TVET CERTIFICATE IV IN WELDING

BRAZING

WLDBR401

Perform Brazing

Competence

Credits: 8

Learning hours: 80

Sector: Mining and Manufacturing

Sub-sector: Welding

Module Note Issue date: July, 2020

Purpose statement

This specific module describes the performance outcomes, skills and knowledge required to prepare and join different types and shapes of metals by the use of brazing process.

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Learning unit 1 – Analyze the brazing work.

LO 1.1 Identify the work

Brazing is a joining process wherein metals are bonded together using a filler metal with a melting (liquidus) temperature greater than 450 °C (840 °F), but lower than the melting temperature of the base metal. Filler metals are generally alloying of silver (Ag), aluminum (Al), gold (Au), copper (Cu), cobalt (Co) or nickel (Ni).

The filler metal is brought slightly above its melting (liquidus) 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 workpieces together. Brazing is similar to soldering, except the temperatures used to melt the filler metal are higher.

The process of brazing has been known for at least 5000 years and must be one of the oldest of all known metal joining techniques. Brazing was practiced in Sumerian as early as 3000 BC, and by 1500 BC the brazing skill of the Egyptian court jewelers had reached a level of excellence which was the equivalent of anything hand-brazed today. From Egypt, the craft spread along the trade routes eastward into India and China, north-west into the Mediterranean area and through Anatolia into northern and western Europe.

Content /Topic 1: Principles of brazing.

Brazing is a joining process wherein metals are bonded together using a filler material with a melting (liquidus) temperature greater than 450°C (840°F), but lower than the melting temperature of the base metal. The molten filler metal is drawn into the space between the closely adjacent surfaces of the parts to be joined by capillary attraction.

How is soldering different from brazing? Soldering is a joining process where in metals are bonded together using a non-ferrous filler with a melting (liquidus) temperature lower than 450°C (840°F). Whenever the filler metal liquidus is greater than 450°C (840°F), the joining process is considered to be a brazing process rather than a soldering process.

'Solidus', 'Liquidus' and 'Melting Range'

The temperature at which a brazing alloy can be used to produce a joint must be higher than that at which the alloy becomes molten. Thus, the melting point of an alloy is of primary importance. In most cases, brazing alloys do not have a single melting point, but melt over a given temperature range. The temperature at which the alloy begins to melt is called the 'solidus', and the temperature at which the alloy becomes fully molten is called the 'liquidus'.

The temperature interval between the solidus and the liquidus temperatures is called 'the melting range' of the alloy, Good brazing practice requires:

- Proper joint design
- Clean materials
- Correct alloy selection
- A compatible flux or atmosphere
- Controlled heating technique

Content /Topic 2: Advantages and disadvantages of brazing:

A. Advantages of Brazing:

Brazing has many advantages over other metal-joining techniques like welding. They are as follows:

1. 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.
2. Non-similar metals and non-metals (i.e. metalized ceramics) can be brazed together.
3. Brazing produces less thermal distortion than welding due to the uniform heating of a brazed piece.
4. Complex and multi-part assemblies can be brazed cost-effectively. Welded joints must sometimes be ground flush, a costly secondary operation that brazing does not require because it produces a clean joint.
5. Another advantage is that the brazing can be coated or clad for protective purposes.
6. Brazing is easily adapted to mass production and it is easy to automate because the individual process parameters are less sensitive to variation.
7. Brazing is the preferred process for plumbing fixtures, tools, construction equipment, and many consumer products. It is well-suited for automated processes, joining of dissimilar metals, and manufacturing two-piece parts once produced as monolithic, one-piece units.
8. The joining of dissimilar metals, and materials.
9. Very thin material can be brazed which would otherwise be damaged by welding.
10. Inaccessible joints can more easily be brazed.
11. Brazing is easily and more economically automated than many welding processes.

B. Disadvantages of brazing are as follows:

1. The lack of joint strength as compared to a welded joint due to the softer filler metals used. The strength of the brazed joint is likely to be less than that of the base metal(s) but greater than the filler metal.

2. Brazed joints can be damaged under high service temperatures. 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 from that of the base metal, creating an aesthetic disadvantage.

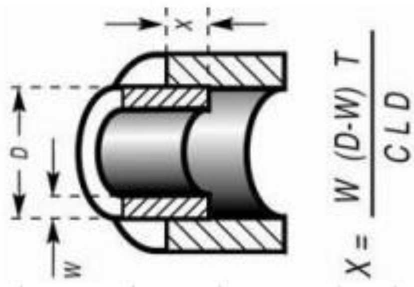
Content /Topic 3: Application of brazing

Brazing and Its Applications. Brazing is defined as a process of joining similar or dissimilar metals in which molten filler metal is drawn by capillary action into the space between closely adjacent surfaces of the parts to be joined. ... Borax (Borax, also known as sodium borate, sodium tetra borate, or disodium tetra borate, is an important boron compound, a mineral, and a salt of boric acid. Powdered borax is white, consisting of soft colorless crystals that dissolve in water) is used as a flux for brazing.

There are various applications of brazing. Some of these are given below:

- **a)** Brazing is used for fastening of pipe fittings, tanks, carbide tips on tools, radiators, heat exchangers, electrical parts, axles, etc.
- **b)** It can join cast metals to wrought metals, dissimilar metals and also porous metal components.
- **c)** It is used to join band saws, parts of bicycle such as frame and rims.

