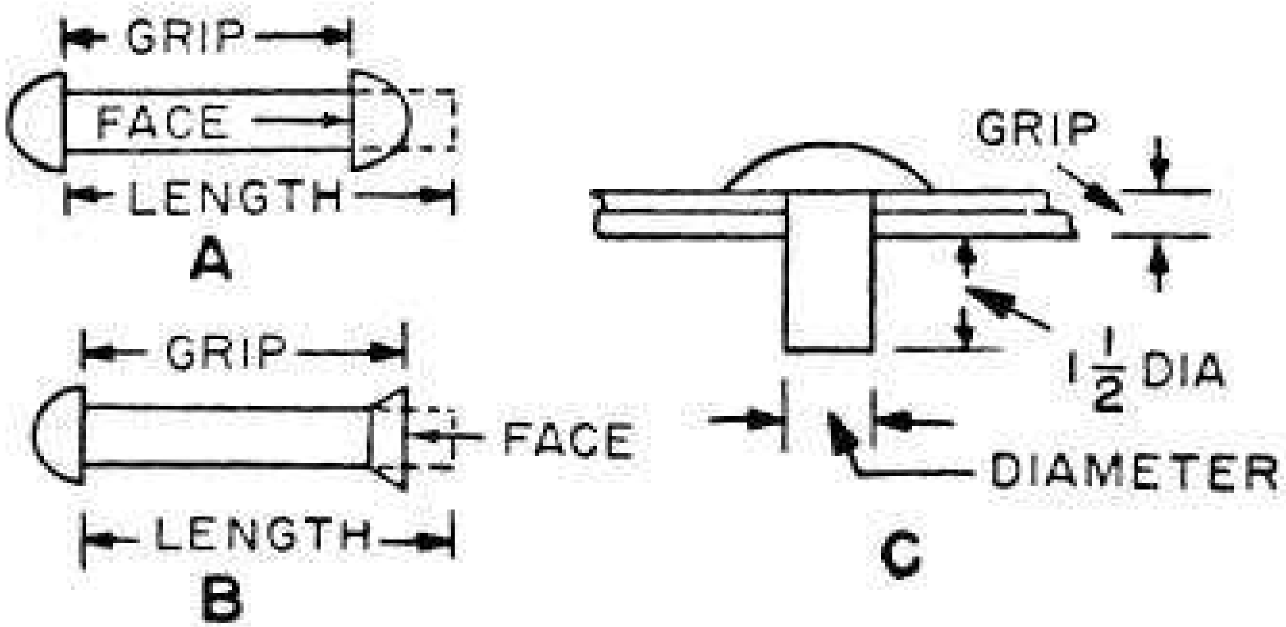
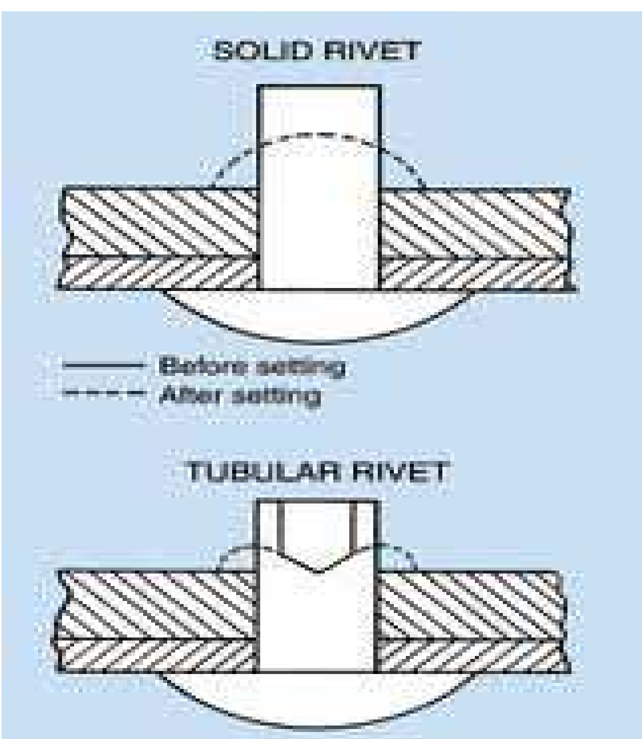
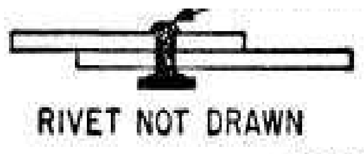


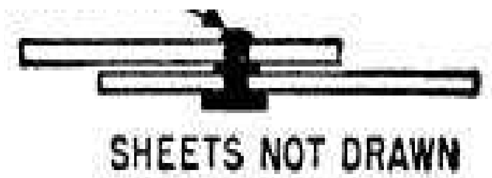
Figure 4-19.—Showing what is meant by "grip" of a rivet.





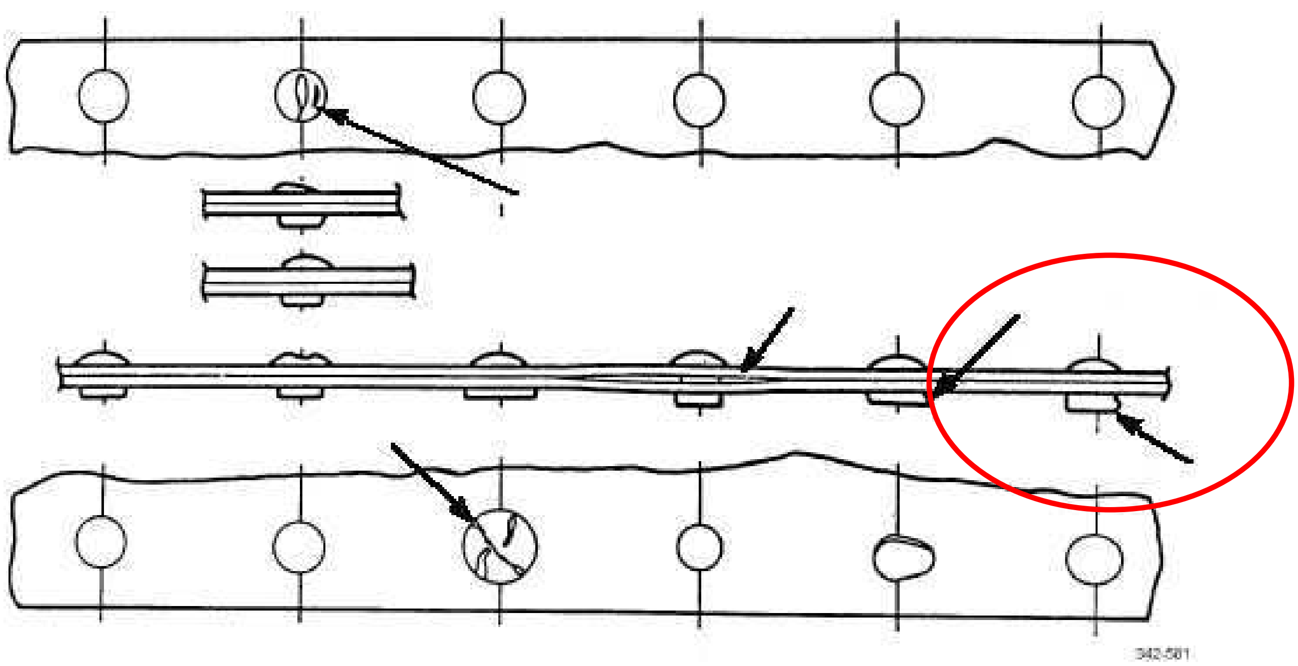
SHEETS NOT CLOSE TOGETHER

while riveting be sure that the sheet are closed together , if there is any gap between the sheets to be riveted it may disturb the assembly or rivet material may flow into the gap while producing buck-end.

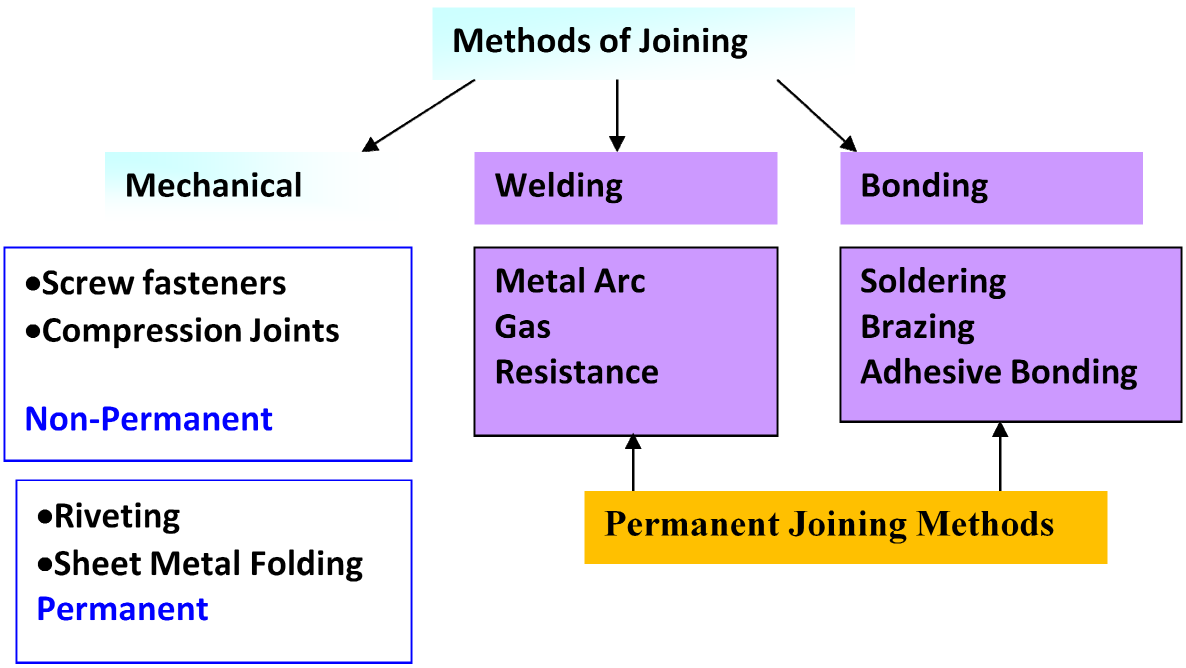


RIVET HEAD OFF CENTRE

While forging buck-tail be attentive that it should be at center otherwise required strength would not be achieved or spoil the good appearance of riveting.



8.6 - IDENTIFY SELF SECURED SHEET METAL JOINTS AND STATE APPLICATIONS



8.6.1 – APPLICATIONS

Fabricate, assemble, install, and repair sheet metal products and equipment, such as ducts, control boxes, drainpipes, and furnace casings. Work may involve any of the following: setting up and operating fabricating machines to cut, bend, and straighten sheet metal; shaping metal over anvils, blocks, or forms using hammer; operating soldering and welding equipment to join sheet metal parts; inspecting, assembling, and smoothing seams and joints of burred surfaces.

8.6.2 - SELF SECURED JOINTS

These joints, as a name implies, are formed by folding and interlocking thin sheet metal edges together in such a manner that they are made secure without the aid of any additional joining process. Their use is confined to fabricated articles made from thin sheet metal less than 1.6mm.

Self-secured joints Grooved is one of the most widely used methods for joining light- and medium-gauge sheet metal. It consists of two folded edges that are locked together with a HAND GROOVER.

THE GROOVED SEAM

This seam consists of two folded edges called “lock”. The two lock (one up and one down) are hooked together. They are finally locked together by use of a hand grooving tool by means of a grooving machine.

THE INTERNAL GROOVED SEAM

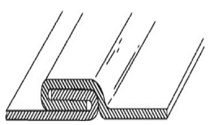
In reality this is countersunk grooved seam and it is made in a similar way to the normal grooved seam. The only difference is that where a grooving tool cannot be used inside the seam that interlocking edges are placed over a special grooving bar and the groove is sunk with the aid of a mallet or hammer.

THE DOUBLE GROOVED SEAM

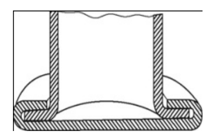
The double grooved seam makes use of a “Lock strip” to hold the folder edges together. The strip or cap combines strength with a pleasing appearance. The seam whilst the paned-down joint can be slipped a part unless it form the base of a cylindrical container or similar the assembled Knocked-up joint is secured such a way that it cannot be easily pulled a part.

There are basic four types of self secured joints in sheet metal.

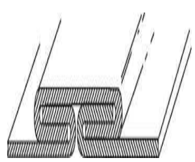
Grooved seam: -



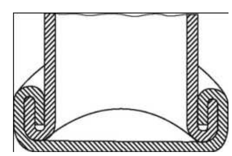
Paned down seam: -



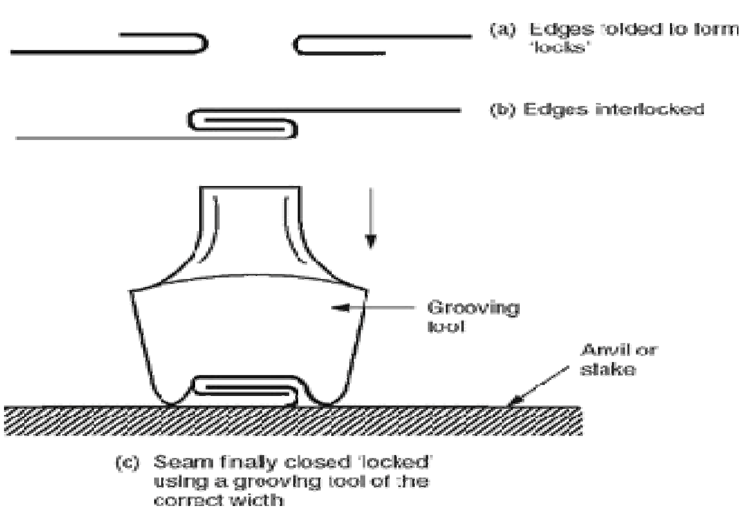
Double grooved seam: -



Knocked up seam: -



Making a grooved seam: -



8.6.3 - ALLOWANCES FOR SELF-SECURED JOINTS

A seam in which the edges of two metal sheets are bent approximately 180°, inserted in each other, flattened, and then locked by pressure.

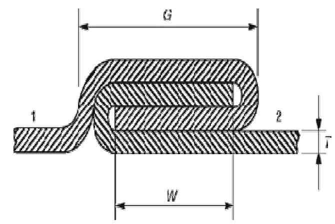
GROOVED SEAM

Total allowance= 3G- 4T shared:

(a) Equally between limbs 1 and 2; or

(b) Two-thirds limb 1 and one-third

limb 2 where joint centre position is critical



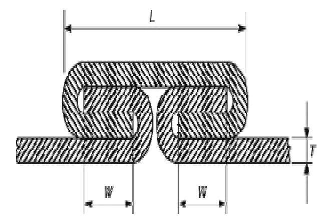
DOUBLE GROOVED SEAM

Add W-T to the edge of each

Blank to be joined.

Allowance for capping strip= 4W+4T,

Where L= 2W+ 4T

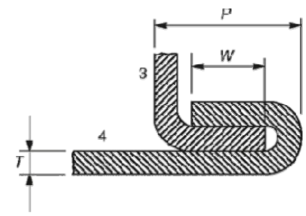


PANED DOWN SEAM

Add W to the single edge 3.

Add 2W+T to the double edge 4.

P=2W+2T.



KNOCKED UP SEAM

Add W to the single edge 5.

Add 2W+T to the double edge 6.

K=2W+3T.

W = width of lock (folded edge)

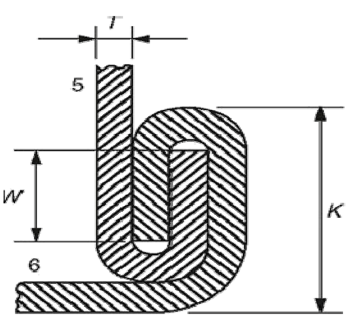
G = width of grooved seam

L = width locking strip

P = width of paned down seam

K = width of knocked up seam

T = thickness of metal

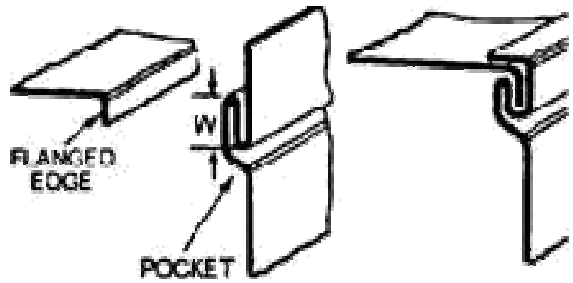


8.6.4 - PITTSBURGH LOCKS SEAM

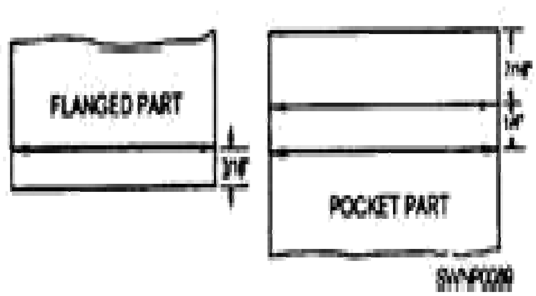
The PITTSBURGH LOCK SEAM is a comer lock seam. A cross section of the two pieces of metal to be joined and a cross section of the finished seam. This seam is used as a lengthwise seam at comers of square and rectangular pipes and elbows as well as fittings and ducts. This seam can be made in a brake but it has proved to be so universal in use that special forming machines have been designed and are available. It appears to be quite complicated, but like lap and grooved seams. It consists of only two pieces. The two parts are the flanged, or single, edge and the pocket that forms the lock the pocket is formed when the flanged edge is inserted into the pocket, and the extended edge is turned over the inserted edge to complete the lock.

The allowance for the pocket is W + W + 3/16 inch. W is the width or depth of the pocket. The width of the flanged edge must be less than W. For example, if you are laying out a 1/4-inch Pittsburgh leek seam. your total allowance should be 1/4 + 1/4 + 3/16 inch, or 11/16 inch for the edge on which you are laying out the pocket and 3/16 inch on the flanged edge

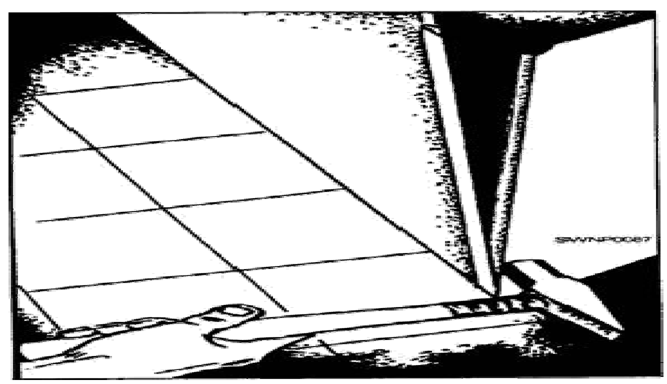
PITTSBURGH LOCKS SEAM:-



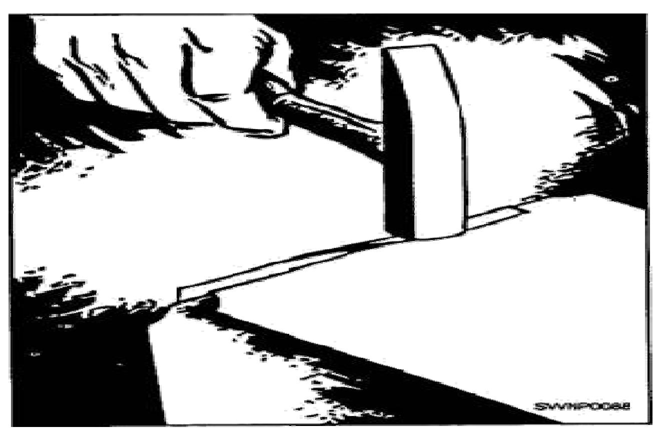
Layout of a 1/4-inch Pittsburgh lock seam: -



Assembly of a Pittsburgh lock seam: -



Closing a Pittsburgh lock seam: -



8.7 - IDENTIFY THE EQUIPMENT AND CONSUMABLES USED FOR SOFT SOLDERING

8.7.1 - SOLDERING

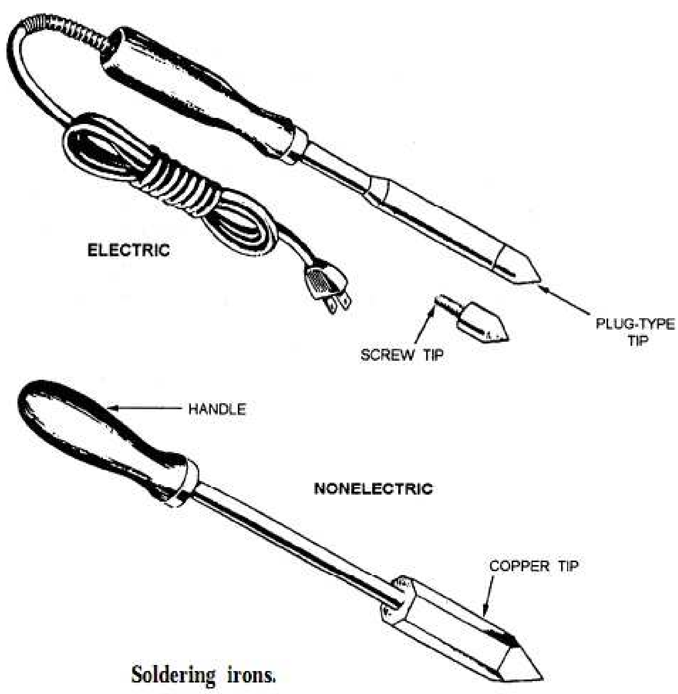
Soldering is a method of using a filler metal (commonly known as solder) for joining two metals without heating them to their melting points. Soldering is valuable to the Steelworker because it is a simple and fast means for joining sheet metal, making electrical connections, and sealing seams against leakage. Additionally, it is used to join iron, nickel, lead, tin, copper, zinc, aluminum, and many other alloys.

Soldering is not classified as a welding or brazing process, because the melting temperature of solder is below 800°F. Welding and brazing usually take place above 800°F. The one exception is lead welding that occurs at 621°F. Do not confuse the process of SILVER SOLDERING with soldering, for this process is actually a form of brazing, because the temperature used is above 800°F.

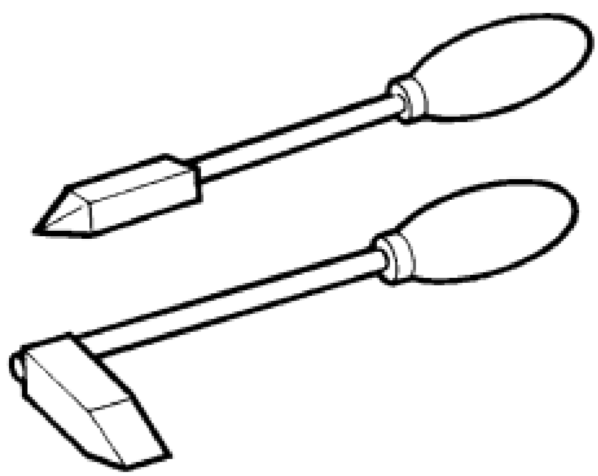
This chapter describes the following: equipment and materials required for soldering.

8.7.2 - EQUIPMENT

Soldering requires very little equipment. For most soldering jobs, you only need a heat source, a soldering copper or iron, solder, and flux.



Soldering irons.

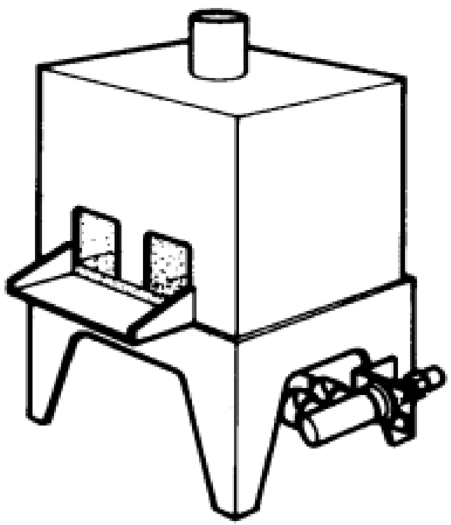


SOLDERING IRONS: Material - Copper bits, steel shafts and wooden handles.

Use - For applying solder to the joint. Obtainable in two styles, hatchet and straight. For best results heat in a soldering stove.

SOURCES OF HEAT

The sources of heat used for soldering vary according to the method used and the equipment available. Welding torches, blow-torches, forges, and furnaces are some of the sources of heat used. Normally, these heating devices are used to heat the soldering coppers that supply the heat to the metal surfaces and thus melt the solder. Sometimes, the heating devices are used to heat the metal directly. When this is done, you must be careful to prevent heat damage to the metal and the surrounding material.



SOLDERING STOVE (OVEN): Allows soldering irons of any style to be kept at working temperature without being burnt.

SOLDERING COPPERS

A soldering copper (usually called a soldering iron) consists of a forged copper head and an iron rod with a handle. (See fig.)

The handle, which may be wood or fiber, is either forced or screwed onto the rod.

Soldering heads are available in various shapes. Figure 1 shows three of the more commonly used types. The pointed copper is for general soldering work The stub copper is used for soldering flat seams that need a considerable amount of heat. The bottom copper is used for soldering seams that are hard to reach, such as those found in pails, pans, trays, and other similar objects.

Nonelectrical coppers are supplied in pairs. This is done so one copper can be used as the other is being heated. The size designation of coppers refers to the weight (in pounds) of TWO copperheads; thus a reference to a pair of 4-pound coppers means that each copper head weighs 2 pounds. Pairs of coppers are usually supplied in 1-pound, 1 1/2-pound, 3-pound, 4-pound, and 6-pound sizes. Heavy coppers are designed for soldering heavy gauge metals, and light coppers are for thinner metals. Using the incorrect size of copper usually results in either poorly soldered joints or overheating.

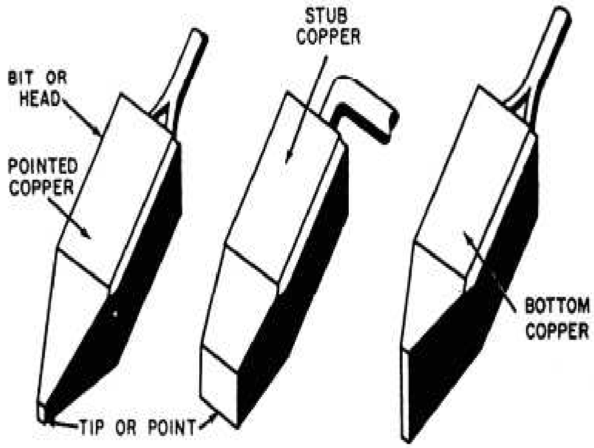
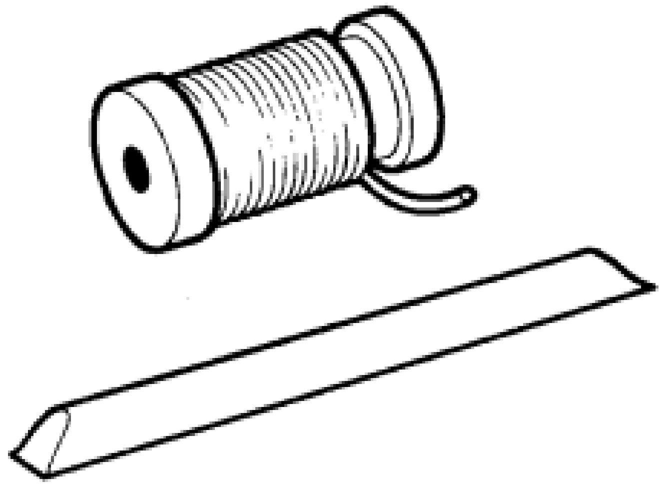


Figure 1 - Soldering copper heads.



SOFT SOLDER

Material - Alloy of tin. lead and antimony.

Tinmans solder = 62% tin, 38% lead.

Plumbers solder = 2 parts lead, 1 part tin.

Temperature = 183^{o}C - 240^{o}C

Use - A filler metal forming a joint between two or more metal surfaces.

NOTE - Some solders are pre-fluxed.

8.7.3 - FILING AND TINNING COPPERS

New soldering coppers must be tinned (coated with solder) before use. Also, coppers must be filed and retained after overheating or for any other reason that caused the loss of their solder coating. The procedure for filing and tinning a copper is as follows:

1. Heat the copper to a cherry red.

2. Clamp the copper in a vise, as shown in figure 2.

3. File the copper with a single-cut bastard file. Bear down on the forward stroke, and release pressure on the return stroke. Do not rock the file. Continue filing the tapered sides of the copper until they are bright and smooth.

CAUTION Remember that the copper is hot! Do not touch it with your bare hands.

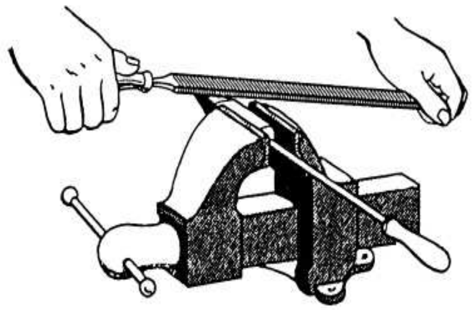


Figure 2 - Filling a soldering copper.

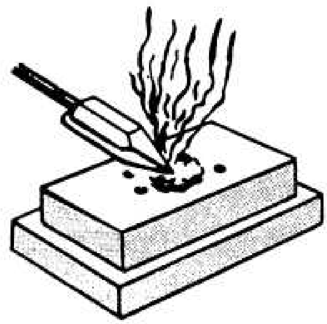


Figure 3 - Tinning a copper (solder placed on cake of sal ammoniac).

4. Smooth off the point of the copper and smooth off any sharp edges.

5. Reheat the copper until it is hot enough to melt the solder.

6. Rub each filed side of the copper back and forth across a cake of sal ammoniac, as shown in figure 3.

7. Apply solder to the copper until it is tinned. You may rub the solder directly onto the copper, or place it on the cake of sal ammoniac. Do not push the iron into the cake of sal ammoniac, because this can split the cake. When sal ammoniac is not available, use powdered rosin instead. In this instance, place the powdered rosin on top of a brick. Rub the copper back and forth to pick up the rosin and then place the solder directly onto the copper. (See fig. 4.)

Commercially prepared soldering salts are also used in tinning soldering coppers. These salts are available in powder form. Dissolve the powder in water according to the directions and dip the soldering copper into the solution and then apply the solder.

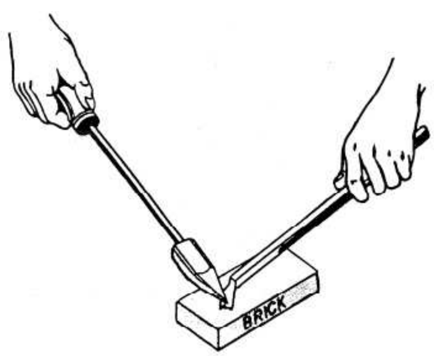


Figure 4 - Tinning a copper (solder placed directly on copper).

8.7.4 - FORGING SOLDERING COPPERS

Soldering coppers may be reshaped by forging when they become blunt or otherwise deformed. The procedure for forging a copper is as follows:

1. File the copper to remove all old tinning and to smooth the surfaces.

2. Heat the copper to a bright red.

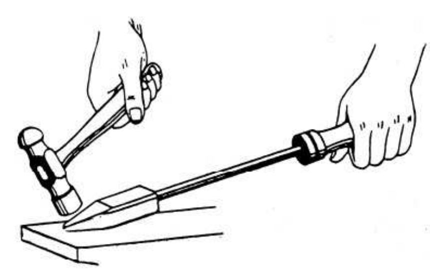


Figure 5 - Forging a soldering copper.

3. Hold the copper on an anvil and forge it to the required shape by striking it with a hammer. (See fig. 6-6.) As you reshape the copper, a hollow will appear at the point. Keep this hollow to a minimum by striking the end of the copper. Do not shape too long a taper or sharp point, because this causes the copper to cool too rapidly. Turn the copper often to produce the necessary squared-off sides and reheat the copper as often as necessary during this part of the forging.

4. Reheat the copper to a bright red, and use a flat-faced hammer to remove as many hollows as possible.

5. File and tin the copper using the previously described procedure.

8.7.5 - ELECTRIC SOLDERING COPPERS

Electric soldering coppers, or soldering irons, as they sometimes are called, are built with internal heating coils. The soldering heads are removable and interchangeable. Tinning is basically the same with the exception that the tip usually does not become cherry red. Forging or reshaping is not necessary, because the heads are easily replaced.

Electric soldering irons are usually used for electrical work or other small jobs. They are especially suited for this type of work, because they do not require auxiliary heating and they can be manufactured as small as a pencil.

8.7.6 - GAS TORCHES

Gas torches can be used in combination with soldering head attachments or as a direct heat source. The Presto-lite heating unit is ideal for soft soldering, because it delivers a small controllable flame. It also may be used effectively to heat soldering coppers. As figure 6 shows, this heating unit includes a fuel tank regulator, hose, and torch. It burns acetylene or MAPP gas as fuel in the presence of oxygen. The torch tip (stem) is interchangeable with other tips that come with the unit.

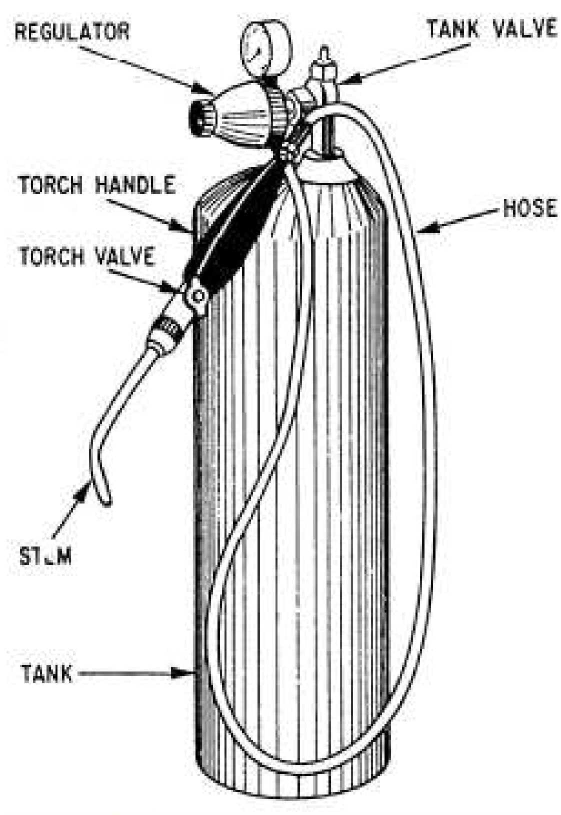


Figure 6 - Presto-lite heating unit.

8.7.7 - SOFT SOLDER

There are many different types of solder being used by industry. Solders are available in various forms that include bars, wires, ingots, and powders. Wire solders are available with or without a flux core. Because of the many types of solder available, this chapter only covers the solders most commonly used by Steelworkers.

TIN-LEAD SOLDER

The largest portion of all solders in use is solders of the tin-lead alloy group. They have good corrosion resistance and can be used for joining most metals. Their compatibility with soldering processes, cleaning, and most types of flux is excellent. In describing solders, it is the custom of industry to state the tin content first; for example, a 40/60 solder means to have 40% tin and 60% lead.

Tin-lead alloy melting characteristics depend upon the ratio of tin to lead. The higher the tin content, the lower the melting temperature. Tin also increases the wetting ability and lowers the cracking potential of the solder.

Solders with lower tin content are less expensive and primarily used for sheet metal products and other high-volume solder requirements. High tin solders are extensively used in electrical work. Solders with 60% tin or more are called fine solders and are used in instrument soldering where temperatures are critical.

TIN-ANTIMONY-LEAD SOLDER

Antimony is added to a tin-lead solder as a substitute for some of the tin. The antimony, up to 6%, increases the strength and mechanical properties of the solder. A word of caution, solders having high antimony content should not be used on aluminum, zinc, or zinc-coated materials. They form an intermetallic compound of zinc and antimony that causes the solder to become very brittle.

TIN-ZINC SOLDER

Several tin-zinc solders have come into use for the joining of aluminum alloys. The 91/9 and 60/40 tin-zinc solders are for higher temperature ranges (above 300°F), and the 80/20 and 70/30 tin-zinc alloys are normally used as precoating solders.

LEAD-SILVER SOLDER

Lead-silver solders are useful where strength at moderately high temperatures is required. The reason lead by itself cannot be used is that it does not normally wet steel, cast iron, or copper and its alloys. Adding silver to lead results in alloys that more readily wet steel and copper. Flow characteristics for straight lead-silver solders are rather poor, and these solders are susceptible to humidity and corrosion during storage. The wetting and flow characteristics can be enhanced as well as an increased resistance to corrosion by introducing a tin content of 1%.

Lead-silver solders require higher soldering temperatures and special fluxing techniques. The use of a zinc-chloride base flux or uncoated metals is recommended, because rosin fluxes decompose rapidly at high temperatures.

TIN-ANTIMONY SOLDER

Tin-antimony solders are used for refrigeration work or for joining copper to cast-iron joints. The most common one is the 95/5 solder.

TIN-SILVER SOLDER

Tin-silver solder (96/4) is used for food or beverage containers that must be cadmium and lead-free. It also can be used as a replacement for tin-antimony solder (95/5) for refrigeration work.

8.7.8 - FLUXES

Scale, rust, and oxides form on most metal surfaces when exposed to air, and heating accelerates this formation. Solder will not adhere to or wet the metal unless these pollutants are removed. Fluxes are chemical compounds used to clean and maintain the metal surfaces during the soldering process. They also decrease the surface tension of the solder, making it a better wetting agent. Fluxes are manufactured in cake, paste, liquid, or powder form and are classified as either noncorrosive or corrosive. Table shows the fluxes that are normally used for soldering common metals.

Metals	Fluxes
Brass, copper, tin	Rosin
Lead	Tallow, rosin
Iron, steel	Borax sal ammoniac
Stainless steel and other nickel alloys	Phosphenic acid
Galvanized iron	Zinc chloride
Zinc	Zinc chloride
Aluminum	Stearine, special flux

Fluxes Used for Soldering Some Common Metals

FLUXES: Material - Hydrochloric acid for zinc and galvanised iron. Tallow for lead plumbing work. Sal ammoniac in powder form for iron and copper. Resin (Fluxite) for electrical work.

Use - Prevents oxidation of the metal and allows the solder to flow.

FLUX: Borax and additives or Borax Cone and Plate.

Use - To prevent oxides forming on the surface of the clean metal. Reduces surface tension, lowers the melting point and helps the solder to flow through the joint.

NONCORROSIVE FLUXES

Noncorrosive fluxes are for soldering electrical connections and for other work that must be free of any trace of corrosive residue. Rosin is the most commonly used noncorrosive flux. In the solid state, rosin is inactive and noncorrosive. When heated, it melts and provides some fluxing action. Rosin is available in powder, paste, or liquid form.

Rosin fluxes frequently leave a brown residue. This residue is nonconductive and sometimes difficult to remove. The removal problem can be reduced by adding a small amount of turpentine to the rosin. Glycerine is added to the rosin to make the flux more effective.

CORROSIVE FLUXES

Corrosive fluxes have the most effective cleaning action, but any trace of corrosive flux that remains on the work can cause corrosion later. For this reason, corrosive fluxes are not used on electrical connections or other work where corrosion would cause a serious problem.

The most commonly used corrosive fluxes are sal ammoniac (ammonium chloride) and zinc chloride. These fluxes are frequently used in either solution or in paste form. The solvent, if present, evaporates as the work heats, leaving a layer of solid flux on the work. When the metal reaches the soldering temperature, this layer of flux melts, partially decomposes, and liberates hydrochloric acid. The hydrochloric acid dissolves the oxides from the work surfaces and the solder, making them ready for soldering.

Zinc chloride (sometimes called **CUT ACID** or **KILLED ACID**) can be made in the shop as long as safety precautions are followed. To prepare zinc chloride, pour a small amount of muriatic acid (the commercial form of hydrochloric acid) into a glass or acid-resistant container and then add small pieces of zinc. As you add the zinc, the acid boils and bubbles as a result of a chemical reaction that produces zinc chloride and hydrogen gas. Keep adding small pieces of zinc to the mixture until the liquid no longer boils and bubbles. At this point, the reaction is complete and you then dilute the liquid in the container with an equal amount of water. Make only enough as required and strain it before use. If any is leftover, store it in a tightly sealed glass container.

WARNING: When diluting the acid, you always add the acid to the water. Adding water to acid can result in an explosive reaction, resulting in serious injuries.

Specific precautions must be taken when preparing zinc chloride. Rubber gloves, a full-face visor, and an apron are required. The fumes given off by muriatic acid or by the mixture of muriatic acid and zinc are a health hazard as well as an explosive. Prepare zinc chloride under a ventilation hood, out in the open, or near openings to the outside to reduce inhalation of the fumes or the danger of explosion. It is essential that precautions be taken to prevent flames or sparks from coming in contact with the liberated hydrogen.

Another type of corrosive flux in use is known as **SOLDERING SALTS**. Commercially prepared soldering salts are normally manufactured in a powder form that is water soluble that allows you to mix only the amount needed.

After a corrosive flux has been used for soldering, you should remove as much of the flux residue as possible from the work. Most corrosive fluxes are water soluble; therefore, washing the work with soap and water and then rinsing thoroughly with clear water usually removes the corrosive residue. To lessen damage, you should ensure the work is cleaned immediately after the soldering.

8.8 – BASIC PRINCIPLES OF SOFT SOLDERING

Soldering is one of the oldest methods for bonding metal joints. The basic principles of soldering must be recognized in order to achieve strong and effective bonds, along with proper tools and solder type.

Soft soldering is a process for joining metals together using fairly low melting point filler metals which have the ability to flow into gaps between joint members by capillary action. In IS0 (International Organization for Standardization) standards, a soft solder is defined as

"A metallic filler material which is used to join metallic parts and which has a melting temperature (liquidus) lower than that of the parts to be joined and, usually, lower than 450°C and which wets the parent metals."