Ten Tips for Designing Braze Joints



Are you looking for high strength, corrosion resistance, electrical conductivity, ductility, hermeticity, good color match, or low-temperature metal joining? These requirements should be considered carefully, because different joint designs and filler metals will dramatically affect the performance of your assembly. Here are some general recommendations and rules when designing a joint for brazing:

1. Basic braze joints are the butt and the lap. A butt joint is simple to prepare, but has limited tensile strength. A lap joint increases the bonding area and changes the stresses from tensile to shear forces to produce a strengthened joint. However, actual results will depend upon the length of the overlap.

2. Joint strength is the product of joint length. Properly designed, the strength of the braze joint can equal or exceed that of the base metal. Generally, a lap area should be at least three times as long as the thickness of the thinner joint member. This rule changes with higher-strength materials.
3. The strongest joints have joint clearances of 0.001-0.005 in. (0.0254-0.127 mm) or typically just a slip fit between parts. Know and maintain your joint clearances.
4. The coefficient of thermal expansion is important when brazing dissimilar metals. Depending on the materials being joined, allow a greater or smaller room temperature clearance so that, at brazing temperature, the clearance is suitable for the filler metal being used.
5. Consider service conditions in joint design and alloy selection. These include: pressure tightness, electrical conductivity, strength, corrosion resistance, service temperature and media contact (e.g. ammonia or salt water). Proper design and filler metal selection ensure joint integrity.
6. For corrosion resistance, select a filler metal containing silver, gold, nickel or palladium elements.
7. Design joints to self-vent. This eliminates flux entrapment and allows expanding air and gases to escape. Joints should also be free of sharp corners and blind holes that can trap flux.
8. Design the joint to prevent concentration of stress from weakening the joint. Where the greatest stress falls, impart flexibility to the heavier member or add strength to the weaker member.
9. For highest-strength joints, use a lap or scarf design to increase joint area. These designs will prevent stress from being concentrated at a single point.
10. Flow rates for filler metals range from very sluggish to extremely fluid. Consider flow rate when choosing a filler metal for larger fillets, to fill a long overlap or for tight or loose joint clearances. Choose the filler metal according to:
    - Service conditions - strength, corrosion and resistance
    - Brazing method - torch, furnace or vacuum
    - Joint design tolerances - tight or loose fit-tips

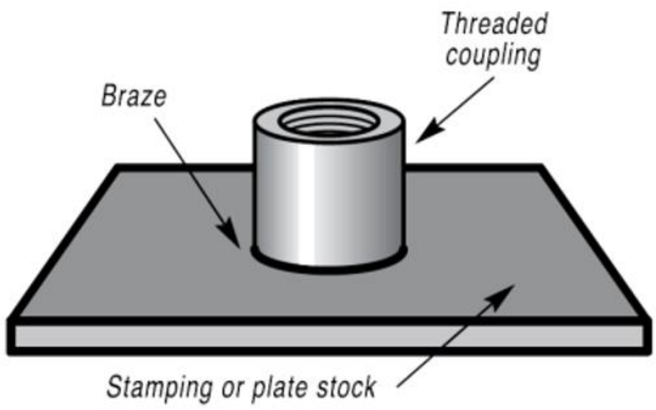
Following these tips will help you achieve successful, robust joints in your assemblies.

Content /Topic 4: Types of brazing work.

A. Plate brazing: So far, we've been talking about brazing as a way of joining two or more metals into a permanent assembly. And we've limited our discussion to the situations where you have a metal assembly in mind from the outset, from initial product concept through finished piece.

A.1. Brazing consideration.

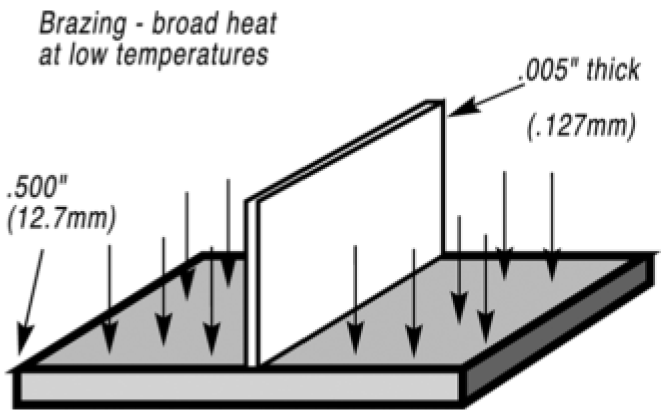
The key factors in deciding in regards to metal-joining will boil down to the size of the parts to be joined, the thickness of the metal sections, configuration of the joint, nature of the base metals, and the number of joints to be made. Let's evaluate each of these brazing considerations.



Welding is usually more suited to the joining of large assemblies than brazing. Why? Because in brazing the heat must be applied to a broad area, often to the entire assembly. And if the assembly is a large one, it's often hard to heat it to the flow point of the filler metal as the heat tends to dissipate faster than you build it up.

You don't meet this limitation in welding. The intense localized heat of welding, sometimes a drawback, becomes an advantage in joining a large assembly. So, does welding's ability to trace a joint.