"Brazing", "hard soldering" and "silver soldering" are terms used for similar capillary joining processes taking place at higher temperatures with filler metals based on aluminium, copper, nickel, zinc and the precious metals. These processes are outside the scope of this handbook.

8.8.1 - HEAT AND TIME

The amount of heat, and the time for which it is applied, are the basic principles of soldering. Heat and time variables are dependent on the thermal properties and mass of the metal surfaces to be joined.

8.8.2 - WETTING

Wetting is the solvent reaction that occurs when melted solder meets and blends with the metal being soldered. Rosin flux is the chemical substance added to solder, which helps facilitate wetting.

8.8.3 - SOLDER FLOW

Solder is designed to flow when melted. Good solder flow is essential to joints, as the molten solder must penetrate gaps in metal and wire parts to form a strong joint. Flow is achieved by proper heat, time and technique.

8.8.4 - SURFACE CONDITION

All surfaces to be soldered must be free of oils, grease, dirt, debris and visible oxidation. Surfaces should be cleaned with a fast evaporating, nonflammable solvent when possible, or abraded with emery cloth.

8.8.5 - THERMAL MASS

Thermal mass is the metal's ability to transfer heat. The larger the mass, the more heat it will require to generate sufficient temperature to melt solder. Higher wattage soldering tools are required to work on surfaces with large thermal masses.

8.8.6 - TOOLS

Adjustable solder stations allow variable temperatures to the soldering iron. A selection of iron tips and solder is needed for work on different surface and thermal mass types. Small holding clamps and vices assist in holding parts together.

8.8.7 - SOLDERING TECHNIQUES

The two soldering methods most often used are soldering with coppers or torch soldering. The considerations that apply to these methods of soldering are as follows:

Clean all surfaces of oxides, dirt, grease, and other foreign matter.

Use the proper flux for the particular job. Some work requires the use of corrosive fluxes, while other work requires the use of noncorrosive fluxes. Remember, the melting point of the flux must be BELOW the melting point of the solder you are going to use.

Heat the surfaces just enough to melt the solder. Solder does not stick to unheated surfaces; however, you should be very careful not to overheat the solder, the soldering coppers, or the surfaces to be joined. Heating solder above the work temperature increases the rate of oxidation and changes the proportions of tin and lead.

After making a soldered joint, you should remove as much of the corrosive flux as possible.

8.9 - IDENTIFY THE EQUIPMENT AND CONSUMABLES USED FOR BRAZING

8.9.1 - BRAZING

Brazing is the process of joining metal by heating the base metal to a temperature above 800°F and adding a nonferrous filler metal that melts below the base metal. Brazing should not be confused with braze welding, even though these two terms are often interchanged. In brazing, the filler metal is drawn into the joint by capillary action and in braze welding it is distributed by tinning. Brazing is sometimes called hard soldering or silver soldering because the filler metals are either hard solders or silver-based alloys. Both processes require distinct joint designs.

ADVANTAGES AND DISADVANTAGES

Brazing has many advantages over other metal-joining techniques, such as welding. Since brazing does not melt the base metal of the joint, it allows much tighter control over tolerances and produces a clean joint without the need for secondary finishing. Additionally, dissimilar metals and non-metals (i.e. metalized ceramics) can be brazed. In general, brazing also produces less thermal distortion than welding due to the uniform heating of a brazed piece. Complex and multi-part assemblies can be brazed cost-effectively. Another advantage is that the brazing can be coated or clad for protective purposes. Finally, brazing is easily adapted to mass production and it is easy to automate because the individual process parameters are less sensitive to variation.

One of the main disadvantages is: the lack of joint strength as compared to a welded joint due to the softer filler metals used.[1][dubious – discuss] The strength of the brazed joint is likely to be less than that of the base metal(s) but greater than the filler metal.[citation needed] Another disadvantage is that brazed joints can be damaged under high service temperatures.[1] Brazed joints require a high degree of base-metal cleanliness when done in an industrial setting. Some brazing applications require the use of adequate fluxing agents to control cleanliness. The joint color is often different than that of the base metal, creating an aesthetic disadvantage.

8.9.2 - FILLER METALS

Some brazes come in the form of trefoils, laminated foils of a carrier metal clad with a layer of braze at each side. The center metal is often copper; its role is to act as a carrier for the alloy, to absorb mechanical stresses due to e.g. differential thermal expansion of dissimilar materials (e.g. a carbide tip and a steel holder), and to act as a diffusion barrier (e.g. to stop diffusion of aluminum from aluminum bronze to steel when brazing these two).

Braze families

Brazing alloys form several distinct groups; the alloys in the same group have similar properties and uses.

- **Pure metals**: Unalloyed. Often noble metals – silver, gold, palladium.
- **Ag-Cu**: Good melting properties. Silver enhances flow. Eutectic alloy used for furnace brazing. Copper-rich alloys prone to stress cracking by ammonia.
- **Ag-Zn**: Similar to Cu-Zn, used in jewelry due to high silver content to be compliant with hallmarking. Color matches silver. Resistant to ammonia-containing silver-cleaning fluids.
- **Cu-Zn** (brass): General purpose, used for joining steel and cast iron. Corrosion resistance usually inadequate for copper, silicon bronze, copper-nickel, and stainless steel. Reasonably ductile. High vapor pressure due to volatile zinc, unsuitable for furnace brazing. Copper-rich alloys prone to stress cracking by ammonia.
- **Ag-Cu-Zn**: Lower melting point than Ag-Cu for same Ag content. Combines advantages of Ag-Cu and Cu-Zn. At above 40% Zn the ductility and strength drop, so only lower-zinc alloys of this type are used. At above 25% zinc less ductile copper-zinc and silver-zinc phases appear. Copper content above 60% yields reduced strength and liquids above 900 °C. Silver content above 85% yields reduced strength, high liquids and high cost. Copper-rich alloys prone to stress cracking by ammonia. Silver-rich brazes (above 67.5% Ag) are hallmark able and used in jewellery; alloys with lower silver content are used for engineering purposes. Alloys with copper-zinc ratio of about 60:40 contain the same phases as brass and match its color; they are used for joining brass. Small amount of nickel improves strength and corrosion resistance and promotes wetting of carbides. Addition of manganese together with nickel increases fracture toughness. Addition of cadmium yields **Ag-Cu-Zn-Cd** alloys with improved fluidity and wetting and lower melting point; however cadmium is toxic. Addition of tin can play mostly the same role.
- **Cu-P**: Widely used for copper and copper alloys. Does not require flux for copper. Can be also used with silver, tungsten, and molybdenum. Copper-rich alloys prone to stress cracking by ammonia.
- **Ag-Cu-P**: Like Cu-P, with improved flow. Better for larger gaps. More ductile, better electrical conductivity. Copper-rich alloys prone to stress cracking by ammonia.
- **Au-Ag**: Noble metals. Used in jewelry.
- **Au-Cu**: Continuous series of solid solutions. Readily wet many metals, including refractory ones. Narrow melting ranges, good fluidity.[1] Frequently used in jewellery. Narrow melting range, excellent fluidity. Alloys with 40–90% of gold harden on cooling but stay ductile. Nickel improves ductility. Silver lowers melting point but worsens corrosion resistance; to maintain corrosion resistance gold has to be kept above 60%. High-temperature strength and corrosion resistance can be improved by further alloying, e.g. with chromium, palladium, manganese and molybdenum. Addition of vanadium allows wetting ceramics. Low vapor pressure.
- **Au-Ni**: Continuous series of solid solutions. Wider melting range than Au-Cu alloys but better corrosion resistance and improved wetting. Frequently alloyed with other metals to reduce proportion of gold while maintaining properties. Copper may be added to lower gold proportion, chromium to compensate for loss of corrosion resistance, and boron for improving wetting impaired by the chromium. Generally no more than 35% Ni is used, as higher Ni/Au ratios have too wide melting range. Low vapor pressure.

- **Au-Pd**: Improved corrosion resistance over Au-Cu and Au-Ni alloys. Used for joining superalloys and refractory metals for high-temperature applications, e.g. jet engines. Expensive. May be substituted for by cobalt-based brazes. Low vapor pressure.
- **Pd**: Good high-temperature performance, high corrosion resistance (less than gold), high strength (more than gold). usually alloyed with nickel, copper, or silver. Forms solid solutions with most metals, does not form brittle intermetallics. Low vapor pressure.
- **Ni**: Nickel alloys, even more numerous than silver alloys. High strength. Lower cost than silver alloys. Good high-temperature performance, good corrosion resistance in moderately aggressive environments. Often used for stainless steels and heat-resistant alloys. Embrittled with sulfur and some lower-melting point metals, e.g. zinc. Boron, phosphorus, silicon and carbon lower melting point and rapidly diffuse to base metals; this allows diffusion brazing and allows the joint to be used above the brazing temperature. Borides and phosphates form brittle phases; amorphous performs can be made by rapid solidification.
- **Co**: Cobalt alloys. Good high-temperature corrosion resistance, possible alternative to Au-Pd brazes. Low workability at low temperatures, preforms prepared by rapid solidification.
- **Al-Si**: for brazing aluminum.
- **Active alloys**: Containing active metals, e.g. titanium or vanadium. Used for brazing non-metallic materials, e.g. graphite or ceramics.

8.9.3 - ROLE OF ELEMENTS

- **Silver**: Enhances capillary flow, improves corrosion resistance of less-noble alloys, worsens corrosion resistance of gold and palladium. Relatively expensive. High vapor pressure, problematic in vacuum brazing. Wets copper. Does not wet nickel and iron. Reduces melting point of many alloys, including gold-copper.
- **Copper**: Good mechanical properties. Often used with silver. Dissolves and wets nickel. Somewhat dissolves and wets iron. Copper-rich alloys sensitive to stress cracking in presence of ammonia.
- **Zinc**: Lowers melting point. Often used with copper. Susceptible to corrosion. Improves wetting on ferrous metals and on nickel alloys. Compatible with aluminium. High vapor tension, produces somewhat toxic fumes, requires ventilation; highly volatile above 500 °C. At high temperatures may boil and create voids. Prone to selective leaching in some environments, which may cause joint failure. Traces of bismuth and beryllium together with tin or zinc in aluminium-based braze destabilize oxide film on aluminium, facilitating its wetting. High affinity to oxygen, promotes wetting of copper in air by reduction of the cuprous oxide surface film. Less

such benefit in furnace brazing with controlled atmosphere. Embrittles nickel. High levels of zinc may result in a brittle alloy.[17]

- **Aluminium**: Usual base for brazing aluminium and its alloys. Embrittles ferrous alloys.
- **Gold**: Excellent corrosion resistance. Very expensive. Wets most metals.
- **Palladium**: Excellent corrosion resistance, though less than gold. Higher mechanical strength than gold. Good high-temperature strength. Very expensive, though less than gold. Makes the joint less prone to fail due to intergranular penetration when brazing alloys of nickel, molybdenum, or tungsten.[18] Increases high-temperature strength of gold-based alloys.[16] Improves high-temperature strength and corrosion resistance of gold-copper alloys. Forms solid solutions with most engineering metals, does not form brittle intermetallics. High oxidation resistance at high temperatures, especially Pd-Ni alloys.
- **Cadmium**: Lowers melting point, improves fluidity. Toxic. Produces toxic fumes, requires ventilation. High affinity to oxygen, promotes wetting of copper in air by reduction of the cuprous oxide surface film. Less such benefit in furnace brazing with controlled atmosphere. Allows reducing silver content of Ag-Cu-Zn alloys. Replaced by tin in more modern alloys.
- **Lead**: Lowers melting point. Toxic. Produces toxic fumes, requires ventilation.
- **Tin**: Lowers melting point, improves fluidity. Broadens melting range. Can be used with copper, with which it forms bronze. Improves wetting of many difficult-to-wet metals, e.g. stainless steels and tungsten carbide. Traces of bismuth and beryllium together with tin or zinc in aluminium-based braze destabilize oxide film on aluminium, facilitating its wetting. Low solubility in zinc, which limits its content in zinc-bearing alloys.[17]
- **Bismuth**: Lowers melting point. May disrupt surface oxides. Traces of bismuth and beryllium together with tin or zinc in aluminium-based braze destabilize oxide film on aluminium, facilitating its wetting.[17]
- **Beryllium**: Traces of bismuth and beryllium together with tin or zinc in aluminium-based braze destabilize oxide film on aluminium, facilitating its wetting.[17]
- **Nickel**: Strong, corrosion-resistant. Impedes flow of the melt. Addition to gold-copper alloys improves ductility and resistance to creep at high temperatures.[16] Addition to silver allows wetting of silver-tungsten alloys and improves bond strength. Improves wetting of copper-based brazes. Improves ductility of gold-copper brazes. Improves mechanical properties and corrosion resistance of silver-copper-zinc brazes. Nickel content offsets brittleness induced by diffusion of aluminium when brazing aluminium-containing alloys, e.g. aluminium bronzes. In some alloys increases mechanical properties and corrosion resistance, by a combination of solid solution strengthening, grain refinement, and segregation on fillet surface and in grain boundaries, where it forms a corrosion-resistant layer. Extensive intersolubility with iron, chromium, manganese, and others; can severely erode such alloys. Embrittled by zinc, many other low melting point metals, and sulfur.[17]
- **Chromium**: Corrosion-resistant. Increases high-temperature corrosion and strength of gold-based alloys. Added to copper and nickel to increase corrosion resistance of them and their alloys.[16] Wets oxides, carbides, and graphite; frequently a major alloy component for high-temperature brazing of such materials. Impairs wetting by gold-nickel alloys, which can be compensated for by addition of boron.[17]
- **Manganese**: High vapor pressure, unsuitable for vacuum brazing. In gold-based alloys increases ductility. Increases corrosion resistance of copper and nickel alloys.[16] Improves high-temperature strength and corrosion resistance of gold-copper alloys. Higher manganese content may aggravate tendency to liquation. Manganese in some alloys may tend to cause porosity in fillets. Tends to react with graphite molds and jigs. Oxidizes easily, requires flux. Lowers melting point of high-copper brazes. Improves mechanical properties and corrosion resistance of silver-copper-zinc brazes. Cheap, even less expensive than zinc. Part of the Cu-Zn-Mn system is brittle, some ratios can not be used.[17] In some alloys increases mechanical properties and corrosion resistance, by a combination of solid solution strengthening, grain refinement, and segregation on fillet surface

and in grain boundaries, where it forms a corrosion-resistant layer. Facilitates wetting of cast iron due to its ability to dissolve carbon.

- **Molybdenum**: Increases high-temperature corrosion and strength of gold-based alloys.[16] Increased ductility of gold-based alloys, promotes their wetting of refractory materials, namely carbides and graphite. When present in alloys being joined, may destabilize the surface oxide layer (by oxidizing and then volatilizing) and facilitate wetting.
- **Cobalt**: Good high-temperature properties and corrosion resistance. In nuclear applications can absorb neutrons and build up cobalt-60, a potent gamma radiation emitter.
- **Magnesium**: Addition to aluminium makes the alloy suitable for vacuum brazing. Volatile, though less than zinc. Vaporization promotes wetting by removing oxides from the surface, vapors act as getter for oxygen in the furnace atmosphere.
- **Indium**: Lowers melting point. Improves wetting of ferrous alloys by copper-silver alloys.
- **Carbon**: Lowers melting point. Can form carbides. Can diffuse to the base metal, resulting in higher remelt temperature, potentially allowing step-brazing with the same alloy. At above 0.1% worsens corrosion resistance of nickel alloys. Trace amounts present in stainless steel may facilitate reduction of surface chromium(III) oxide in vacuum and allow fluxless brazing. Diffusion away from the braze increases its remelt temperature; exploited in diffusion brazing.[17]
- **Silicon**: Lowers melting point. Can form silicides. Improves wetting of copper-based brazes. Promotes flow. Causes intergranular embrittlement of nickel alloys. Rapidly diffuses into the base metals. Diffusion away from the braze increases its remelt temperature; exploited in diffusion brazing.
- **Germanium**: Lowers melting point. Expensive. For special applications. May create brittle phases.
- **Boron**: Lowers melting point. Can form hard and brittle borides. Unsuitable for nuclear reactors. Fast diffusion to the base metals. Can diffuse to the base metal, resulting in higher remelt temperature, potentially allowing step-brazing with the same alloy. Can erode some base materials or penetrate between grain boundaries of many heat-resistant structural alloys, degrading their mechanical properties. Has to be avoided in nuclear applications due to its interaction with neutrons. Causes intergranular embrittlement of nickel alloys. Improves wetting of/by some alloys, can be added to Au-Ni-Cr alloy to compensate for wetting loss by chromium addition. In low concentrations improves wetting and lowers melting point of nickel brazes. Rapidly diffuses to base materials, may lower their melting point; especially a concern when brazing thin materials. Diffusion away from the braze increases its remelt temperature; exploited in diffusion brazing.
- **Mischmetal**, in amount of about 0.08%, can be used to substitute boron where boron would have detrimental effects.[17]
- **Cerium**, in trace quantities, improves fluidity of brazes. Particularly useful for alloys of four or more components, where the other additives compromise flow and spreading.
- **Strontium**, in trace quantities, refines the grain structure of aluminium-based alloys.

8.9.4 - DEOXIDIZERS

- **Phosphorus**: Lowers melting point. Deoxidizer, decomposes copper oxide; phosphorus-bearing alloys can be used on copper without flux. Does not decompose zinc oxide, so flux is needed for brass. Forms brittle phosphides with some metals, e.g. nickel (Ni_3P) and iron, phosphorus alloys unsuitable for brazing alloys bearing iron, nickel or cobalt in amount above 3%. The phosphides segregate at grain boundaries and cause intergranular embrittlement. (Sometimes the brittle joint is actually desired, though. Fragmentation grenades can be brazed with phosporus bearing alloy to produce joints that shatter easily at detonation.) Avoid in environments with presence of sulfur dioxide (e.g. paper mills) and hydrogen sulfide (e.g. sewers, or close to volcanoes); the phosphorus-rich phase rapidly corrodes in presence of sulfur and the joint fails. Phosphorus can be also present as an impurity introduced from e.g. electroplating baths.[18] In low concentrations improves wetting and lowers melting point of nickel brazes. Diffusion away from the braze increases its remelt temperature; exploited in diffusion brazing.
- **Lithium**: Deoxidizer. Eliminates the need for flux with some materials. Lithium oxide formed by reaction with the surface oxides is easily displaced by molten braze alloy.[17]

8.9.5 - ACTIVE METALS

- **Titanium**: Most commonly used active metal. Few percents added to Ag-Cu alloys facilitate wetting of ceramics, e.g. silicon nitride.[19] Most metals, except few (namely silver, copper and gold), form brittle phases with titanium. When brazing ceramics, like other active metals, titanium reacts with them and forms a complex layer on their surface, which in turn is wettable by the silver-copper braze. Wets oxides, carbides, and graphite; frequently a major alloy component for high-temperature brazing of such materials.[17]
- **Zirconium**: Wets oxides, carbides, and graphite; frequently a major alloy component for high-temperature brazing of such materials.[17]
- **Hafnium**
- **Vanadium**: Promotes wetting of alumina ceramics by gold-based alloys.[16]
- **Aluminium**: Base component of most brazes for aluminium. Embrittles ferrous metals.

8.9.6 - IMPURITIES

- **Sulfur**: Compromises integrity of nickel alloys. Can enter the joints from residues of lubricants, grease or paint. Forms brittle nickel sulfide (Ni_3S_2) that segregates at grain boundaries and cause intergranular failure.

Some additives and impurities act at very low levels. Both positive and negative effects can be observed. Strontium at levels of 0.01% refines grain structure of aluminium. Beryllium and bismuth at similar levels help disrupt the passivation layer of aluminium oxide and promote wetting. Carbon at 0.1% impairs corrosion resistance of nickel alloys. Aluminium can embrittle mild steel at 0.001%, phosphorus at 0.01%.[17]

In some cases, especially for vacuum brazing, high-purity metals and alloys are used. 99.99% and 99.999% purity levels are available commercially.

Care has to be taken to not introduce deletrious impurities from joint contaminations or by dissolution of the base metals during brazing.

8.9.7 - MELTING BEHAVIOR

Alloys with larger span of solidus/liquidus temperatures tend to melt through a "mushy" state, where the alloy is a mixture of solid and liquid material. Some alloys show tendency to liquation, separation of the liquid from the solid portion; for these the heating through the melting range has to be sufficiently fast to avoid this effect. Some alloys show extended plastic range, when only a small portion of the alloy is liquid and most of the material melts at the upper temperature range; these are suitable for bridging large gaps and for forming fillets. Highly fluid alloys are suitable for penetrating deep into narrow gaps and for brazing tight joints with narrow tolerances but are not suitable for filling larger gaps. Alloys with wider melting range are less sensitive to non-uniform clearances.

When the brazing temperature is suitably high, brazing and heat treatment can be done in a single operation simultaneously.