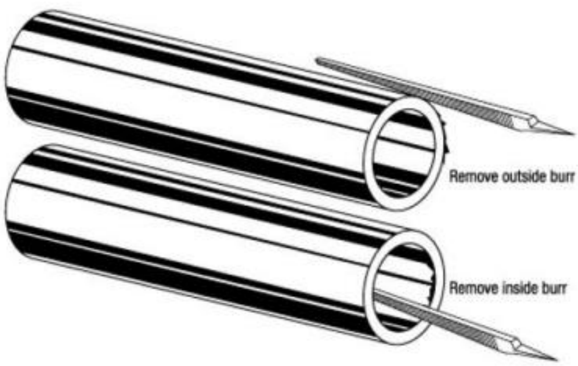
Thickness of base metal sections is an important consideration in selecting your metal joining method. If both sections are relatively thick say .500" (12.7mm) either welding or brazing can produce a strong joint. But if you want to make a T-joint, bonding a .005" (.127mm) thick sheet metal section to half-inch stock, for example, brazing is the better choice. The intense heat of welding is likely to burn through, or at least warp, the thin section. The broader heat and lower temperature of brazing allows you to join the sections without warpage or metal distortion.



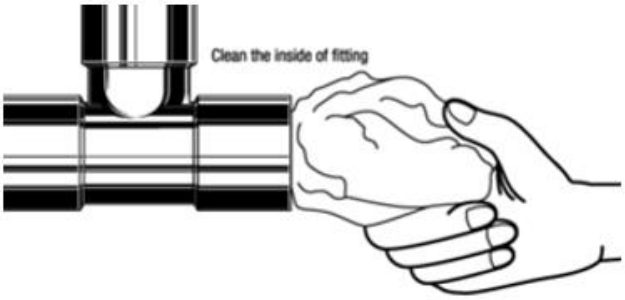
B. Pipe brazing: The American Welding Society (AWS), defines brazing as a group of joining processes that produce coalescence of materials by heating them to the brazing temperature and by using a filler metal (solder) having a liquidus above 840°F (450°C), and below the solidus of the base metals. Procedures for Brazing Pipe and Tubing are:

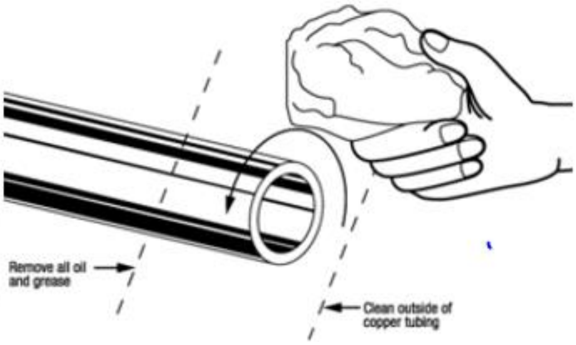
B.1 Cut pipe square.

Cut to the exact length required using a tube cutter or hacksaw. if a hacksaw is used, a sawing fixture should also be used to ensure square cuts. remove all inside and outside burrs with a reamer, file, or other sharp edge scraping tool. if tube is out of round, it should be brought to true dimension and roundness with a sizing tool.



1. Clean tube end and inside surface of fitting. The joint surface areas should be clean and free from oil, grease, or oxide contamination. Surfaces may be 6 properly cleaned for brazing by brushing with a stainless-steel wire brush or by a stiff rubbing with emery cloth or Scotch Brite®. If oil or grease is present, clean with a commercial solvent. Remember to remove small foreign particles such as emery dust, by wiping with a clean dry cloth. The joint surface MUST be clean.

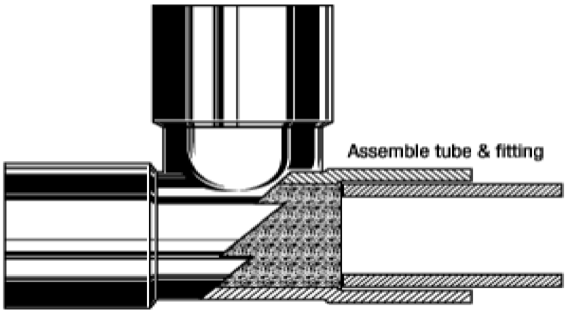




2. **Select brazing alloy**: Refer to the Harris Filler Metal Selection Guide for recommended brazing Filler Metal selection. When brazing copper to copper, alloys such as Dynaflow, Stay-Silv5, or Stay-Silv15 are recommended. These alloys contain phosphorus and are self- fluxing on copper. When brazing brass or bronze fittings, Stay-Silv white flux is required with these alloys. When brazing iron, steel or other ferrous metals, select one of the Stay-Silv brazing alloys such as Safety-Silv 45 or Safety-Silv 56 with Safety-Silv white brazing flux. Do not use phosphorus bearing alloys as the joint may be brittle.