Eutectic alloys melt at single temperature, without mushy region. Eutectic alloys have superior spreading; non-eutectics in the mushy region have high viscosity and at the same time attack the base metal, with correspondingly lower spreading force. Fine grain size gives eutectics both increased strength and increased ductility. Highly accurate melting temperature allows joining process to be performed only slightly above the alloy's melting point. On solidifying, there is no mushy state where the alloy appears solid but is not yet; the chance of disturbing the joint by manipulation in such state is reduced (assuming the alloy did not significantly change its properties by dissolving the base metal). Eutectic behavior is especially beneficial for solders.[17]

Metals with fine grain structure before melting provide superior wetting to metals with large grains. Alloying additives (e.g. strontium to aluminium) can be added to refine grain structure, and the preforms or foils can be prepared by rapid quenching. Very rapid quenching may provide amorphous metal structure, which possess further advantages.[17]

8.9.8 - INTERACTION WITH BASE METALS

For successful wetting, the base metal has to be at least partially soluble in at least one component of the brazing alloy. The molten alloy therefore tends to attack the base metal and dissolve it, slightly change its composition in process. The composition change is reflected in the change of the alloy's melting point and the corresponding change of fluidity. For example, some alloys dissolve both silver and copper; dissolved silver lowers their melting point and increases fluidity, copper has the opposite effect.

The melting point change can be exploited. As the remelt temperature can be increased by enriching the alloy with dissolved base metal, step brazing using the same braze can be possible.

Alloys that do not significantly attack the base metals are more suitable for brazing thin sections.

Nonhomogenous microstructure of the braze may cause non-uniform melting and localized erosions of the base metal.

Wetting of base metals can be improved by adding a suitable metal to the alloy. Tin facilitates wetting of iron, nickel, and many other alloys. Copper wets ferrous metals that silver does not attack, copper-silver alloys can therefore braze steels silver alone won't wet. Zinc improves wetting of ferrous metals, indium as well. Aluminium improves wetting of aluminium alloys. For wetting of ceramics, reactive metals capable of forming chemical compounds with the ceramic (e.g. titanium, vanadium, zirconium...) can be added to the braze.

Dissolution of base metals can cause detrimental changes in the brazing alloy. For example, aluminium dissolved from aluminium bronzes can embrittle the braze; addition of nickel to the braze can offset this.

The effect works both ways; there can be detrimental interactions between the braze alloy and the base metal. Presence of phosphorus in the braze alloy leads to formation of brittle phosphides of iron and nickel, phosphorus-containing alloys are therefore unsuitable for brazing nickel and ferrous alloys. Boron tends to diffuse into the base metals, especially along the grain boundaries, and may form brittle borides. Carbon can negatively influence some steels.

Care has to be taken to avoid galvanic corrosion between the braze and the base metal, and especially between dissimilar base metals being brazed together.

Formation of brittle intermetallic compounds on the alloy interface can cause joint failure. This is discussed more in-depth with solders.

The potentially detrimental phases may be distributed evenly through the volume of the alloy, or be concentrated on the braze-base interface. A thick layer of interfacial intermetallics is usually considered detrimental due to its commonly low fracture toughness and other sub-par mechanical properties. In some situations, e.g. die attaching, it however does not matter much as silicon chips are not typically subjected to mechanical abuse.[17]

On wetting, brazes may liberate elements from the base metal. For example, aluminium-silicon braze wets silicon nitride, dissociates the surface so it can react with silicon, and liberates nitrogen, which may create voids along the joint interface and lower its strength. Titanium-containing nickel-gold braze wets silicon nitride and reacts with its surface, forming titanium nitride and liberating silicon; silicon then forms brittle nickel silicides and eutectic gold-silicon phase; the resulting joint is weak and melts at much lower temperature than may be expected.[17]

Metals may diffuse from one base alloy to the other one, causing embrittlement or corrosion. An example is diffusion of aluminium from aluminium bronze to a ferrous alloy when joining these. A diffusion barrier, e.g. a copper layer (e.g. in a trimet strip), can be used.

A sacrificial layer of a noble metal can be used on the base metal as an oxygen barrier, preventing formation of oxides and facilitating fluxless brazing. During brazing, the noble metal layer dissolves in the filler metal. Copper or nickel plating of stainless steels performs the same function.[17]

In brazing copper, a reducing atmosphere (or even a reducing flame) may react with the oxygen residues in the metal, which are present as cuprous oxide inclusions, and cause hydrogen embrittlement. The hydrogen present in the flame or atmosphere at high temperature reacts with the oxide, yielding metallic copper and water vapour, steam. The steam bubbles exert high pressure in the metal structure, leading to cracks and joint porosity. Oxygen-free copper is not sensitive to this effect, however the most readily available grades, e.g. electrolytic copper or high-conductivity copper, are. The embrittled joint may then fail catastrophically without any previous sign of deformation or deterioration.[20]

	Fastening & Joining	Module No.	8.10
		Prepared by	M. Younus
Course	Certificate in Engineering Skills	Duration	30 - Mins
Teaching Aid			
Topic	Explain the basic principles of brazing.		

8.10 - EXPLAIN THE BASIC PRINCIPLES OF BRAZING

8.10.1 - BRAZING

Brazing is a metal-joining process whereby a filler metal is heated above and distributed between two or more close-fitting parts by capillary action. The filler metal is brought slightly above its melting (liquids) temperature while protected by a suitable atmosphere, usually a flux. It then flows over the base metal (known as wetting) and is then cooled to join the work pieces together.[1] It is similar to soldering, except the temperatures used to melt the filler metal is above 450 °C (842 °F), or, as traditionally defined in the United States, above 800 °F (427 °C).

Brazing can be divided into three categories:

HARD BRAZING (FORTE) : temperatures above 450°C and below melting point of joint material; preparation of joint suitable for favoring penetration of alloy by capillary action.

SOFT BRAZING (DOLCE) : temperatures below 450°C and below melting point of joint material; preparation of joint suitable for favoring penetration of alloy by capillary action.

BRAZEWELDING: utilizes alloys with higher melting points in respect to those utilized in hard brazing and at any rate below that of melting point of joint material; preparation of joint similar to that carried out With autogenous welding.


8.10.2 - FUNDAMENTALS

In order to obtain high-quality brazed joints, parts must be closely fitted, and the base metals must be exceptionally clean and free of oxides. In most cases, joint clearances of 0.03 to 0.08 mm (0.0012 to 0.0031 in) are recommended for the best capillary action and joint strength. However, in some brazing operations it is not uncommon to have joint clearances around 0.6 mm (0.024 in). Cleanliness of the brazing surfaces is also of vital importance, as any contamination can cause poor wetting. The two main methods for cleaning parts, prior to brazing are chemical cleaning, and abrasive or mechanical cleaning. In the case of mechanical cleaning, it is of vital importance to maintain the proper surface roughness as wetting on a rough surface occurs much more readily than on a smooth surface of the same geometry. Another consideration that cannot be over-looked is the effect of temperature and time on the quality of brazed joints. As the temperature of the braze alloy is increased, the alloying and wetting action of the filler metal increases as well. In general, the brazing temperature selected must be above the melting point of the filler metal.

However, there are several factors that influence the joint designer's temperature selection. The best temperature is usually selected so as to: (1) be the lowest possible braze temperature, (2) minimize any heat effects on the assembly, (3) keep filler metal/base metal interactions to a minimum, and (4) maximize the life of any fixtures or jigs used. In some cases, a higher temperature may be selected to allow for other factors in the design (e.g. to allow use of a different filler metal, or to control metallurgical effects, or to sufficiently remove surface contamination). The effect of time on the brazed joint primarily affects the extent to which the aforementioned effects are present; however, in general most production processes are selected to minimize brazing time and the associated costs. This is not always the case, however, since in some non-production settings, time and cost are secondary to other joint attributes (e.g. strength, appearance).

8.10.3 - FLUX

In the case of brazing operations not contained within an inert or reducing atmosphere environment (i.e. a furnace), flux is required to prevent oxides from forming while the metal is heated. The flux also serves the purpose of cleaning any contamination left on the brazing surfaces. Flux can be applied in any number of forms including flux paste, liquid, powder or pre-made brazing pastes that combine flux with filler metal powder. Flux can also be applied using brazing rods with a coating of flux, or a flux core. In either case, the flux flows into the joint when applied to the heated joint and is displaced by the molten filler metal entering the joint. Excess flux should be removed when the cycle is completed because flux left in the joint can lead to corrosion, impede joint inspection, and prevent further surface finishing operations. Phosphorus-containing brazing alloys can be self-fluxing when joining copper to copper. Fluxes are generally selected based on their performance on particular base metals. To be effective, the flux must be chemically compatible with both the base metal and the filler metal being used. Self-fluxing phosphorus filler alloys produce brittle phosphates if used on iron or nickel. As a general rule, longer brazing cycles should use less active fluxes than short brazing operations.

8.10.4 - FILLER MATERIALS

A variety of alloys are used as filler metals for brazing depending on the intended use or application method. In general, braze alloys are made up of 3 or more metals to form an alloy with the desired properties. The filler metal for a particular application is chosen based on its ability to: wet the base metals, withstand the service conditions required, and melt at a lower temperature than the base metals or at a very specific temperature. Braze alloy is generally available as rod, ribbon, powder, paste, cream, wire and performs (such as stamped washers).[5] Depending on the application, the filler material can be pre-placed at the desired location or applied during the heating cycle. For manual brazing, wire and rod forms are g generally used as they are the easiest to apply while heating. In the case of furnace brazing, alloy is usually placed beforehand since the process is usually highly automated.[6] Some of the more common types of filler metals used are

Aluminum-silicon, Copper, Copper-phosphorus, Copper-zinc (brass), Gold-silver, Nickel alloy, Silver , Amorphous brazing foil using nickel, iron, copper, silicon, boron, phosphorus, etc.

8.10.5 - TORCH BRAZING

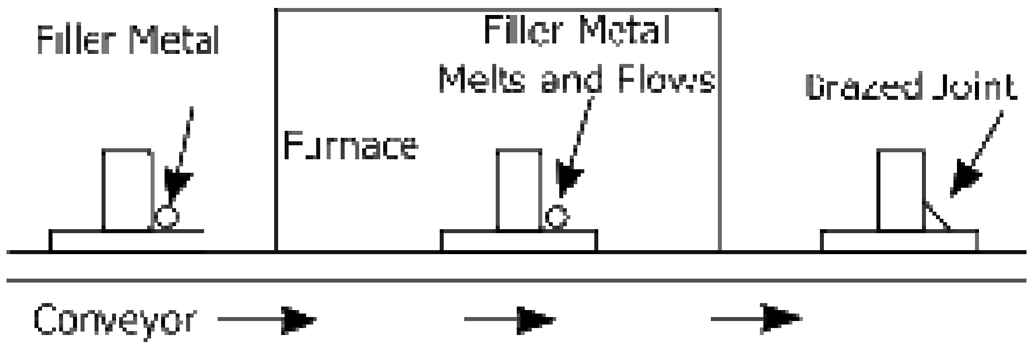
Torch brazing is by far the most common method of mechanized brazing in use. It is best used in small production volumes or in specialized operations, and in some countries, it accounts for a majority of the brazing taking place. There are three main categories of torch brazing in use:[10] manual, machine, and automatic torch brazing.

Manual torch brazing is a procedure where the heat is applied using a gas flame placed on or near the joint being brazed. The torch can either be hand held or held in a fixed position depending on if the operation is completely manual or has some level of automation. Manual brazing is most commonly used on small production volumes or in applications where the part size or configuration makes other brazing methods impossible.[10] The main drawback is the high labor cost associated with the method as well as the operator skill required to obtain quality brazed joints. The use of flux or self-fluxing material is required to prevent oxidation.

Machine torch brazing is commonly used where a repetitive braze operation is being carried out. This method is a mix of both automated and manual operations with an operator often placing brazes material, flux and jigging parts while the machine mechanism carries out the actual braze.[10] The advantage of this method is that it reduces the high labor and skill requirement of manual brazing. The use of flux is also required for this method as there is no protective atmosphere, and it is best suited to small to medium production volumes.

Automatic torch brazing is a method that almost eliminates the need for manual labor in the brazing operation, except for loading and unloading of the machine. The main advantages of this method are: a high production rate, uniform braze quality, and reduced operating cost. The equipment used is essentially the same as that used for Machine torch brazing, with the main difference being that the machinery replaces the operator in the part preparation.[10]

8.10.6 - FURNACE BRAZING



FURNACE BRAZING SCHEMATIC

Furnace brazing is a semi-automatic process used widely in industrial brazing operations due to its adaptability to mass production and use of unskilled labor. There are many advantages of furnace brazing over other heating methods that make it ideal for mass production. One main advantage is the ease with which it can produce large numbers of small parts that are easily jigged or self-locating.[11] The process also offers the benefits of a controlled heat cycle (allowing use of parts that might distort under localized heating) and no need for post braze cleaning. Common atmospheres used include: inert, reducing or vacuum atmospheres all of which protect the part from oxidation. Some other advantages include: low unit cost when used in mass production, close temperature control, and the ability to braze multiple joints at once. Furnaces are typically heated using either electric, gas or oil depending on the type of furnace and application. However, some of the disadvantages of this method include: high capital equipment cost, more difficult design considerations and high power consumption.[11]

There are four main types of furnaces used in brazing operations: batch type; continuous; retort with controlled atmosphere; and vacuum.

Batch type furnaces have relatively low initial equipment costs and heat each part load separately. It is capable of being turned on and off at will which reduces operating expenses when not in use. These furnaces are well suited to medium to large volume production and offer a large degree of flexibility in type of parts that can be brazed.[11] Either controlled atmospheres or flux can be used to control oxidation and cleanliness of parts.

Continuous type furnaces are best suited to a steady flow of similar-sized parts through the furnace.[11] These furnaces are often conveyor fed, allowing parts to be moved through the hot zone at a controlled speed. It is common to use either controlled atmosphere or pre-applied flux in continuous furnaces. In particular, these furnaces offer the benefit of very low manual labor requirements and so are best suited to large scale production operations.

Retort-type furnaces differ from other batch-type furnaces in that they make use of a sealed lining called a "retort". The retort is generally sealed with either a gasket or is welded shut and filled completely with the desired atmosphere and then heated externally by conventional heating elements.[11] Due to the high temperatures involved, the retort usually made of heat resistant alloys that resist oxidation. Retort furnaces are often either used in a batch or semi-continuous versions.

Vacuum furnaces is a relatively economical method of oxide prevention and is most often used to braze materials with very stable oxides (aluminum, titanium and zirconium) that cannot be brazed in atmosphere furnaces. Vacuum brazing is also used heavily with refractory materials and other exotic alloy combinations unsuited to atmosphere furnaces. Due to the absence of flux or a reducing atmosphere, the part cleanliness is critical when brazing in a vacuum. The three main types of vacuum furnace are: single-wall hot retort, double-walled hot retort, and cold-wall retort. Typical vacuum levels for brazing range from pressures of 1.3 to 0.13 pascals (10^{-2} to 10^{-3} Torr) to 0.00013 Pa (10^{-6} Torr) or lower.[11] Vacuum furnaces are most commonly batch-type, and they are suited to medium and high production volumes.

8.10.7 - SILVER BRAZING

Silver brazing, colloquially (however, incorrectly) known as a silver soldering or hard soldering, is brazing using a silver alloy based filler. These silver alloys consist of many different percentages of silver and other metals, such as copper, zinc and cadmium.

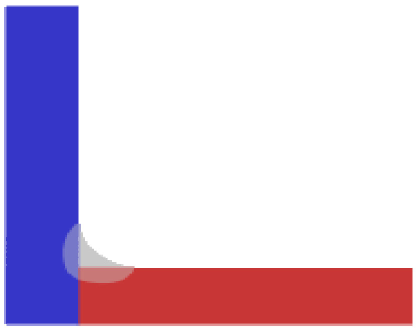
Brazing is widely used in the tool industry to fasten hardmetal (carbide, ceramics, cermet, and similar) tips to tools such as saw blades. "Pretinning" is often done: the braze alloy is melted onto the hardmetal tip, which is placed next to the steel and remelted. Pretinning gets around the problem that hardmetals are hard to wet.

Brazed hardmetal joints are typically two to seven mils thick. The braze alloy joins the materials and compensates for the difference in their expansion rates. In addition it provides a cushion between the hard carbide tip and the hard steel which softens impact and prevents tip loss and damage, much as the suspension on a vehicle helps prevent damage to both the tires and the vehicle. Finally the braze alloy joins the other two materials to create a composite structure, much as layers of wood and glue create plywood.

The standard for braze joint strength in many industries is a joint that is stronger than either base material, so that when under stress, one or other of the base materials fails before the joint.

One special silver brazing method is called pinbrazing or pin brazing. It has been developed especially for connecting cables to railway track or for cathodic protection installations. The method uses a silver- and flux-containing brazing pin which is melted down in the eye of a cable lug. The equipment is normally powered from batteries.

8.10.8 - BRAZE WELDING



A braze-welded T-joint

Braze welding, also known as fillet brazing,[citation needed] is the use of a bronze or brass filler rod coated with flux to join steel workpieces. The equipment needed for braze welding is basically identical to the equipment used in brazing. Since braze welding usually requires more heat than brazing, acetylene or methylacetylene-propadiene (MPS) gas fuel is commonly used. The American Welding Society states that the name comes from the fact that no capillary action is used.

Braze welding has many advantages over fusion welding. It allows the joining of dissimilar metals, minimization of heat distortion, and can reduce the need for extensive pre-heating. Additionally, since the metals joined are not melted in the process, the components retain their original shape; edges and contours are not eroded or changed by the formation of a fillet. Another side effect of braze welding is the elimination of stored-up stresses that are often present in fusion welding. This is extremely important in the repair of large castings. The disadvantages are the loss of strength when subjected to high temperatures and the inability to withstand high stresses.

Carbide, cermet and ceramic tips are plated and then joined to steel to make tipped band saws. The plating acts as a braze alloy.

8.10.9 - CAST IRON "WELDING"

The "welding" of cast iron is usually a brazing operation, with a filler rod made chiefly of nickel being used although true welding with cast iron rods is also available. Ductile cast iron pipe may be also "cadwelded," a process which connects joints by means of a small copper wire fused into the iron when previously ground down to the bare metal, parallel to the iron joints being formed as per hub pipe with neoprene gasket seals. The purpose behind this operation is to use electricity along the copper for keeping underground pipes warm in cold climates.

8.10.10 - VACUUM BRAZING

Vacuum brazing is a materials joining technique that offers significant advantages: extremely clean, superior, flux-free braze joints of high integrity and strength. The process can be expensive because it must be performed inside a vacuum chamber vessel. Temperature uniformity is maintained on the work piece when heating in a vacuum, greatly reducing residual stresses due to slow heating and cooling cycles. This, in turn, can significantly improve the thermal and mechanical properties of the material, thus providing unique heat treatment capabilities. One such capability is heat-treating or age-hardening the workpiece while performing a metal-joining process, all in a single furnace thermal cycle.

Vacuum brazing is often conducted in a furnace; this means that several joints can be made at once because the whole workpiece reaches the brazing temperature. The heat is transferred using radiation, as many other methods cannot be used in a vacuum.

8.10.11 - DIP BRAZING

Dip brazing is especially suited for brazing aluminum because air is excluded, thus preventing the formation of oxides. The parts to be joined are fixtured and the brazing compound applied to the mating surfaces, typically in slurry form. Then the assemblies are dipped into a bath of molten salt (typically NaCl, KCl and other compounds) which functions both as heat transfer medium and flux.