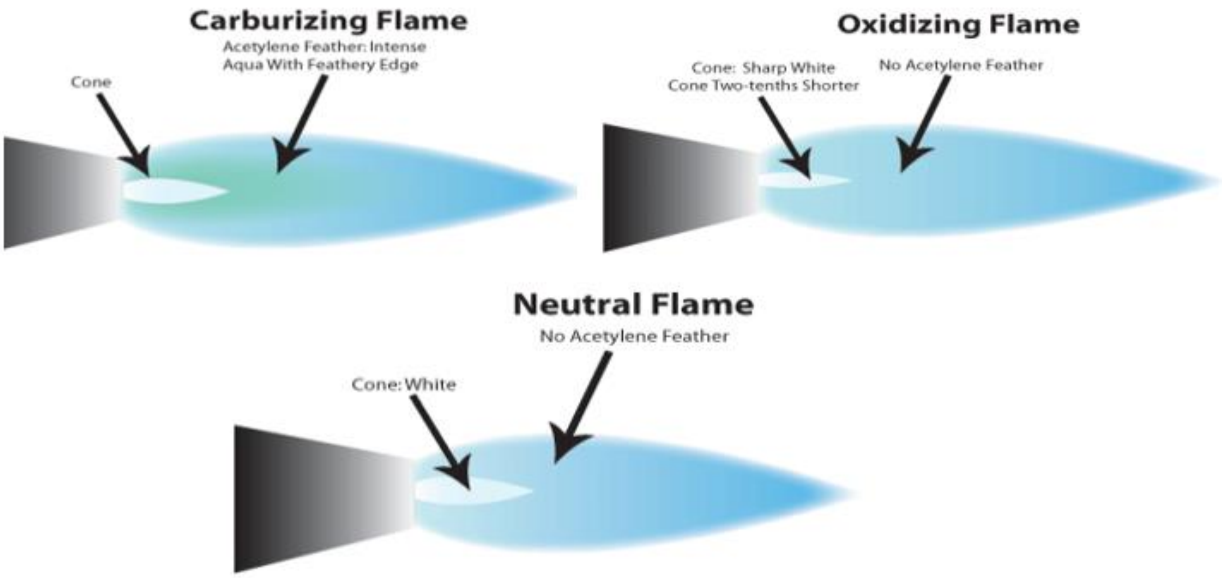
3. **Proper fluxing:** is important because the flux absorbs oxides formed during heating and promotes the flow of filler metal. When using Stay-Silv white flux, apply it only with a brush. To prevent excess flux residue inside refrigeration lines, apply a thin layer of flux to only the male tubing. Insert the tube into the fitting and, if possible, revolve the fitting once or twice on the tube to ensure uniform coverage. Stay-Silv white brazing flux is available in 7 Oz, 1/4 lb, 1/2 lb, 1 lb, 5 lb. jars, 25 lb. and 60 lb pails.

4. **Assemble the tube and fittings:** Insert the fluxed tube end into the fitting. Maintain support to ensure the proper alignment until the brazing alloy solidifies. After brazing maintain support for a few seconds (or more) depending upon the size of the joint area.



The assembly is now ready to braze, using brazing alloy in rod, wire, or in coil form manually fed into the joint.

5. **Adjust torch flame:** Oxygen/Acetylene. For most brazing jobs using oxygen-acetylene gases, a carburizing or neutral flame should be used. The neutral flame has a well-defined inner cone See diagram. Avoid an oxidizing flame. Excess acetylene removes surface oxides from the copper. The copper will appear bright rather than having a dull or blackened surface due to an improper oxidizing flame.

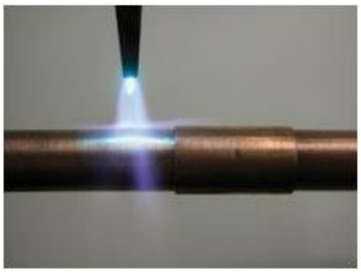


Air/acetylene using swirl combustion tips.

Brazing with air/ acetylene torches is a popular alternative to oxygen mixed fuel gas. The fuel gas flow aspirates air into a mixer that contains an internal vane that spins the gas to improve combustion and increase flame temperature.

If the tank has a delivery pressure gauge set the delivery pressure at 14-15 psi. If the tank has only a contents gauge delivery pressure is preset at the factory so open the regulator adjusting screw all the way by turning it clockwise until it "bottoms."
Open the torch value. Opening about 3/4 of a turn will provide sufficient fuel gas delivery. Do not try to meter pressure, (reducing the flame), by using the torch handle valve. If a higher or lower flame is required change to a different tip size.

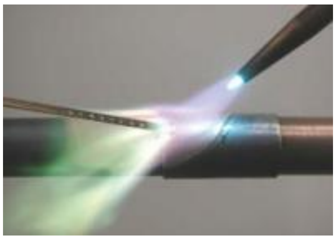
6. **Heating the joint area:** Always keep the torch in short motion. Then...
   - **i.** Start heating the tube, first applying flame at a point just adjacent to the fitting. Work the flame alternately around the tube and fitting until both reach brazing temperatures before applying the brazing filler metal.



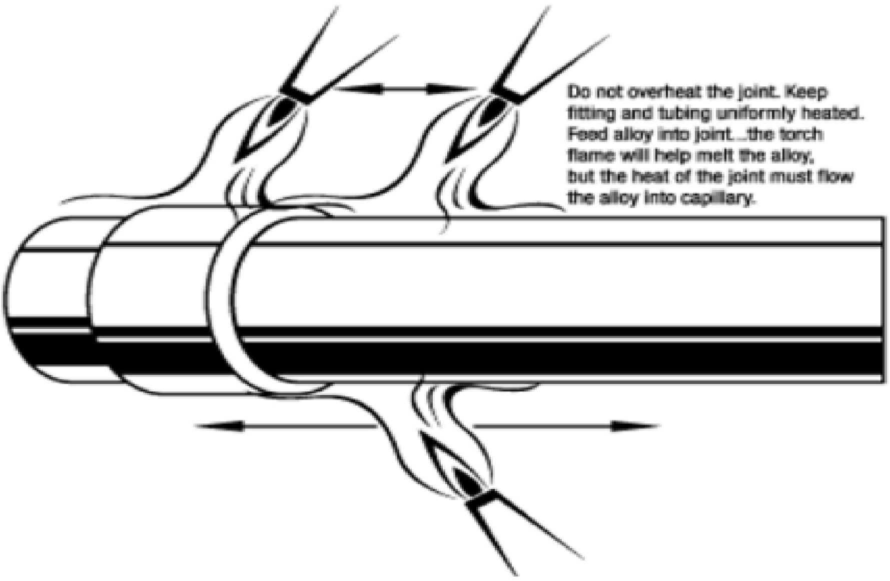

   - **ii.** When a flux is used, it will be a good temperature guide. Continue heating the tube until the flux passes the "bubbling" temperature range and becomes quiet, completely fluid and transparent and has the appearance of clear water.