8.10.12 - HEATING METHODS

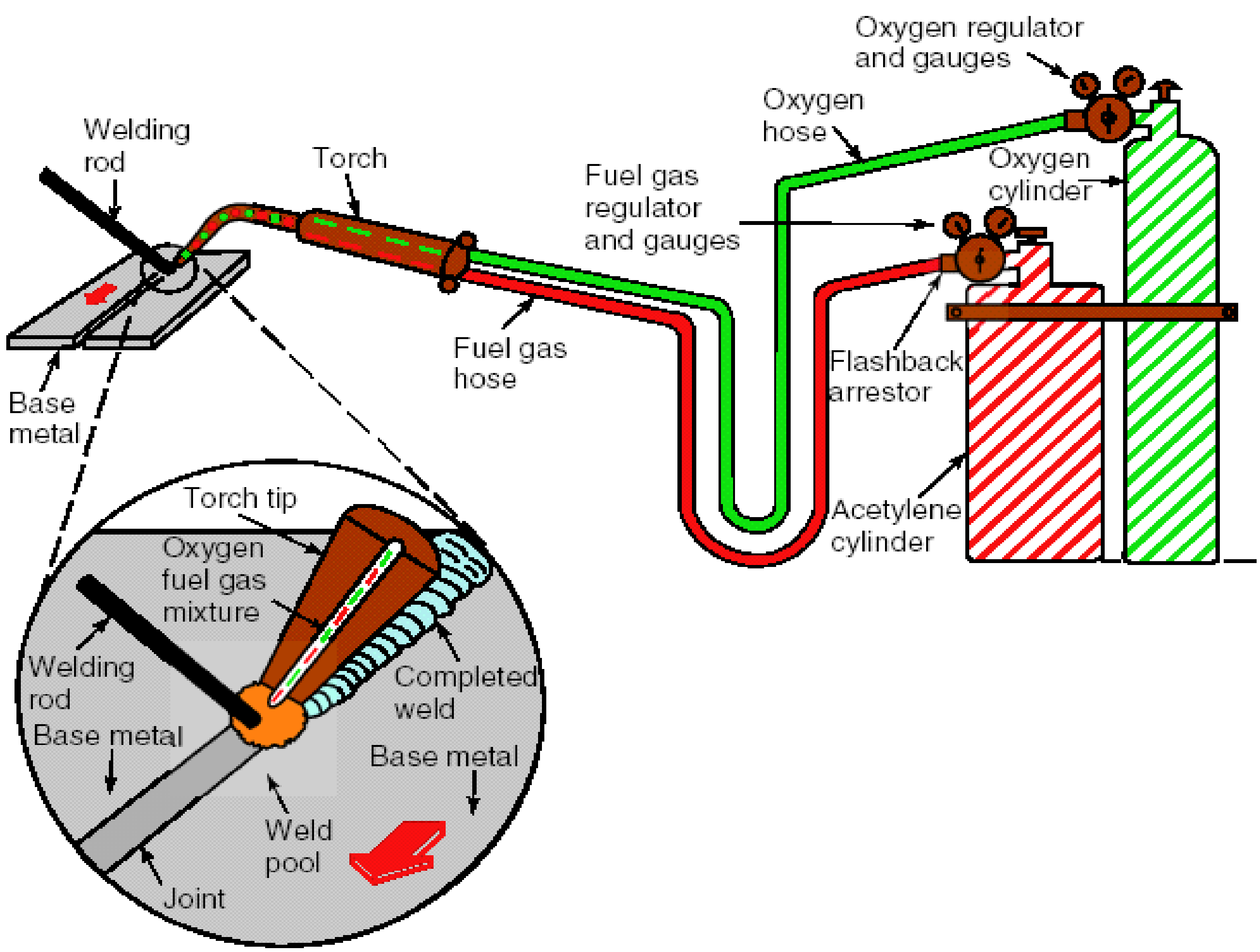
There are many heating methods available to accomplish brazing operations. The most important factor in choosing a heating method is achieving efficient transfer of heat throughout the joint and doing so within the heat capacity of the individual base metals used. The geometry of the braze joint is also a crucial factor to consider, as is the rate and volume of production required. The easiest way to categorize brazing methods is to group them by heating method. Here are some of the most common:[1][12]

- Torch brazing
- Furnace brazing
- Induction brazing
- Dip brazing
- Resistance brazing
- Infrared brazing
- Blanket brazing
- Electron beam and laser brazing
- Braze welding

8.11 - IDENTIFY THE EQUIPMENT AND CONSUMABLES USE FOR OXY-FUEL GAS WELDING

8.11.1 - EQUIPMENT AND CONSUMABLES USE FOR OXY-FUEL GAS WELDING

- Cylinder
- Torch
- Regulator
- Hose
- Filler Wire



8.11.2 - CYLINDER

A portable compressed gas container, fabricated to the "Rules for the Construction of Unfired Pressure Vessels," Section VIII, ASME Boiler & Pressure Vessel Code.

FLAMMABLE GAS

A gas that is flammable in a mixture of 13 percent or less (by volume) with air, or the flammable range with air is wider that 12 percent regardless of the lower limit, at atmospheric temperature and pressure.

HANDLING

Moving, connecting, or disconnecting a compressed or liquefied gas cylinder.

INSIDE DIAMETER (I.D.)

Inside cylinder diameter.

LIQUEFIED GAS

A gas, which under charging pressure, is partially liquid at a temperature of 20^{o}C (70^{o}F).

NONFLAMMABLE GAS

A gas that does not meet the definition of a flammable gas.

OUTSIDE DIAMETER (O.D.)

Outside cylinder diameter.

OXIDIZING GAS

A gas that can support and accelerate combustion of other materials.

SAFETY RELIEF DEVICE

A device intended to prevent rupture on a cylinder under certain conditions of exposure.

STANDARD CUBIC FOOT (SCF)

One cubic foot of gas at 70oF (21oC) and 14.7 psia (an absolute pressure of 101 kilo pascals [kPa]).

Acetylene Cylinder Identify by Red Color.
Oxygen Cylinder Identify by Blue Color.

STORAGE

An inventory of compressed or liquefied gases in containers that are not in the process of being examined, serviced, refilled, loaded, or unloaded.

TOXIC GAS

A gas having a health hazard rating of 3 or 4 defined in NFPA 704, Standard System for the Identification of the Fire Hazards of Materials

USE

The consumption of a compressed or liquefied gas in a non recoverable manner.

USER

An individual, group, or organization who utilizes the compressed or liquefied gas in a non recoverable manner

VALVE PROTECTION DEVICE

A device attached to the neck ring or body of the cylinder for the purpose of protecting the cylinder valve from being struck or damaged from impact resulting from a fall or an object striking the cylinder.

VALVE PROTECTIVE CAP

A rigid, removable cover provided for compressed gas container valve protection.

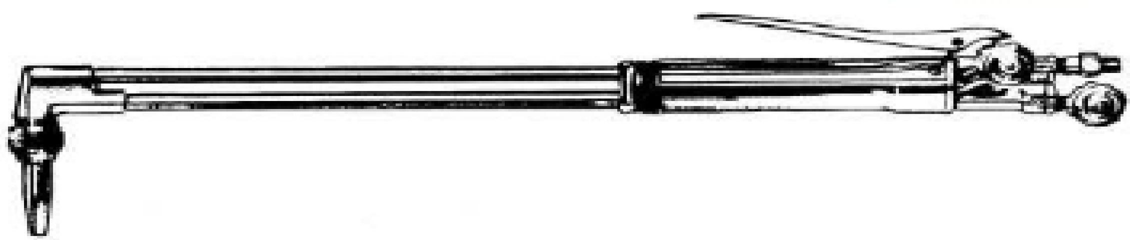
8.11.3 - TORCH

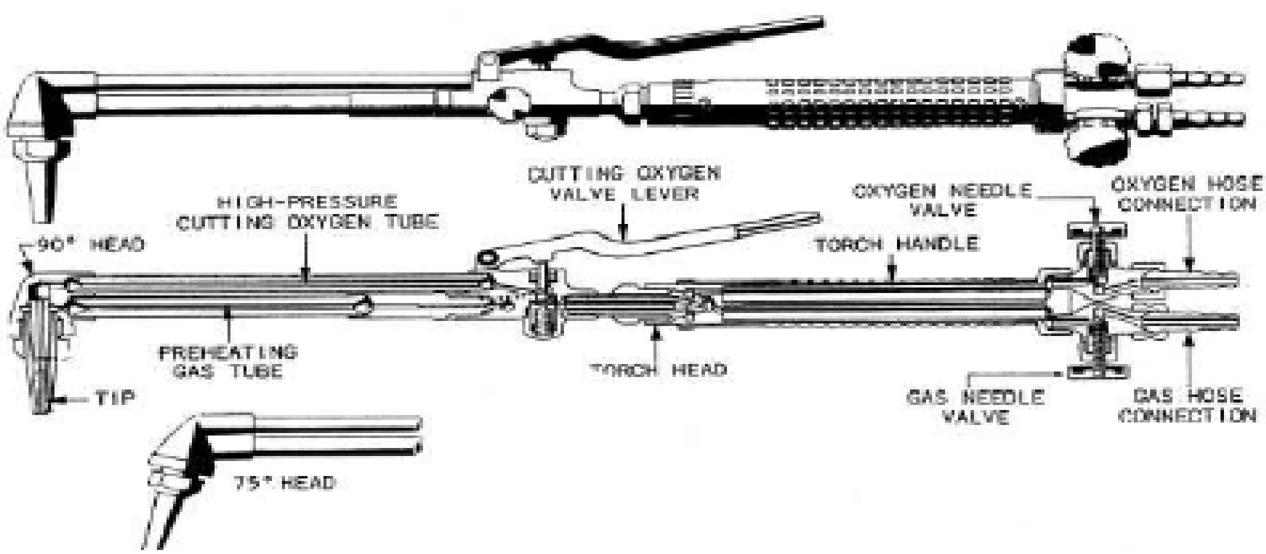
The oxyacetylene welding torch is used to mix oxygen and acetylene in definite proportions. It also controls the volume of these gases burning at the welding tip, which produces the required type of flame. The torch consists of a handle or body which contains the hose connections for the oxygen and the fuel gas. The torch also has two needle valves, one for adjusting the flow of oxygen and one for acetylene, and a mixing head. In addition, there are two tubes, one for oxygen, the other for acetylene; inlet nipples for the attachment of hoses; a tip; and a handle. The tubes and handle are of seamless hard brass, copper-nickel alloy, stainless steel. For a description and the different sized tips.

TORCH TYPES

Gas Welding Torch

Gas Cutting Torch





8.11.4 - REGULATOR

Acetylene Regulator Identify by Red Color.
Oxygen Regulator Identify by Blue Color.

8.11.5 - HOSE

Use for Supple of gas from Cylinder to Torch.
Acetylene Regulator Identify by Red Color.
Oxygen Regulator Identify by Blue Color.

8.11.6 - FILLER WIRE

A filler metal is a metal added in the making of a joint through welding, brazing, or soldering. Four types of filler metals exist—covered electrodes, bare electrode wire or rod, tubular electrode wire and welding fluxes. Sometimes non consumable electrodes are included as well, but since these metals are not consumed by the welding process, they are normally excluded.

The filler wire is a closed tube, in whose interior is located a filling of two or more pulverulent material components. With the split tube still open, the filling is introduced in the form of layers and then the split tube is closed. As a result of the filling introduced in layer form, a favorable set of conditions for closing or sealing the tube, for example by welding, is provided.

The system divides the filler metals into eight classes. The class to which a filler metal is assigned is based in most cases on the major element present but in some instances

The eight classes are as follows.

1) AL: Filler metals containing aluminium as the major element.

2) AG: Filler metals containing silver as a significant addition, even if not the major element.

3) CP: Filler metals containing copper as the major element with an addition of phosphorus.

4) CU: Filler metals containing copper as the major element, not elsewhere classified.

5) NI: Filler metals containing nickel as the major element.

6) CO: Filler metals containing cobalt as the major element.

7) PD: Filler metals containing palladium, in any amount.

8) AU: Filler metals containing gold, in any amount.

	Fastening & Joining	Module No.	8.12
		Prepared by	Muhammad Nasir
Course	Certificate in Engineering Skills	Duration	30 - Mins
Teaching Aid			
Topic	Explain the basic principles of oxy-fuel gas welding.		

8.12 - EXPLAIN THE BASIC PRINCIPLES OF OXY-FUEL GAS WELDING

8.12.1 - OXY-FUEL WELDING

OXY- FUEL WELDING

LOW PRESSURE SYSTEM		HIGH PRESSURE SYSTEM
By cylinder	oxygen	By cylinder
By generator	Acetylene	By cylinder
Below 1 bar	Acetylene gas pressure	Above 1 bar
Only for light weld	Use	For heavy welding/cutting
Only injector type	Torch	Injector type/non-injector

8.12.2 - GAS WELDING PROCESS AND GASES

Gas welding process and gases

- Gas flame is Source of heat [3482 C]
- Burning of acetylene
- Presence of oxygen

Oxygen

AIR

- Nitrogen 78%
- Oxygen 21%
- Other gases 01%
- COMPRESS COOL →
- LIQUID FORM
- BOILS OF NITROGEN -195.5 C
- BOILS OFF OXYGEN -182 C
- STOREED IN CYLENDER

WATER

Hydrogen 66 %

Oxygen 34%

ELECTROLITIC PROCESS

VERY COSTLY

SO IT IS NOT USE

Acetylene

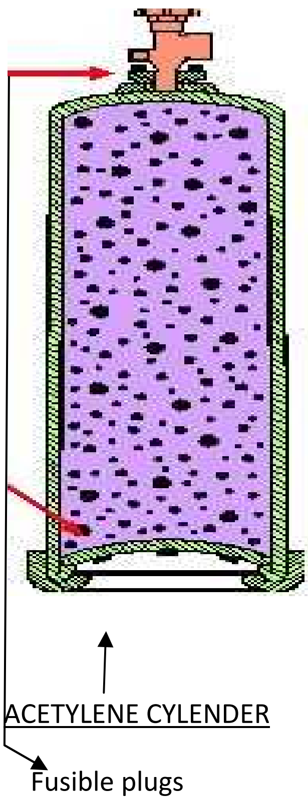
Made by calcium carbide

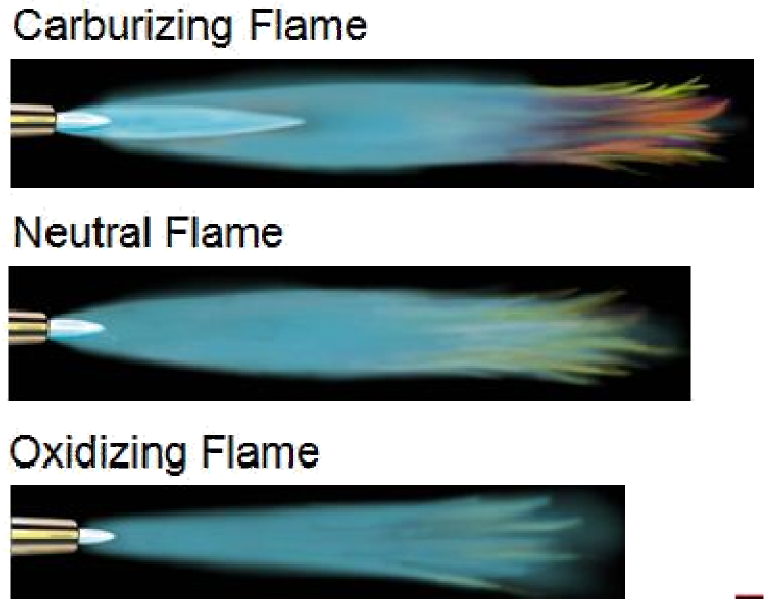
+ Water

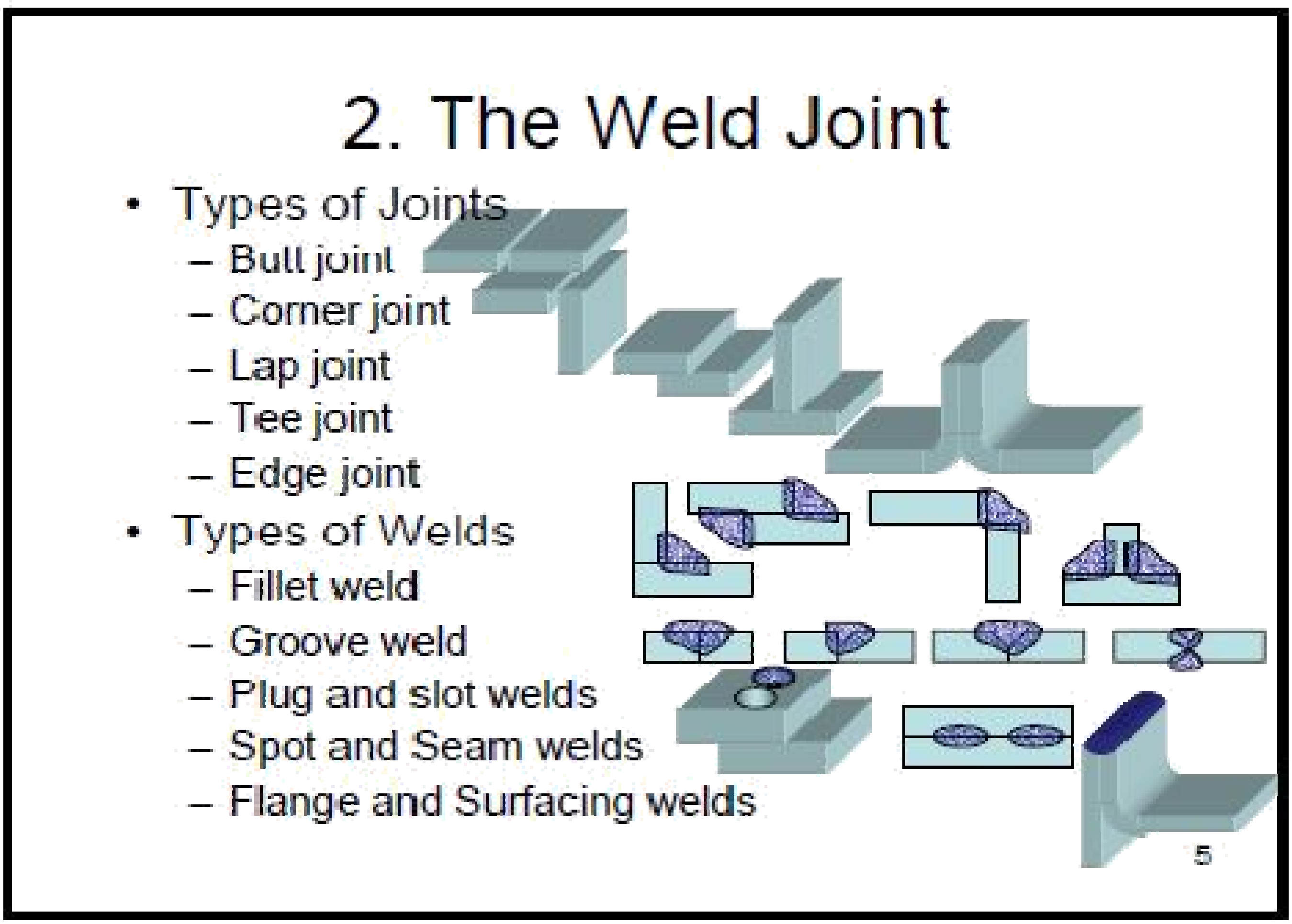
Prepared in generator

Available in cylinder

8.12.3 - APPLICATION


ACETYLENE CYLENDER
Fusible plugs


Carburizing Flame
Neutral Flame
Oxidizing Flame


2. The Weld Joint
• Types of Joints
– Butt joint
– Corner joint
– Lap joint
– Tee joint
– Edge joint
• Types of Welds
– Fillet weld
– Groove weld
– Plug and slot welds
– Spot and Seam welds
– Flange and Surfacing welds
5

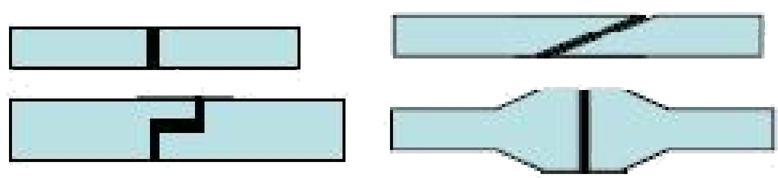
1. Overview

- **Welding** – A joining process of two materials that coalesced at their contacting (faying) surfaces by the application of pressure and/or heat.
  - Weldment – The assemblage
  - Sometime a filler material to facilitate coalescence.
- **Advantage**: portable, permanent, stronger than the parent materials with a filler metal, the most economical method to join in terms of material usage and fabrication costs .
- **Disadvantage**: Expensive manual Labor, high energy and dangerous, does not allow disassemble and defects

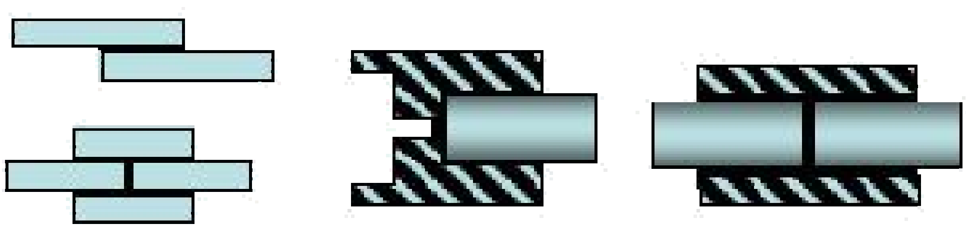
2

Brazed Joints

- Butt



- Lap – a wider area for brazing metal



- Lap joints take more load than butt joints.