   - iii. Direct the flame from the tube to the flange-base of the fitting and heat until the flux that remains in the fitting is also completely fluid.

   - **iv.** Sweep the flame back and forth along the axis of the assembled joint, tube, and fitting to get and then maintain uniform heat in both parts.



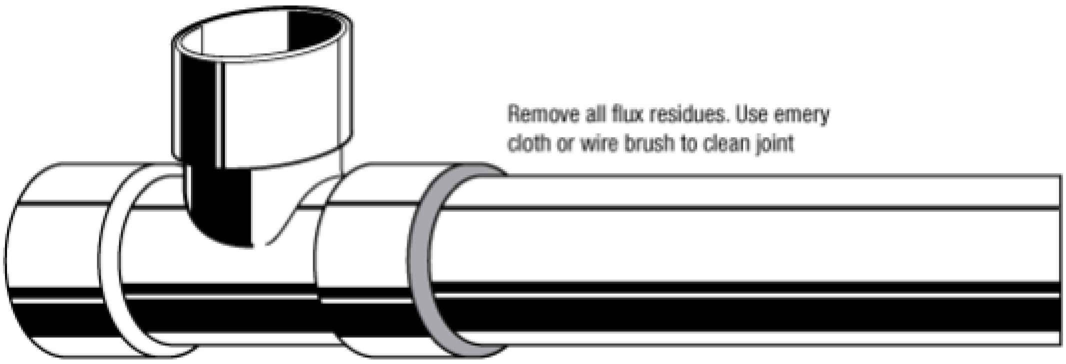
7. **Apply the brazing alloy:** Feed the alloy into the joint between the tube and the fitting. Only after the base metals have been heated to brazing temperatures should the filler metal be added. At that time, the flame may be detected momentarily to the tip of the filler metal to begin the melting process. Always keep both the fitting and the tube heated by playing the flame over the tube and the fitting as the brazing alloy is drawn into the joint. The brazing alloy will diffuse into and completely fill all joint areas. Do not continue feeding brazing alloy after the joint area is filled. Excess fillets do not improve the quality or the dependability of the braze and are a waste of material.



a) **When making vertical alloy-up joints:** Heat the tube first, then apply heat to the fitting. It is important to bring both pieces up to temperature evenly. Keep the flame directed toward the fitting. If the tube is overheated, the brazing alloy may run down the tube rather than into the joint.

b) **When making horizontal joints:** Heat the circumference of the tube first, and then apply heat to the fitting. Deciding where to start feeding the alloy will depend on the size of the pipe and operator preference. On large diameter pipe, however, sometimes the best approach is to start at the bottom of the pipe. As the alloy solidifies, it will create a "dam" and help prevent the brazing alloy from running out of the joint as the remainder of the connection is filled. When adding alloy, make sure both the pipe and fitting are up to temperature.

8. **Clean after brazing:** All fluxes residues must be removed for inspection and pressure testing. Immediately after the brazing alloy has set, quench or apply a wet brush or swab to crack and remove the flux residues. Use emery cloth or a wire brush if necessary.



C. **Dissimilar materials** can be described as: "**materials** or **material** combinations that are difficult to join, either because of their individual chemical compositions or because of large differences in physical properties between the two **materials** being joined.

D. **Standard brazing rods**: Brazing Rods for Joining Copper, Brass and Bronze must be Packaged in Convenient Plastic Tubes and Color-Coded Caps for Easy Composition Identification.

D. 1. 15 % Silver Brazing Rods:

- 15% Silver, 5% Phosphorus, remainder Copper
- Best alloy at filling gaps when close fit-ups cannot be made
- Highest joint ductility and strength in HVAC-R applications
- Phosphorus acts as a fluxing agent when joining copper to copper. When joining brass use Worthington Brazing Flux.
- Solidus Temperature: 1190°F, 643°C.
- Liquidus Temperature: 1475°F, 802°C
- Recommended Brazing Range: 1300-1500°F, 705-815°C
- Meets AWS BCup-5.

D.2. SilTron 15 Brazing Rods:

- Patented formulation
- Lower melting temperature, less oxidation and brighter finish than BCuP-5

- Phosphorus acts as a fluxing agent when joining copper to copper. When joining brass use Worthington Brazing Flux. - Solidus Temperature: 1044°F, 562°C
- Liquidus Temperature: 1348°F, 729°C - Recommended Brazing Range: 1250-1370°F, 678-743°C

D.3. 6% Silver Brazing Rods:

- 6% Silver, 7.5% Phosphorus, remainder Copper
- Similar to 15% silver phosphorus copper with the ability to fill gaps and form fillets without adversely affecting strength.
- Phosphorus acts as a fluxing agent when joining copper to copper. When joining brass use Worthington Brazing Flux.
- Solidus Temperature: 1190°F, 643°C
- Liquidus Temperature: 1325°F, 718°C
- Recommended Brazing Range: 1275-1450°F, 690-790°C
- Meets AWS BCuP-4 12

D.4. Power Glide Brazing Rods:

- Proprietary formulation
- Power Glide is an economical alternative to 15% silver. It melts and performs similar to BCuP-5 alloy.
- 6% Silver, 6.1% Phosphorus, remainder copper.
- Solidus Temperature: 1190°F, 643°C
- Liquidus Temperature: 1465°F, 796°C
- Recommended Brazing Range: 1275-1550°F, 691-840°C
- Direct cross-reference to Dynaflow

D.5. 5% Silver Brazing Rods:

- 5% Silver, 6% Phosphorus, remainder Copper
- Similar to 15% silphos with the ability to fill gaps and form fillets without adversely affecting strength - Phosphorus acts as a fluxing agent when joining copper to copper. When joining brass use Worthington Brazing Flux.
- Solidus Temperature: 1190°F, 643°C
- Liquidus Temperature: 1495°F, 813°C
- Recommended Brazing Range: 1325-1500°F, 720-815°C
- Meets AWS BCuP-3

D.6. 2% Silver Brazing Rods:

- 2% Silver, 7% Phosphorus, remainder Copper

- Phosphorus acts as a fluxing agent when joining copper to copper. When joining brass use Worthington Brazing Flux.
- Solidus Temperature: 1190°F, 643°C
- Liquidus Temperature: 1450°F, 788°C
- Recommended Brazing Range: 1350-1500°F, 730-815°C
- Meets AWS BCuP-6

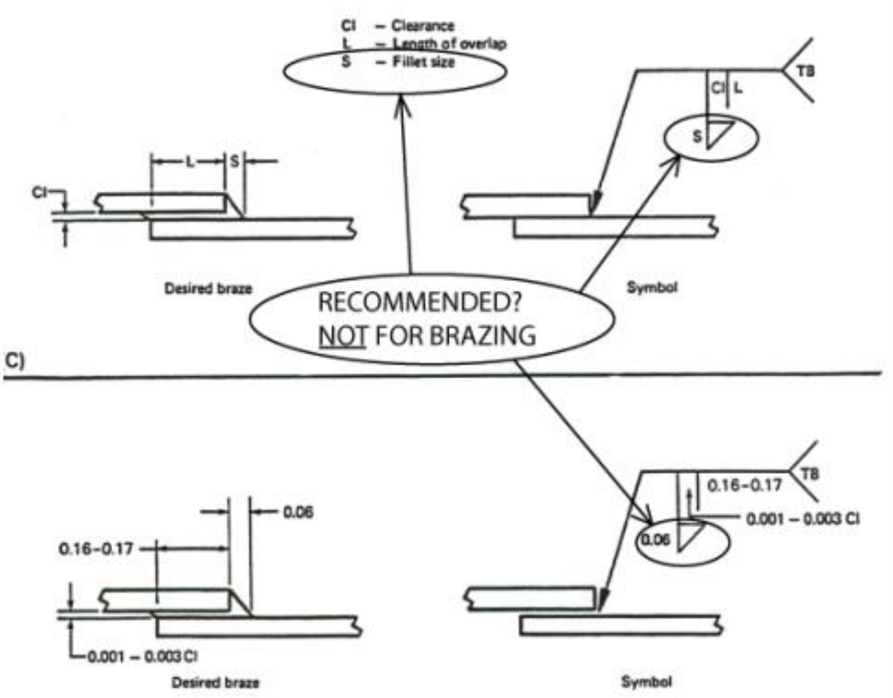
D.7. 0% Silver Brazing Rods:

- 0% Silver, 7.25% Phosphorus, remainder Copper
- Phosphorus acts as a fluxing agent when joining copper to copper. When joining brass use Worthington Brazing Flux.
- Very fluid, medium temperature brazing alloy
- Solidus Temperature: 1310°F, 710°C
- Liquidus Temperature: 1460°F, 793°C
- Recommended Brazing Range: 1350-1550°F, 730-845°C
- Meets AWS BCuP-2

LO 1.2 – Perform hand draft drawing

Content /Topic 1: Brazing symbols

The American Welding Society (AWS) document that is most commonly used for specifying how to properly place such requirements on a drawing is AWS A2.4 “Standard Symbols for Welding, Brazing and Nondestructive Examination.



Remember, if you specify a dimension, then it must be verified by inspection. What would then happen if a braze fillet turned out to be a bit smaller than the allowed dimensional range specified on a drawing? If properly handled, it would need to be sent back to the brazing department for additional brazing filler metal (BFM) to be applied. What if the added BFM now caused the dimension of the braze fillet after re-brazing to be just a little bit larger than the maximum allowed by the tolerance spread shown on the drawing? The excess would have to be ground away to bring the dimension into allowed tolerance bands shown on the drawing.

A. Use braze-fillets to help spread stress at edge of joint?

NO! In my opinion (and long experience) never use braze fillets to "help spread the stress" at the edge of the joint. That is a VERY poor design criterion to use in a brazed-joint design. "Stress spreading" is strictly a function of the design of the base-metal components, which must be designed in such a way that stresses do not concentrate at the corner/edge of a brazed joint. You NEVER intentionally build up a braze fillet to help "spread the stress" at the edge of a joint. That's "weld think," and although it might work for a weld fillet, it will NOT be effective for braze joints and can actually be harmful to a brazed joint.

B. What size and shape should a braze-fillet be?

A braze fillet should ideally be very small and show a concave shape at the edge. Large braze fillets are castings with inherent weakness.