32

انفارمیشن شیٹ

آکسیجن ایسی ٹیلین گیس ویلڈنگ: یہ گیس ویلڈنگ کا وہ عمل طریقہ ہے جس میں ویلڈ کیے جانے والے جوڑ کو ویلڈ کرنے کے درجہ حرارت تک گرم کرنے کیلئے آکسیجن اور ایسی ٹیلین گیس کو صحیح اور ضروری مقدار میں ملا کر جلایا جاتا ہے۔ اور فلیم Flame بنا کر استعمال کیا جاتا ہے فلیم کا درجہ حرارت Temprature سینٹی گریڈ سے بھی زیادہ ہوتا ہے۔

آکسیجن: یہ ایک بے رنگ، بے بو اور بے ذائقہ گیس ہے۔ یہ خود نہیں جلتی بلکہ جلنے والی چیزوں کو جلاتی ہے۔ ہوا جس میں ہم سانس لیتے ہیں اس میں 21٪ آکسیجن اور 78٪ نائٹروجن ہوتی ہے۔ اور باقی دوسری گیسیں ہوتی ہیں۔ آکسیجن گیس ویلڈنگ کیلئے ایسے سلنڈروں میں بھری ہوئی ملتی ہے جو کہ سٹیل کا بغیر جوڑ کے بنا ہوا ہوتا ہے۔ آکسیجن سلنڈر شناخت کیلئے کالا یا نیلا (Black or Blue) رنگ کیا ہوا ہوتا ہے۔ اس کی جوڑی کی Thread سیدھی ہوتی ہے۔

ایسی ٹیلین: یہ ایک جلنے والی گیس ہے۔ جو کہ کیلشیم کاربائیڈ اور پانی کے کیمیائی عمل سے تیار کی جاتی ہے۔ یہ ایک بے رنگ گیس ہے۔ لیکن ایک خاص قسم کی بدبو دیتی ہے۔ جس کی وجہ سے آسانی سے پہچانی جا سکتی ہے۔

گیس ویلڈنگ ٹارچ: آکسی ایسی ٹیلین ویلڈنگ میں بلو پائپ یا ویلڈنگ ٹارچ ویلڈنگ کیلئے استعمال کی جاتی ہے۔ اور اسی بلو پائپ کے ذریعے مختلف فلیم بنائے جاتے ہیں۔ بلو پائپ پر دو والو (valves) لگے ہوتے ہیں۔ ایک آکسیجن کے لیے دوسرا ایسی ٹیلین کے لیے
عام پریشر گیس ویلڈنگ میں جو ٹارچ استعمال کی جاتی ہے اسکو نان انجکٹر ٹائپ (NON.INJECTOR TYPF) کہتے ہیں اور لو پریشر کیلئے جو ویلڈنگ ٹارچ استعمال ہوتی ہے اسے (INJECTOR type) ویلڈنگ ٹارچ کہتے ہیں۔

نوزل ٹپ: یہ کسی ایسی دھات کے بنائے جاتے ہیں جو زیادہ حرارت برداشت کر سکے عام طور پر تانبے copper کے بنائے جاتے ہیں۔ یہ مختلف سائز کے ہوتے ہیں۔ ویلڈنگ ٹارچ کے آگے ہلکے اور بھاری کام کیلئے مختلف سائز کے نوزل فٹ کیے جا سکتے ہیں۔

PROGRESS TEST پراگرس ٹیسٹ

سوال نمبر ۱۔ مندرجہ ذیل فقرات میں الفاظ صحیح کریں۔

A — Injector type torch B — medium pressure

a. ________ آکسیجن گیس درمیان سے گزرتی ہے اور ایسی ٹیلین سائیڈ سے گزرتی ہے۔

b. ________ ایسی ٹیلین گیس درمیان سے گزرتی ہے اور آکسیجن جس درمیان سے گزرتی ہے۔

c. ________ لو پریشر جنریٹر کے ساتھ استعمال کی جاتی ہے۔

d. ________ کسی بھی ایسی ٹیلین پریشر پر استعمال کی جا سکتی ہے۔

سوال نمبر ۲۔ آکسی ایسی ٹیلین ٹارچ کے متعلق کونسا فقرہ درست نہیں ہے۔

(a) ۔ ویلڈنگ ٹارچ آکسیجن اور ایسی ٹیلین گیس کو خاص نسبت سے ملاتی ہے۔

(b) ۔ ویلڈنگ ٹارچ ہینڈل اور ہینڈل والو پر مشتمل ہوتی ہے۔ اور گیس کے بہاؤ کو کنٹرول کرتی ہے۔

(c) ۔ ٹارچ ہوا کی آکسیجن کو ایسی ٹیلین کو خاص نسبت سے ملاتی ہے

سوال نمبر ۳۔ مندرجہ ذیل میں کون سا فقرہ انجیکٹر ٹائپ ویلڈنگ ٹارچ کے متعلق درست نہیں ہے۔

(a) کم پریشر ایسی ٹیلین گیس کو استعمال کیا جا سکتا ہے۔

(b) ۔ ایسی ٹیلین گیس جنریٹر پر استعمال نہیں کی جا سکتی

(c) ۔ لو پریشر جنریٹر پر استعمال کی جا سکتی ہے۔

سوال نمبر ۴: بیس فولڈ سسٹم جہاں ہر پریشر پر استعمال کیا جاتا ہے **غلط / درست**

سوال نمبر ۵۔ خالی جگہ پر کریں۔

(i) ۔ ایسی ٹیلین جنریٹر میں گیس کا پریشر ________ بار ہوتا ہے۔

(ii) ۔ اگر گیس ویلڈنگ کا عمل سلنڈروں کی مدد سے سرانجام دیا جا رہا ہو تو اسے ________ سسٹم کہیں گے۔

(iii) ۔ انجیکٹر گیس کی ________ کو بڑھاتا ہے۔

سوال نمبر ۶۔ ________ سسٹم میں ایک وقت میں کئی ________ پر کام کیا جا سکتا ہے۔

ورکشیٹ

سوال نمبر ۱۔ الفاظ میچ کریں۔

ایسیٹیلین = A و آکسیجن = B

(i) ______ جب آکسیجن کیساتھ مل کر جلتی ہے تو سٹیل کی ویلڈنگ کیلئے کارآمد ہوتی ہے۔

(ii) ______ سٹیل Steel کی کٹنگ کیلئے استعمال ہوتی ہے۔

(iii) ______ جب خالص آکسیجن کے ساتھ ملکر جلتی ہے تو درجہ حرارت 3200°C بنتا ہے۔

(iv) ______ اسے ہوائی پریشر 200 bar سے سٹیل سلنڈروں میں بھرا جاتا ہے۔

سوال نمبر ۲۔ درست فقرے پر نشان لگائیں۔

(a)- ورکنگ پریشر کیلئے سلنڈر کے پریشر کو زیادہ کرتا ہے۔

(b)- ورکنگ پریشر working-Pressure سلنڈر کے پریشر کو زیادہ کرتا ہے۔

(c)- گیس کا یکساں بہاؤ مہیا کرتا ہے۔

سوال نمبر ۳۔ پریشر ریگولیٹر کے متعلق کون سا فقرہ درست ہے

(i)۔ ریگولیٹر سلنڈر اور ورکنگ پریشر کو بتاتا ہے۔

(ii)۔ ریگولیٹر یکساں بہاؤ مہیا کرتا ہے سلنڈر میں چاہیے جتنا پریشر ہو۔

(iii)۔ ریگولیٹر ورکنگ پریشر کو دو حصوں میں تبدیل کرتا ہے۔

سوال نمبر ۴۔ کونسی گیس کو تیل و گریس میں سے محفوظ رکھنا چاہیئے۔

(a) - پروپین گیس

(b)- آکسیجن گیس

(c)- ایسیٹیلین گیس

(d)- ہائیڈروجن گیس

سوال نمبر ۵۔ لو پریشر سسٹم میں دھات کی موٹی چادروں کو ویلڈ کیا جاتا ہے

درست/غلط

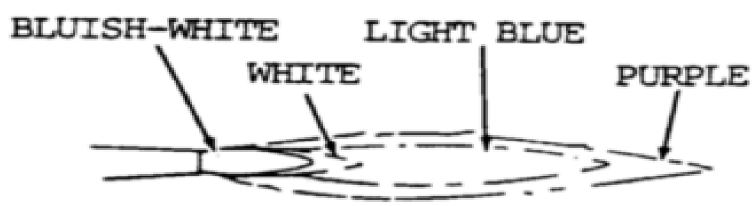
8.13 - IDENTIFY FLAME SETTING, OXIDIZING, CARBURIZING, AND NEUTRAL

8.13.1 - FLAME

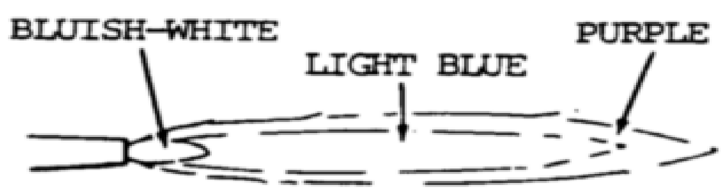
A flame is the visible gaseous part of a fire. The oxyfuel gas welding torch mixes the combustible and combustion-supporting gases. A range of tip sizes is provided for obtaining the required volume or size of welding flame which may vary from a short, small diameter needle flame to a flare 3/16 in. (4.8 mm) or more in diameter and 2 in. (51 mm) or more in length. The inner cone or vivid blue flare of the burning mixture of gases issuing from the tip is called the working flare. The closer the end of the inner cone is to the surface of the metal being heated or welded, the more effective is the heat transfer from flame to metal. The flame can be made soft or harsh by varying the gas flow. Most oxyacetylene welding is done with a neutral flame having approximately a 1:1 gas ratio. An oxidizing action can be obtained by increasing the oxygen flow, and a reducing action will result from increasing the acetylene flow. Both adjustments are valuable aids in welding.

TYPES OF FLAMES

There are three basic flame types: neutral (balanced), excess acetylene (carburizing), and excess oxygen (oxidizing).



REDUCING FLAME
5700 °F



NEUTRAL FLAME
5850 °F

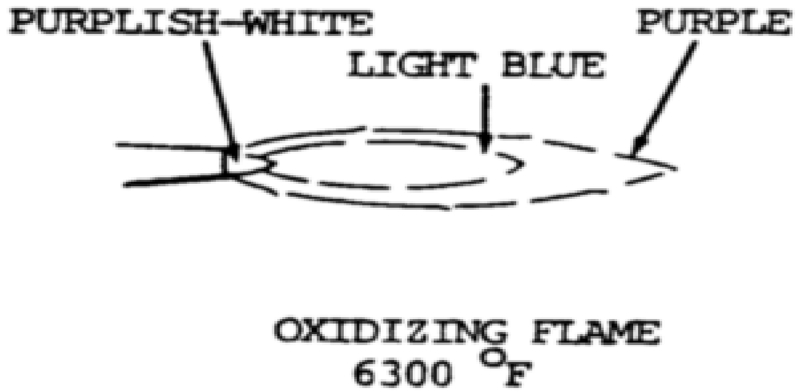


Figure 11-2. Oxyacetylene flames.

8.13.2 - CREATING A FLAME

When the welder is ready to start, he opens the valves on the gas tanks and ignites the gas exiting the torch. The welder then adjusts the ratio of oxygen and fuel gas by opening or closing valves on the torch. These valves allow the welder to change the properties of the flame depending on the task at hand.

NEUTRAL FLAME

The neutral flame is the primary flame used by gas welders. A neutral flame has two zones: a hotter, lighter inner zone and a cooler, darker outer zone. In a neutral flame, all of the fuel gas is being burned in the process, resulting in a clean flame. The welder uses the tip of the inner flame zone to heat the parts to be welded, as this is the hottest part of the flame.

CARBONIZING FLAME

If the oxygen is reduced, a carbonizing flame is created from a neutral flame. In this case, not all of the fuel gas is being burned by the flame. A carbonizing flame has three zones, and is cooler than a neutral flame because the excess carbon acts as an insulator. Carbonizing flames deposit soot on the work piece that has to be cleaned when the part is cooled, but the addition of carbon to the metal is desirable in some iron and steel welding applications.

OXIDIZING FLAME

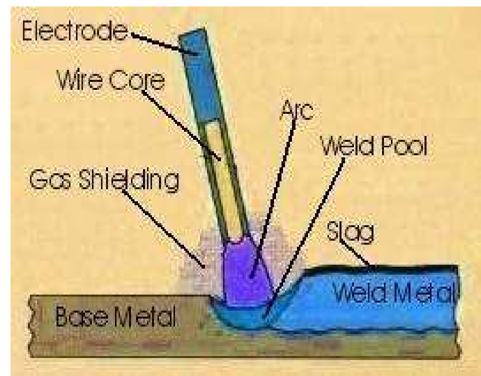
An oxidizing flame is caused by increasing the oxygen from a neutral flame. Because of the excess oxygen, this flame is hotter than the neutral or carbonizing flames. Welders generally do not use an oxidizing flame, because it can increase the oxides in the base material. However, an oxidizing flame is used for bronze and brass work.

	Fastening & Joining					Module No.	8.14
						Prepared by	Imran Ali
Course	Certificate in Engineering Skills					Duration	60 - Mins
Teaching Aid							
Topic	Identify the equipment and consumables used for manual metal arc welding.						

8.14 - IDENTIFY THE EQUIPMENT AND CONSUMABLES USED FOR MANUAL METAL ARC WELDING

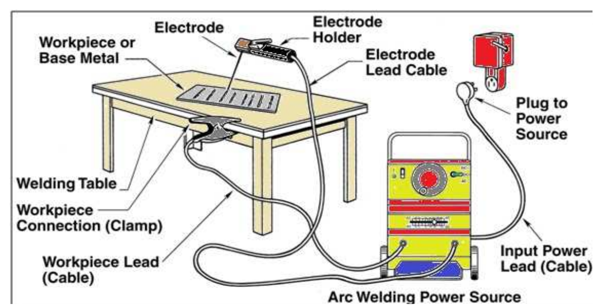
8.14.1 - OVERVIEW

Manual/Shielded Metal Arc Welding (SMAW) or Stick welding is a process which melts and joins metals by heating them with an arc between a coated metal electrode and the workpiece. The electrode outer coating, called flux, assists in creating the arc and provides the shielding gas and slag covering to protect the weld from contamination. The electrode core provides most of the weld filler metal.



8.14.2 - EQUIPMENTS & CONSUMABLES

Manual metal arc welding equipments typically consists of a constant current welding power supply, an electrode holder, a ground clamp, welding cables (also known as welding leads) and an electrode.



WELDING POWER SUPPLY

A welding power supply is a device that provides an electric current to perform welding. Welding usually requires high current (over 80 amperes) and it can need above 12,000 amps in spot welding.

Most welding power supplies are of the following designs:

1. Transformer
2. Generator and alternator
3. Inverter

TRANSFORMER

A transformer style welding power supply converts the high voltage and low current electricity from the utility mains into a high current and low voltage, typically between 17 to 45 volts and 55 to 590 amps. A rectifier converts the AC into DC. This design typically allows the welder to select the output current by either moving a magnetic shunt in and out of the core of the transformer or allows the welder to select the output voltage from a set of taps on the transformer. These machines are typically the least expensive.

GENERATOR & ALTERNATOR

Welding power supplies may also use generators or alternators to convert mechanical energy into electrical energy. Modern designs are usually driven by an internal combustion engine but some older machines use an electric motor to drive the alternator or generator. In this configuration the utility power is converted first into mechanical energy then back into electrical energy to achieve the step-down effect similar to a transformer. Because the output of the generator can be direct current, these older machines can produce DC from AC without any need for rectifiers of any type.

INVERTER

Inverters generally first rectify the utility AC power to DC; then they switch (invert) the DC power into a step-down transformer to produce the desired welding voltage or current.

ELECTRODE HOLDER

It can hold the electrode at various angles and energizes it at the same time. The jaws of the holder, which retain the electrode, remain under spring pressure. The jaws mayor may not be insulated, but insulated jaws avoid danger of short-circuiting.

Electrode holders are available to work from 100 to 500 amps and are provided with a heat shield to protect welder's hand during welding. An electrode holder is light, but sturdy at the same time. It provides easy holding of the electrode. The handle of the electrode is highly resistant to heat and electricity.

GROUND CLAMP

A welding ground clamp includes a pair of frame legs that are connected together by a pivot pin assembly that also establishes electrical contact between the clamp and a ground cable. The electrical contact is such that the electrical path between the work piece engaging elements of the clamp and the ground cable are all essentially identical, and the connection to the ground cable is spaced from the work piece engaging elements. A handle locking assembly combines the advantages of both a spring assembly and a screw lock assembly and are located away from the work piece engaging elements.

CABLES

Welding cable is a popular portable cord that is used in various welding applications as well as many power supply applications not exceeding 600V where some flexibility is required.

The jacket on most welding cable is thermoset, typically synthetic rubbers, EPDM (ethylene propylene diene Monomer) or Neoprene. The most widely manufactured colors of standard welding cable are black and red. The standard temperature rating 90C.

ELECTRODES

The choice of electrode for SMAW depends on a number of factors, including the weld material, welding position and the desired weld properties. The electrode is coated in a metal mixture called flux, which gives off gases as it decomposes to prevent weld contamination, introduces deoxidizers to purify the weld, causes weld-protecting slag to form, improves the arc stability, and provides alloying elements to improve the weld quality.

Types:

Electrodes can be divided into three groups, those designed to melt quickly are called "fast-fill" electrodes, those designed to solidify quickly are called "fast-freeze" electrodes, and intermediate electrodes go by the name "fill-freeze" or "fast-follow" electrodes.

FLUX

Consumable electrodes are coated with chemicals known as flux. Most flux coatings are designed to create a smoother, protected weld. As the flux burns it produces a small cloud of gas, shielding the weld from oxygen and other contaminants that can ruin its cooling process. The metal of the consumable electrode is also burned and added to the weld to help with stability. There are many different kinds of flux coatings with slightly different effects to choose between.

8.15 - EXPLAIN THE BASIC PRINCIPLES OF MANUAL METAL ARC WELDING

8.15.1 - SHIELDED METAL ARC WELDING

SMAW welding in the field

Shielded metal arc welding (SMAW), also known as manual metal arc (MMA) welding or informally as stick welding, is a manual arc welding process that uses a consumable electrode coated in flux to lay the weld. An electric current, in the form of either alternating current or direct current from a welding power supply, is used to form an electric arc between the electrode and the metals to be joined. As the weld is laid, the flux coating of the electrode disintegrates, giving off vapors that serve as a shielding gas and providing a layer of slag, both of which protect the weld area from atmospheric contamination.

Because of the versatility of the process and the simplicity of its equipment and operation, shielded metal arc welding is one of the world's most popular welding processes. It dominates other welding processes in the maintenance and repair industry, and though flux-cored arc welding is growing in popularity, SMAW continues to be used extensively in the construction of steel structures and in industrial fabrication. The process is used primarily to weld iron and steels (including stainless steel) but aluminum, nickel and copper alloys can also be welded with this method.

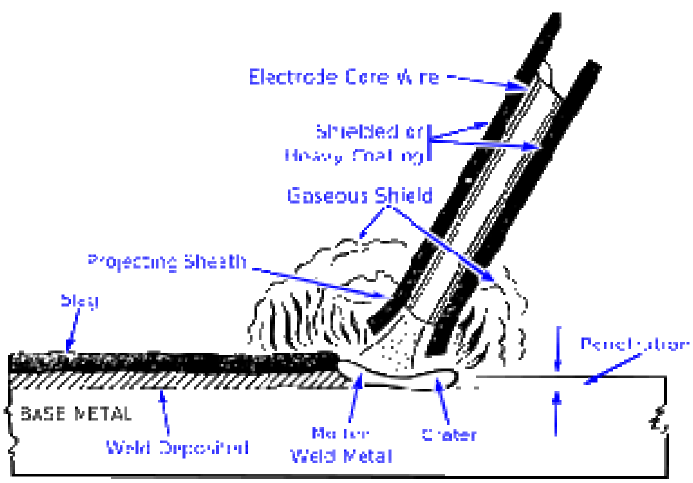
8.15.2 - DEVELOPMENT

After the discovery of the electric arc in 1800 by Humphry Davy there was little development in electrical welding until Nikolay Benardos developed carbon arc welding, obtaining patents in the 1880s showing a rudimentary electrode holder. In 1888 consumable metal electrode was invented by Nikolay Slavyanov. Later in 1890 C. L. Coffin received U.S. Patent 428,459 for his arc welding method that utilized a metal electrode. The process, like SMAW, deposited melted electrode metal into the weld as filler.

Around 1900 A. P. Strohmenger and Oscar Kjellberg released the first coated electrodes. Strohmenger used Clay and lime coating to stabilize the arc, while Kiellberg dipped iron wire into mixtures of carbonates and silicates to coat the electrode. In 1912 Strohmenger released a heavily coated electrode but high cost and complex production methods prevented these early electrodes from gaining popularity. In 1927 the development of an extrusion process reduced the cost of coating electrodes while allowing manufacturers to produce more complex coating mixtures designed for specific applications. In the 1950s manufacturers introduced iron powder into the flux coating, making it possible to increase the welding speed.

In 1938 K. K. Madsen described an automated variation of SMAW, now known as gravity welding. It briefly gained popularity in the 1960s after receiving publicity for its use in Japanese shipyards though today its applications are limited. Another little used variation of the process, known as firecracker welding, was developed around the same time by George Hafergut in Austria.

8.15.3 - OPERATION



SMAW WELD AREA

To strike the electric arc, the electrode is brought into contact with the work piece by a very light touch with the electrode to the base metal then is pulled back slightly. This initiates the arc and thus the melting of the work piece and the consumable electrode, and causes droplets of the electrode to be passed from the electrode to the weld pool. As the electrode melts, the flux covering disintegrates, giving off shielding gases that protect the weld area from oxygen and other atmospheric gases. In addition, the flux provides molten slag which covers the filler metal as it travels from the electrode to the weld pool. Once part of the weld pool, the slag floats to the surface and protects the weld from contamination as it solidifies. Once hardened, it must be chipped away to reveal the finished weld. As welding progresses and the electrode melts, the welder must periodically stop welding to remove the remaining electrode stub and insert a new electrode into the electrode holder. This activity, combined with chipping away the slag, reduce the amount of time that the welder can spend laying the weld, making SMAW one of the least efficient welding processes. In general, the operator factor, or the percentage of operator's time spent laying weld, is approximately 25%.

The actual welding technique utilized depends on the electrode, the composition of the work piece, and the position of the joint being welded. The choice of electrode and welding position also determine the welding speed. Flat welds require the least operator skill, and can be done with electrodes that melt quickly but solidify slowly. This permits higher welding speeds. Sloped, vertical or upside-down welding requires more operator skill, and often necessitates the use of an electrode that solidifies quickly to prevent the molten metal from flowing out of the weld pool. However, this generally means that the electrode melts less quickly, thus increasing the time required to lay the weld.