LO 1.3 - Estimate the cost

Content /Topic 1: Elements of Bill of quantity

1. **Types of materials:** is the king or categories of the material. Example: tubes 20*20 made in mild steel
2. **Quantity of materials**: is the total of materials in number. Example: 20 tubes
3. **Unit price**: the cost of a single material, good or service. Example: 4500 frw
4. **Tax:** a compulsory contribution to state revenue, levied by the government on workers' income and business profits, or added to the cost of some goods, services, and transactions. Example: 21%
5. **Labor**: is the cost payed for the worker (who's working). Example: 1000frw per day
6. **Depreciation of equipment**: a statement or account giving the characteristics of someone or something.
7. **Transports:** is the money given for taking goods from one location to another. Examples: 5000 frw
8. **Total Cost**: is the total amount of all activity in money.

No	Designation	Specification	Quantity	UNIT PRICE	TOTAL PRICE
1	HS	6000mm	4p	400F	1200frws
2	Sheet metal	1,5mm	1/2p	200f	200frws
3	Tubes	20x20mm	1p	400f	400frws
4	Tee bar	2x20mm	1/4	400f	400frws
5	Flat bar	2x20mm	1/4	400f	400frws
6	Cutting disc	230x3x22 ,23mm	1p	2000f	2000frws
7	Grinding disc		1/2p	2000f	1000frws
Sub-Total					5600frws
Labor Cost (Main d'oeuvre)			(5600fx35) :100=9260f		
G.TOTAL			**6526frws**		

Prepared by……………………………………. Approved by……………………………….

Learning unit 2 – Organize the workplace.

LO 2.1. Identify the equipment and tools for brazing process

Content /Topic 1: Workshop Layout.

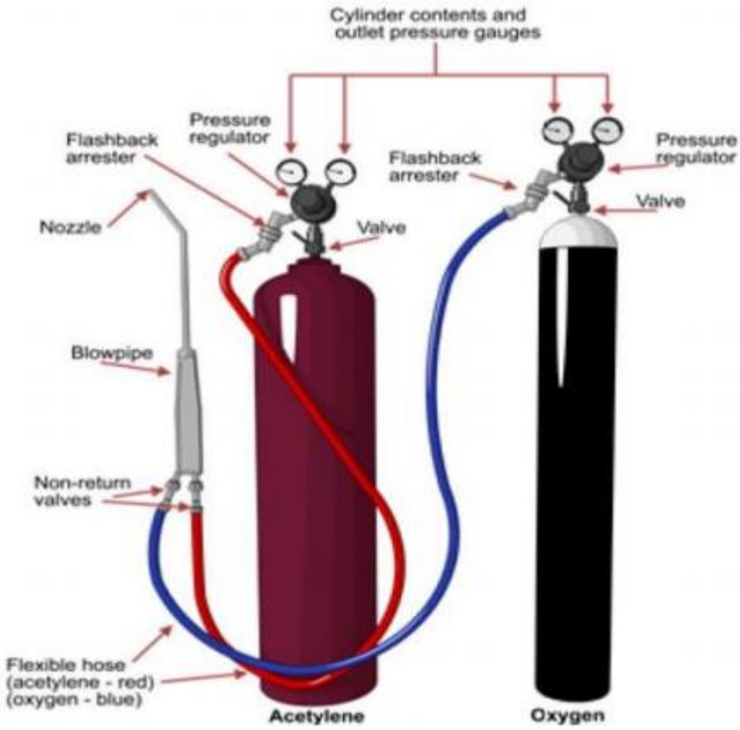
One of the best ways to avoid workplace strains and sprains is to design a workspace that reduces injury risk factors. Factors to consider include:

1. **Height of the work to be performed**: Workers should be able to sit or stand erect without having to lean forward. Storage should be organized such that the heaviest items are stored between knee and shoulder height to avoid bending and reaching overhead.
2. **Standing workstations:** Long-term standing can place excessive stress on the back and legs. Where long-term standing is required, a footrest or rail, resilient floor mats, height-adjustable chairs or stools, and opportunities for workers to change positions should be provided.
3. **Seated workstations:** Chairs should be fully adjustable, especially where workstations are used by multiple users.
4. **Overhead storage:** If items must be stored overhead, a warehouse ladder, stepstool or other means should be provided to achieve better lifting conditions.

Content /Topic 2: Equipment and tools used in torch brazing.

Brazing requires three basic items: a heat source, filler metal, and flux. The heating method for a brazing operation largely determines the equipment required.

Identifying Torch Brazing Equipment Oxy/acetylene equipment is portable and easy to use. It comprises oxygen and acetylene gases stored under pressure in steel cylinders. The cylinders should be fitted with regulators, to control the pressure and flow of gases. Flexible hoses are used to connect the regulators to the torch or blowpipe. Specially designed safety devices, called flame traps or “Flashback Arrestors” are fitted between the hoses and the regulators. Flashback arrestors prevent flames generated by a 'flashback' from reaching the cylinders



A. Gas cylinder

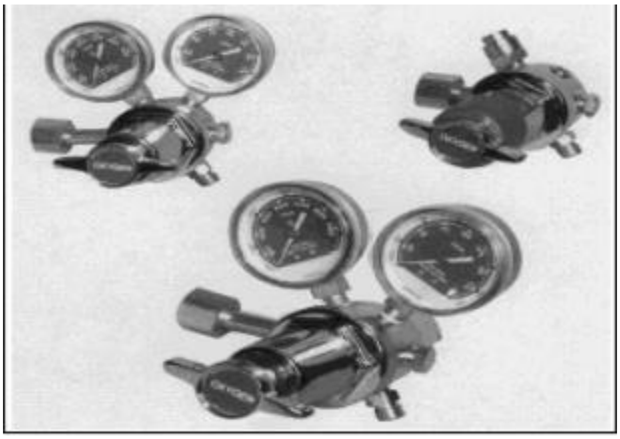
A.1. Oxygen cylinder

- Oxygen is stored within cylinders of various sizes and pressures ranging from 2000-2640 PSI. (Pounds Per square inch)
- Oxygen cylinders are forged from solid armor plate steel. No part of the cylinder may be less than 1/4" thick.
- Cylinders are then tested to over 3,300 PSI using a (NDE) hydrostatic pressure test.