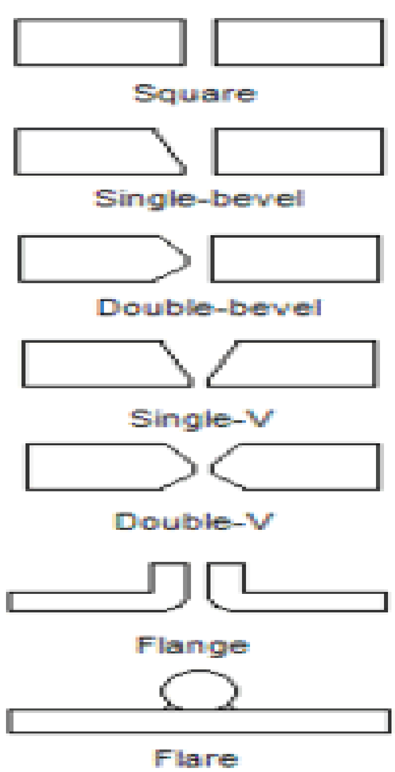
WELDING JOINT TYPES

While designing for welding, it appears both logical and fundamental to first consider the various forms of weld joints. A joint indicates the position where two or more members of a structure meet and are to be joined by welding. Weld joints may be classified as follows:

BUTT JOINT

A butt joint is used to join two members aligned in the same plane .This joint is frequently used in plate, sheet metal, and pipe work. A joint of this type may be either square or grooved.

Square
Single Vee
Single bevel
Single J
Single U
Double Vee
Double bevel
Double J
Double U



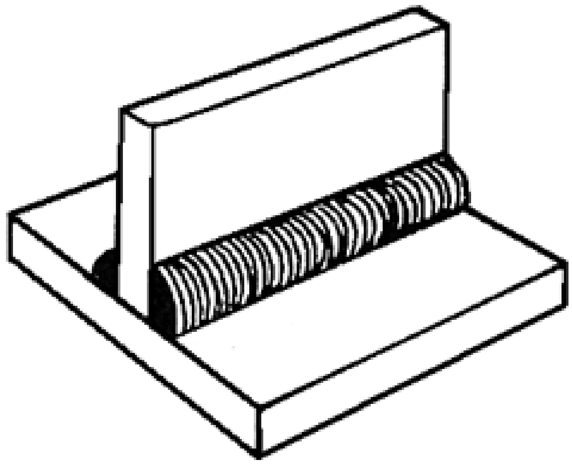
T-JOINT

T- Joint - a joint between two members located approximately at right angles to each other in the form of a T .

Single fillet

Double fillet

Single bevel



LAP JOINT

A lap joint, as the name implies, is made by lapping one piece of metal over another.This is one of the strongest types of joints available; however, for maximum joint efficiency, you should overlap the metals a minimum of three times the thickness of the thinnest member you are joining. Lap joints are commonly used with torch brazing and spot welding applications.

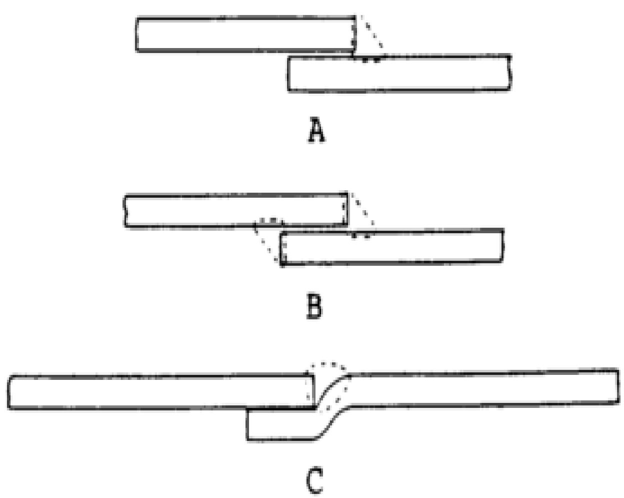
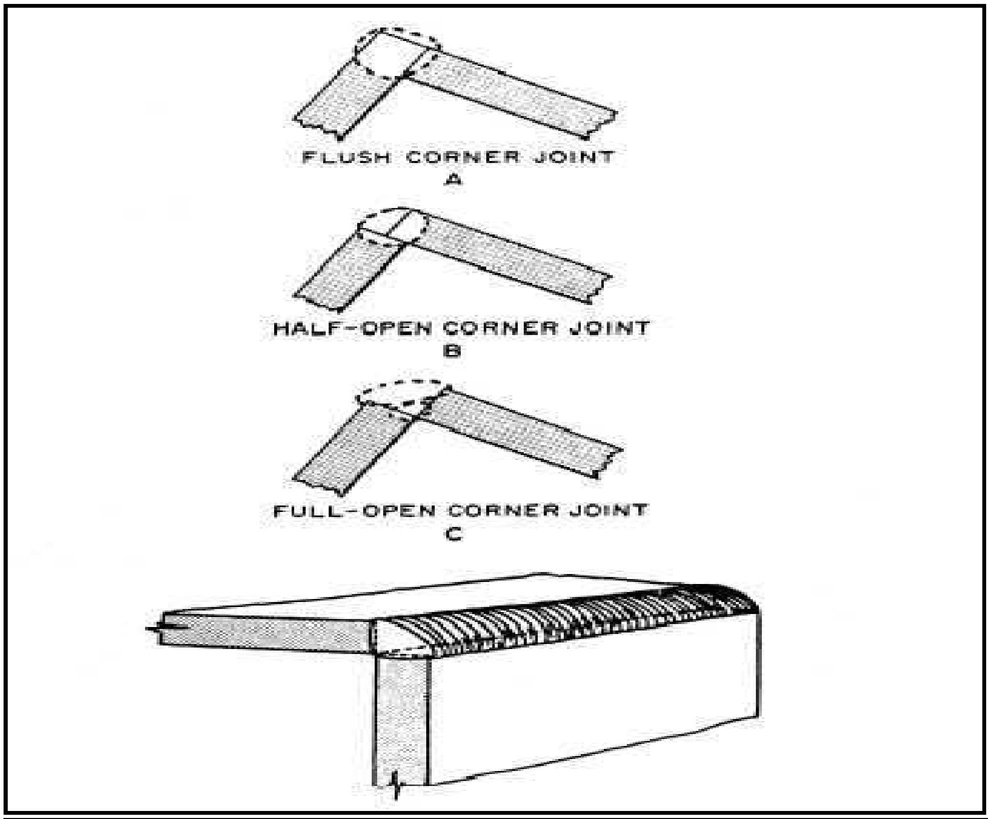


Figure 6-21. Lap joints.

CORNER JOINT

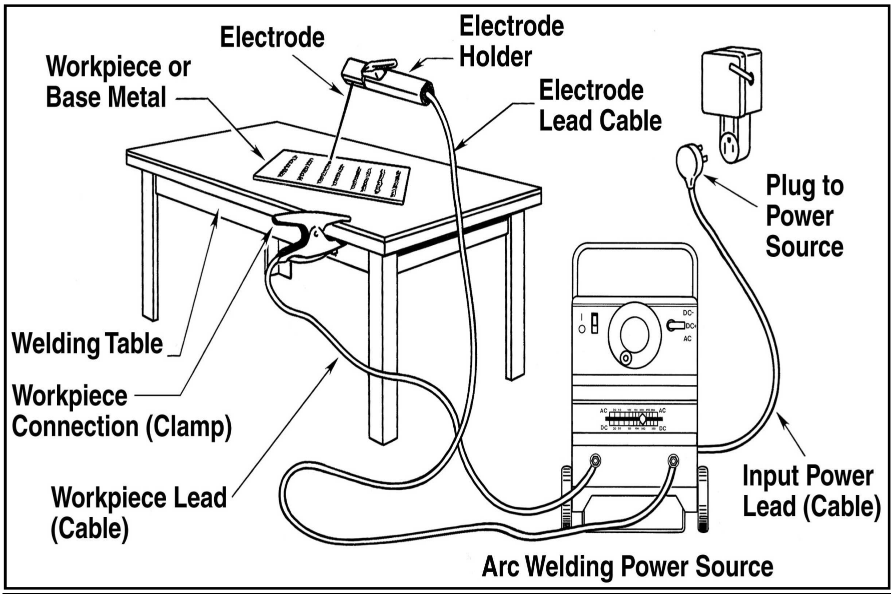
Corner and tee joints are used to join two members located at right angles to each other.In cross section, the corner joint forms an L-shape, and the tee joint has the shape of the letter T. Various joint designs of both types have uses in many types of metal structures.



EDGE JOINT

An edge joint is used to join the edges of two or more members lying in the same plane. In most cases, one of the members is flanged, While this type of joint has some applications in plate work, it is more fix quietly used in sheet metal work An edge joint should only be used for joining metals 1/4 inch or less in thickness that are not subjected to heavy loads.

EQUIPMENT



QUALITY

The most common quality problems associated with SMAW include weld spatter, porosity, poor fusion, shallow penetration, and cracking. Weld spatter, while not affecting the integrity of the weld, damages its appearance and increases cleaning costs. It can be caused by excessively high current, a long arc, or arc blow, a condition associated with direct current characterized by the electric arc being deflected away from the weld pool by magnetic forces. Arc blow can also cause porosity in the weld, as can joint contamination, high welding speed, and a long welding arc, especially when low-hydrogen electrodes are used. Porosity, often not visible without the use of advanced nondestructive testing methods, is a serious concern because it can potentially weaken the weld. Another defect affecting the strength of the weld is poor fusion, though it is often easily visible. It is caused by low current, contaminated joint surfaces, or the use of an improper electrode. Shallow penetration, another detriment to weld strength, can be addressed by decreasing welding speed, increasing the current or using a smaller electrode. Any of these weld-strength-related defects can make the weld prone to cracking, but other factors are involved as well. High carbon, alloy or sulfur content in the base material can lead to cracking, especially if low-hydrogen electrodes and preheating are not employed. Furthermore, the work pieces should not be excessively restrained, as this introduces residual stresses into the weld and can cause cracking as the weld cools and contracts.

SAFETY

SMAW welding, like other welding methods, can be a dangerous and unhealthy practice if proper precautions are not taken. The process uses an open electric arc, which presents a risk of burns which are prevented by personal protective equipment in the form of heavy leather gloves and long sleeve jackets. Additionally, the brightness of the weld area can lead to a condition called arc eye, in which ultraviolet light causes inflammation of the cornea and can burn the retinas of the eyes. Welding helmets with dark face plates are worn to prevent this exposure, and in recent years, new helmet models have been produced that feature a face plate that self-darkens upon exposure to high amounts of UV light. To protect bystanders, especially in industrial environments, transparent welding curtains often surround the welding area. These curtains, made of a polyvinyl chloride plastic film, shield nearby workers from exposure to the UV light from the electric arc, but should not be used to replace the filter glass used in helmets.

In addition, the vaporizing metal and flux materials expose welders to dangerous gases and particulate matter. The smoke produced contains 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. Additionally, gases like carbon dioxide and ozone can form, which can prove dangerous if ventilation is inadequate. Some of the latest welding masks are fitted with an electric powered fan to help disperse harmful fumes.

APPLICATION AND MATERIALS

Shielded metal arc welding is one of the world's most popular welding processes, accounting for over half of all welding in some countries. Because of its versatility and simplicity, it is particularly dominant in the maintenance and repair industry, and is heavily used in the construction of steel structures and in industrial fabrication. In recent years its use has declined as flux-cored arc welding has expanded in the construction industry and gas metal arc welding has become more popular in industrial environments. However, because of the low equipment cost and wide applicability, the process will likely remain popular, especially among amateurs and small businesses where specialized welding processes are uneconomical and unnecessary.

SMAW is often used to weld carbon steel, low and high alloy steel, stainless steel, cast iron, and ductile iron. While less popular for nonferrous materials, it can be used on nickel and copper and their alloys and, in rare cases, on aluminium. The thickness of the material being welded is bounded on the low end primarily by the skill of the welder, but rarely does it drop below 0.05 in (1.5 mm). No upper bound exists: with proper joint preparation and use of multiple passes, materials of virtually unlimited thicknesses can be joined. Furthermore, depending on the electrode used and the skill of the welder, SMAW can be used in any position.

ADVANTAGES OF SHIELDED METAL ARC WELDING (SMAW):

Simple, portable and inexpensive equipment;

Wide variety of metals, welding positions and electrodes are applicable;

Suitable for outdoor applications.

Adaptable to confined spaces and remote locations

Versatility - readily applied to a variety of applications and a wide choice of electrodes

DISADVANTAGES OF SHIELDED METAL ARC WELDING (SMAW):

The process is discontinuous due to limited length of the electrodes;

Weld may contain slag inclusions;

Fumes make difficult the process control.

Likely to be more costly to deposit a given quantity of metal

Current limits are lower than for continuous or automatic processes (reduces deposition rate)

8.16 - IDENTIFY MANUAL OXY-FUEL GAS CUTTING EQUIPMENT

8.16.1 - OXY-ACETYLENE CUTTING

The other side of the dual-purpose nature of gas equipment is the ability to *cut* as well as join metals. The gas torch can make short work of cutting through even large or thick pieces of steel. For sheet metal work you will probably continue to use shears and other hand tools to cut light-gauge material, but being faced with cutting through a half-inch steel plate with a hacksaw will easily convince you of the value of a cutting torch.

The only oxy-acetylene cutting component different from your basic welding setup is the torch itself. The cutting torch has one major difference from the welding torch: it has an extra oxygen supply, operated by a lever instead of a valve.

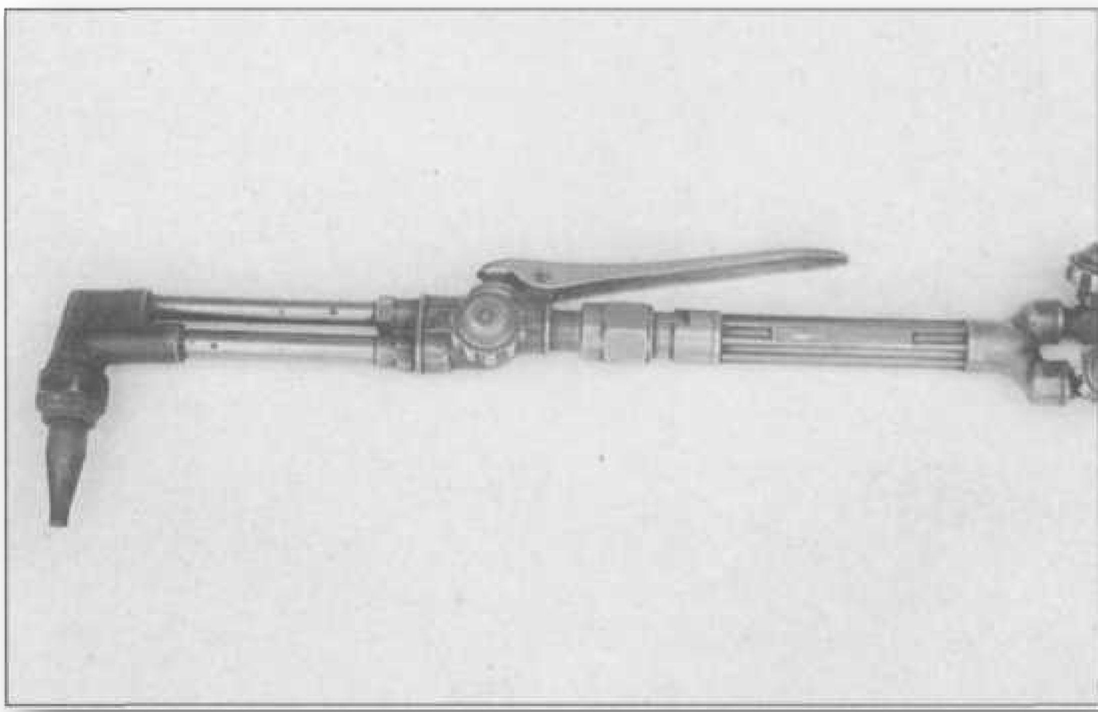


Figure 1: Oxy-Acetylene Cutting Torch

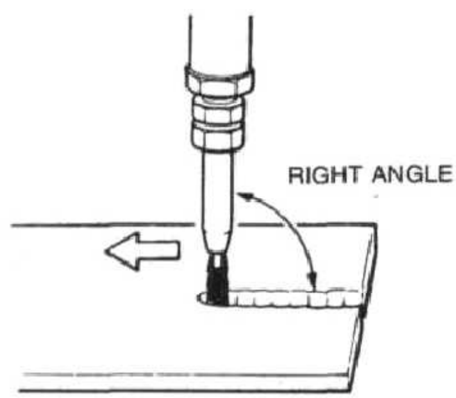
The cutting torch is adjusted for a good flame, and then checked with the extra-oxygen supplied when the cutting lever is depressed. The flame should remain close to neutral. The excess oxygen is what is used to push the molten slag from the kerf (groove) as you cut.

Actually, when you cut steel with a torch, it isn't the flame that is really doing the cutting; it is a strong flow of oxygen that hits a heated part and the oxidation of the metal happens so fast the affected area disintegrates into flying sparks. The basic principle of oxy-acetylene cutting is that the torch tip has several small holes surrounding a central larger hole. The smaller outside holes are where the basic oxy-acetylene flame comes out - actually several small flames. These flames are really used to preheat the metal to be cut.

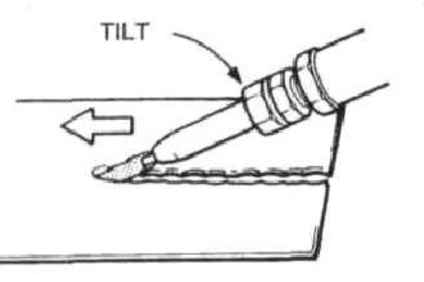
The welder adjusts the gas and oxygen flow on the torch for the proper flames from the pre-heat holes and plays the torch on the end of the piece to be cut. When the end is heated to a cherry red color, the welder presses down on the cutting lever, which activates a strong flow of pure oxygen through the large central hole in the tip. This is the oxygen that really cuts through the metal. Because oxy-acetylene cutting involves a huge shower of sparks from the underside of the metal you're cutting, you must be prepared before cutting. Clear the area around your welding table, have the proper welding attire on (including leather welding gloves), and make sure the area under the test piece is clear of any obstructions.

It's best to support your test piece on some firebrick, leaving the area under the cut line open. If there were any restriction to the flow of sparks under your test piece, molten shrapnel could blow back into the welder’s face.

Mark your cut line using a sharpened piece of soapstone and a straightedge. After marking the cut line, find a piece of tubing or angle-iron that you can clamp down onto the work piece to act as a guide for the torch head.



Cutting Thick Panel



The cutting torch should be held more nearly vertical to the work when cutting heavier metals, and angled back when cutting thinner material like exhaust pipe or sheet metal. Use scraps steel tubing or angle as a brace to guide the torch for steadier cutting.

8.16.2 - SAFETY

1. Eye protection
2. Fuel leakage
3. Safety with cylinders
4. Chemical exposure
5. Flashback

- Wear personal protective equipment.
- Wear welding gloves, helmet, leather apron, welding chaps, leather shoes, welding goggles, and other personal protective equipment to help prevent weld burns and injury.
- Make sure the welding goggles or face shield have at least a No. 4 filter lens.
- Do not wear clothing made of synthetic fibers while welding.
- Fasten cylinders securely.
- Do not handle cylinders roughly.
- Chain cylinders in an upright position to a wall or cart.
- When regulators are not on cylinders, keep safety caps in place. Caps will prevent damage to cylinder valves.
- Never use oil on welding equipment. Oil and grease may ignite spontaneously, when in contact with oxygen.
- Open cylinder valves correctly. Open the valve on the acetylene cylinder no more than three-fourths of a turn so it can be closed quickly in case of emergency. Open the valve on the oxygen tank fully. While welding or cutting, leave the valve wrench in position.
- Keep the tip pointed away from your body.
- Do not saturate your clothing with oxygen or acetylene. Before and while lighting the flame, keep the tip pointed away from your body.
- Light the flame with an approved lighter. Using matches to light the torch brings fingers too close to the tip.
- Set the operating pressure carefully.
- Never use acetylene at a pressure over 15 psi. Follow the manufacturer's recommendations for the correct operating pressures for the metal being welded and for the tip size being used.
- Do not smoke or allow anyone else to smoke near the oxy-fuel gas welder. If fuel gas were to leak from the unit, smoking could provide ignition and cause a fire or an explosion.
- Treat the flame with respect. Keep the flame and heat away from the cylinder, hoses, and people. Never lay down a lighted torch.
- Be sure the flame is out before laying down the torch. Never walk around with a lighted torch.
- Control flashbacks and backfires.
- Make certain that reverse flow-check valves and flash arrestors are installed on the oxygen and acetylene lines.
- Do not leave the work area until the cylinder valves are closed.
- Be sure the cylinder valves are closed and pressure is relieved from the hoses before you leave the work area.
- Never stand in front of a regulator while you are opening a tank valve.
- Do not weld or cut on containers that have held flammable materials.
- Remove regulators and replace protective caps before transporting cylinders.

- Store oxygen cylinders away from acetylene cylinders.
- A non-combustible wall at least 5 feet high should be used to separate cylinders.
- Handle hot metal with pliers or tongs.
- Do not leave hot metal on the welding table because unsuspecting persons may touch it and be burned.
- Check connections for leaking gases.
- To prevent fires or explosions, use soapy water to check connections for leaks.

8.16.3 - EQUIPMENT

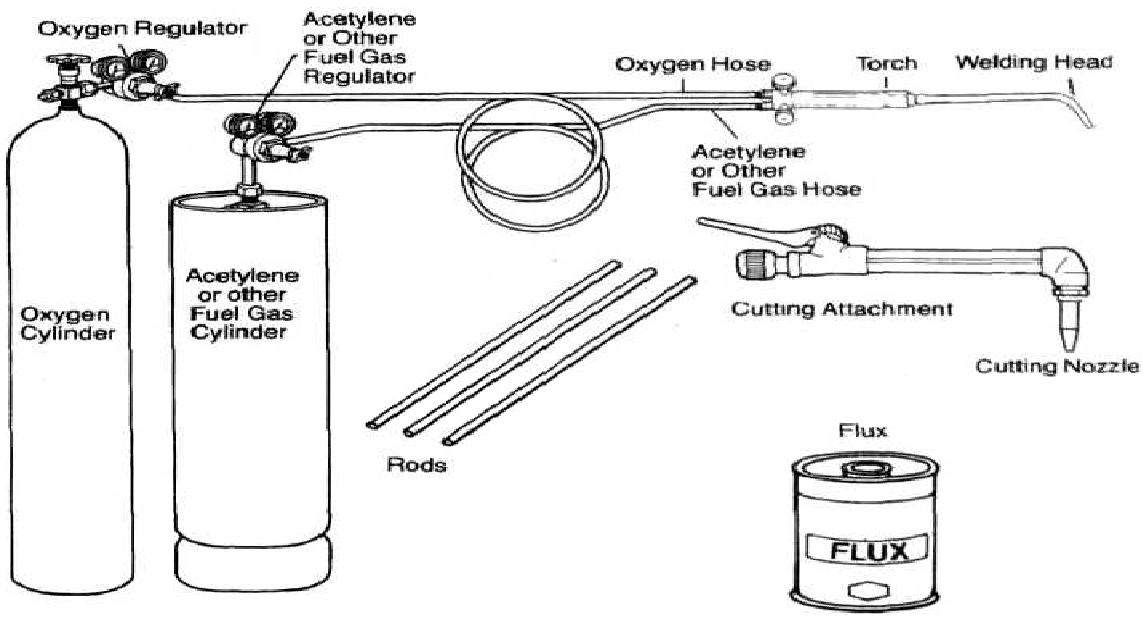
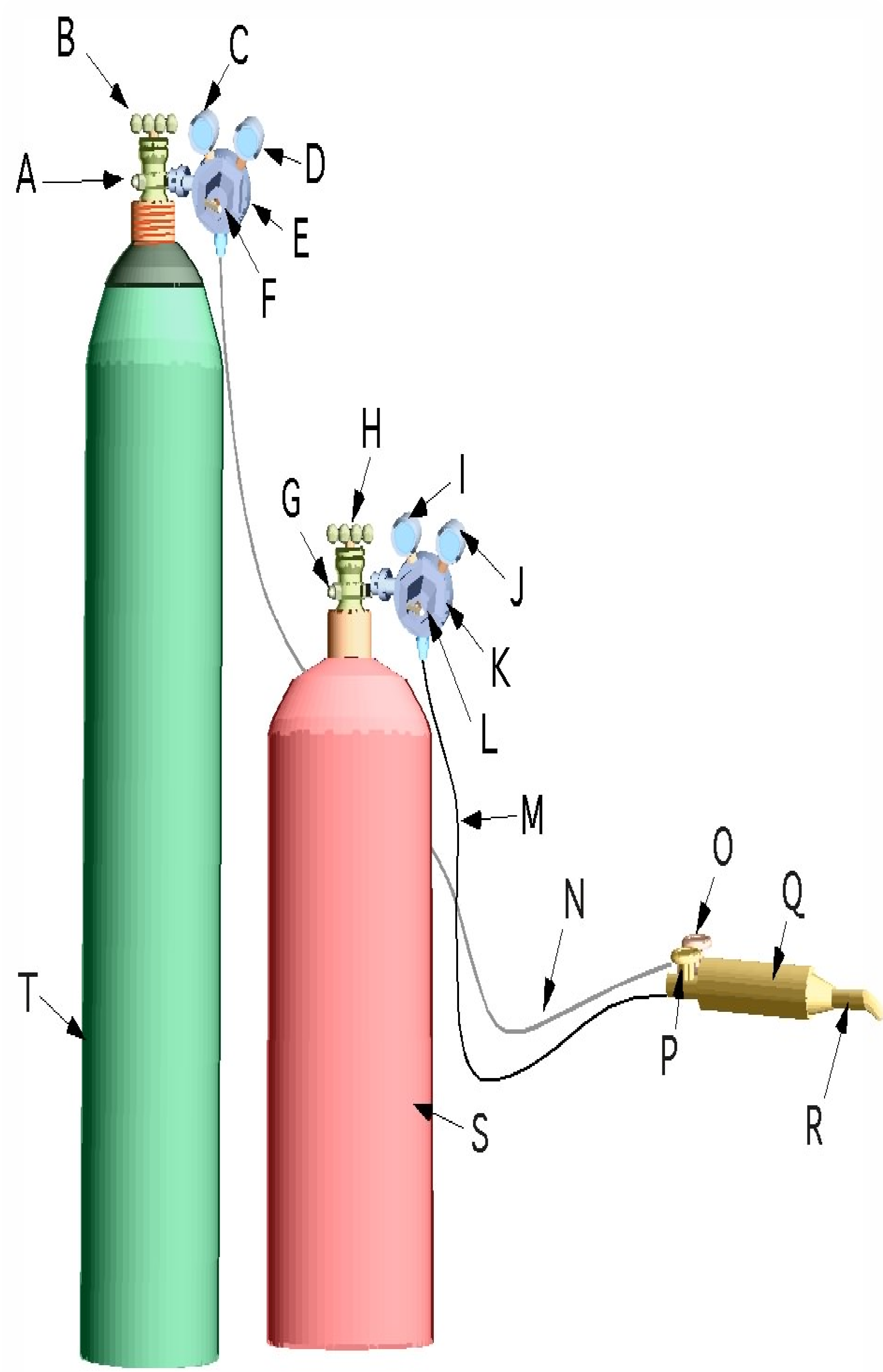


Figure 2: Welding Equipment

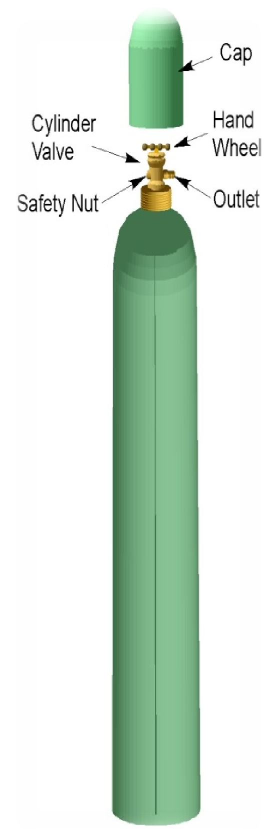
1. Acetylene Cylinder
2. Oxygen Cylinder
3. Regulators
4. Valves
    a. Non- Return Valve
    b. Check Valve
5. Gas Hoses
6. Torches
    a. Welding Torch
    b. Cutting Torch
7. Nozzles
8. Filler Rods

A. Oxygen safety disc
B. Oxygen cylinder valve
C. Oxygen cylinder pressure gauge
D. Oxygen working pressure gauge
E. Oxygen regulator
F. Oxygen regulator adjusting screw
G. Acetylene cylinder safety disc
H. Acetylene cylinder valve
I. Acetylene cylinder pressure gauge
J. Acetylene working pressure gauge
K. Acetylene regulator
L. Acetylene regulator adjusting screw
M. Acetylene hose
N. Oxygen hose
O. Oxygen torch valve
P. Acetylene torch valve
Q. Torch
R. Welding tip
S. Acetylene cylinder
T. Oxygen cylinder



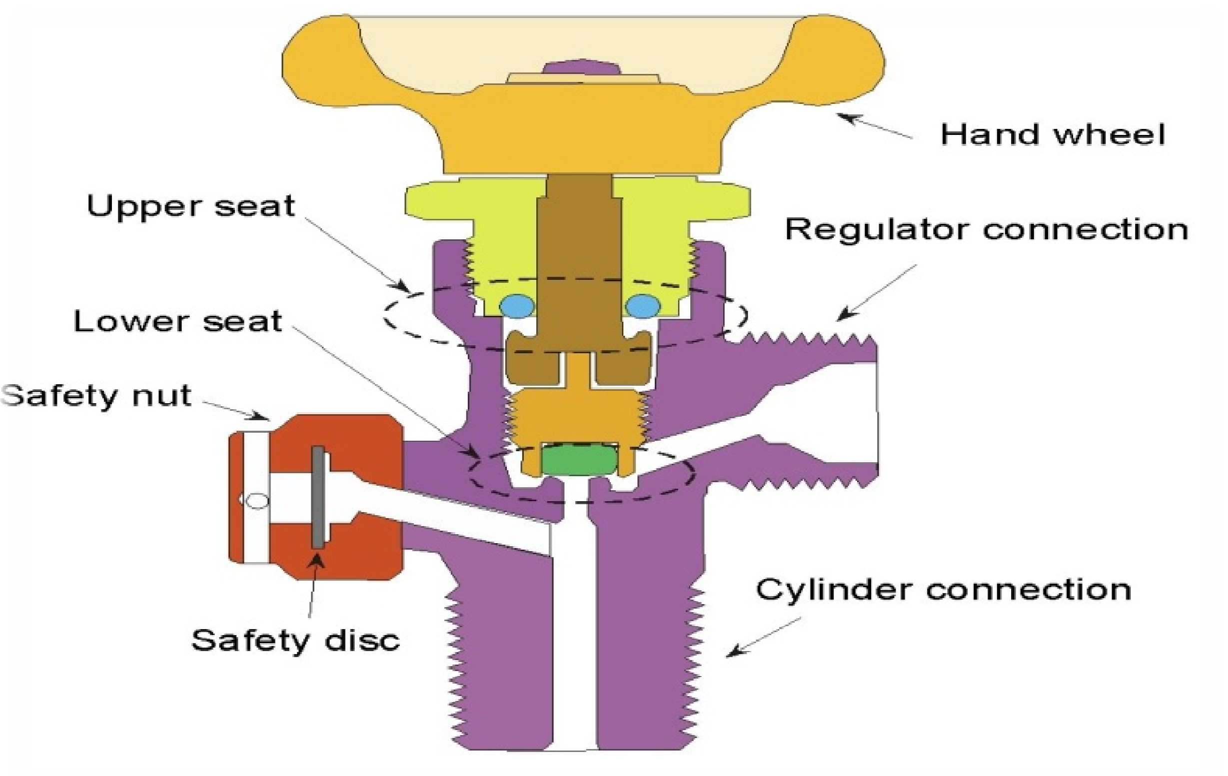
OXYGEN CYLINDER

- One piece, seamless construction.
- Each cylinder has unique serial number and number is recorded in national registry.
- Scheduled inspection required.
- 2,200+ psi when filled
- Safety disc, nut, releases at 3,000 psi.
- Must not be dropped.
- Should not be used as a roller.
- Never use any lubricates on threads or any part of the cylinder.
- Three common sizes are 244, 150 & 80 cubic feet.
- The valve should never be left exposed. It must always have the regulator attached or the cap on.

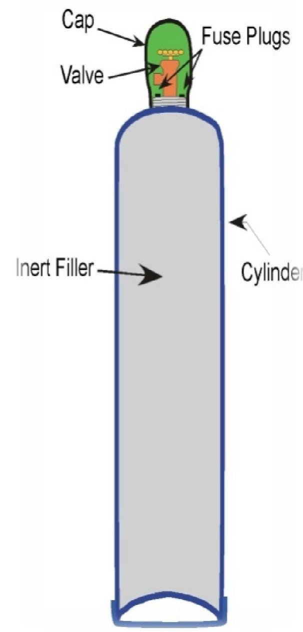


OXYGEN CYLINDER VALVE

- Special double seat valve.
- Must be opened all of the way when in use.
- Right hand threads



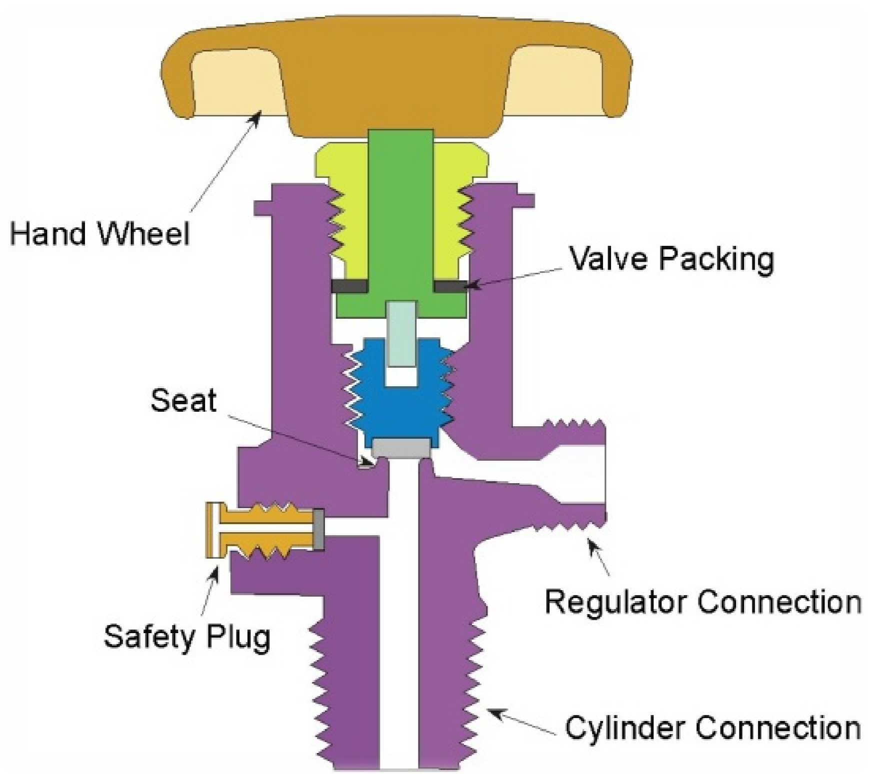
ACETYLENE CYLINDER



- Acetylene cylinders are filled entirely with a porous materials which must be able to stop the propagation of an acetylene decomposition within the cylinder initiated by a backfire or an external heating of the acetylene cylinder.
- 250 psi when filled.
- Protected by fuse plugs that melt at 212 oF.
- The cylinder should be opened only 1/2 to 3/4 of a turn when in use.
- The withdrawal rate in cubic feet per hour should never exceed 1/7 times the cylinder capacity.
- Common sizes are 300, 120 and 75 cubic feet.
- The cylinders must always be used, transported and stored upright.
- Special cylinder because acetylene is unstable above 15 psi.
- Acetylene is shock sensitive.

ACETYLENE CYLINDER VALVE

- Acetylene cylinders are low pressure cylinders, therefore the valve packing can contain the cylinder pressure and only a single seat is used.
- Fuel cylinders are left hand threads.



PRESSURE REGULATORS

- Gas systems must have a pressure regulator to reduce the pressure from the high pressure in the cylinder down to the working pressure.
- Many different designs are used.

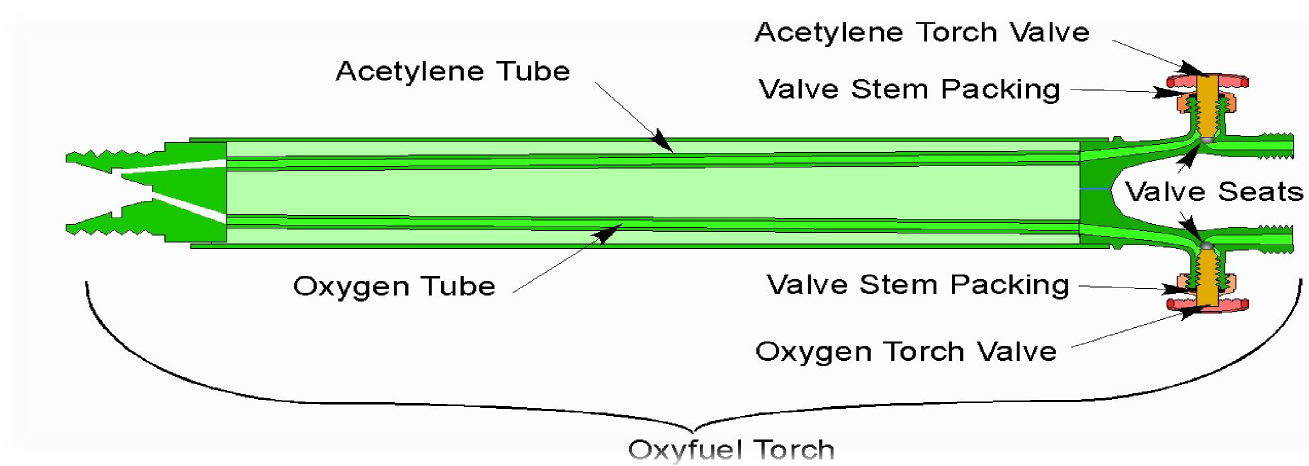
HOSES & CONNECTIONS

- Requires special nonporous hoses.
- Connections
  - Oxygen: right hand
  - Acetylene: left hand
- Hoses should be protected from hot metal and physical damage.

Green: oxygen

Red or Black: fuel gas

OXY-FUEL TORCH

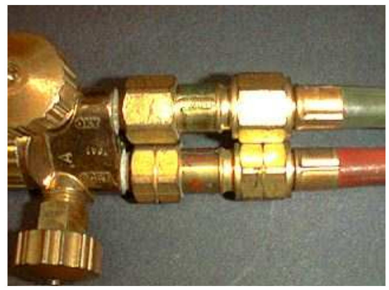


- The oxy-fuel torch is the handle for holding and controlling the system.
- It the controls the flow rate of the gasses and delivers them to the welding tip, or cutting attachment.
- The torch valves should only be hand secured, not tightened.

- The valve stem packing should be tightened if gasses leak past or when the torch valve becomes too easy to turn.

CHECK VALVES & FLASHBACK ARRESTORS

- Safety codes require torches to have check valves and flashback arresters.
- If not included, they should be added in line between the regulator and the torch.



8.17 - IDENTIFY GASES USED FOR MANUAL OXY-FUEL GAS CUTTING

When gasses are used in other types of welding, they are usually of the inert kind, like argon, CO2 or helium, which are involved in the welding process only to keep the molten weld puddle clear of impurities from the air during formation. In oxy-acetylene welding/cutting, however, the gases are what make the flame itself. Acetylene gas is quite flammable, and combined with oxygen, which by itself does not burn but speeds up the oxidation or burning of any other fuel, makes one of the hottest possible gas flames (5600-6300° F),suitable for the rapid welding, cutting or heating of most ferrous and non-ferrous materials. Although all compressed gasses pose some shop hazards because of the pressure inside the bottles, oxygen and acetylene are considerably more dangerous to work around, and require much more caution and close attention to safety rules.

8.17.1 - OXYGEN

Oxygen, while not exactly flammable by itself, is the gas necessary both for us to breathe and for any type of combustion to take place. Combustion is really nothing more than very rapid oxidation, and if pure oxygen is directed at something flammable, a fire can start very easily. Some inexperienced welders have been known to dust off their work clothes with their unlit gas torch, but the extra oxygen that gets into their clothes can make it so flammable that any tiny spark could start the clothes on fire. Likewise, oxygen gas must be kept away from things like oily rags or any petroleum products. Oxygen as used in welding equipment is generally stored in high-pressure, 1/4-inch-thick-walled steel cylinders s2200 psi. While oxygen may be important for our lungs to work, it can still be dangerous if too much is introduced to the bloodstream. For this reason, oxygen gas should be kept away from open cuts such as you might have on your hands.

8.17.2 - ACETYLENE

Acetylene gas on the other hand is flammable to the point of being explosive and is also mildly poisonous, causing nausea and headaches if you breathe much of it.

Pressure in the acetylene gas cylinder is much less than with oxygen, at 250-325 psi, but the construction of the cylinder is different. Acetylene cylinders are shorter and fatter than oxygen bottles, and are constructed in two halves. Because acetylene is unstable at high pressures, the only way to get sufficient quantities into the standard bottle is to dissolve the acetylene in another medium. In welding tanks, the two halves are filled with an asbestos/cement mixture and then welded together. After baking, the material forms a honeycomb inside the tank.

Liquid acetone is put into the tank because it will absorb 25 times its own volume in acetylene gas, thus stabilizing the acetylene.

8.17.3 - STORAGE

Because of the differences in chemical action and storage of oxygen and acetylene, there must be no mix-ups between the two. For this reason, the tanks are made in different proportions and different colors; the acetylene bottle has only left-hand threads, and the hoses for each bottle are different, i.e. red hose for acetylene, green hose for oxygen.