A.2. Acetylene cylinder

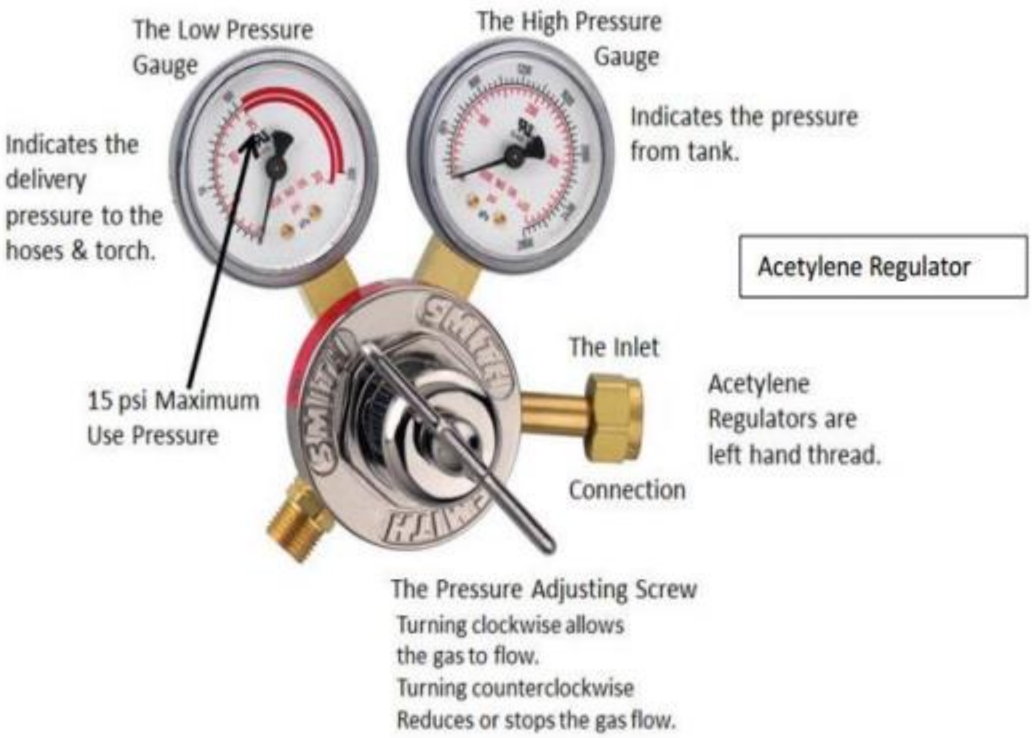
- Acetylene is stored in cylinders specially designed for this purpose only.
- Acetylene is extremely unstable in its pure form at pressure above 15 PSI (Pounds per Square Inch)
- Acetone is also present within the cylinder to stabilize the acetylene.
- Acetylene cylinders should always be stored in the upright position to prevent the acetone form escaping thus causing the acetylene to become unstable.
- Cylinders have safety (Fuse) plugs in the top and bottom designed to melt at 212° F (100 °C).

B. Pressure regulators: Pressure regulators are used on both the oxygen and fuel cylinders. They are required to 16 reduce cylinder pressure to a usable working pressure. They are designed to maintain a constant delivery pressure regardless of pressure changes in the cylinders. Most regulators have a gauge for cylinder pressure and working pressure its function is to reduce high storage cylinder pressure to lower working pressure. Two gauges are mounted on the regulator. The high-pressure gauge indicates the pressure in the oxygen or fuel cylinder (pressure into the regulator). The low-pressure gauge indicates the regulated hose or working pressure.



B.1. Oxygen pressure regulator: although similar in design, the oxygen and acetylene (fuel) regulators are not interchangeable. An oxygen regulator has right-hand threads on both the inlet and outlet fittings and generally has green color. The gauges are calibrated with high reading numbers. An oxygen regulator is shown in Figure.

B.2. Acetylene pressure regulator: The fuel regulator has left-hand threads on both the inlet and outlet fitting and generally has red markings. The gauges are calibrated with lower reading numbers. An acetylene regulator is shown in Figure.



C. Hoses: Hoses are made in rubber and linen braid. They are flexible, durable, resistant to gas and oil and able to withstand pressures up to 400 psi (2760 kPa). The hoses may be individual lines, but most often the oxygen and fuel hoses are bonded together. Position the hoses to avoid damage from the flame, hot slag, welding sparks, falling steel and traffic. Hoses should be checked periodically for physical damage.

Identification of oxygen and fuel hoses are as follow:

C.1. Oxygen Hose

- Connections have right-hand thread.
- The color of the hose is green or blue.

C.2. Acetylene Hose

- Connections have left-hand thread.
- The color of hoses s red or maroon

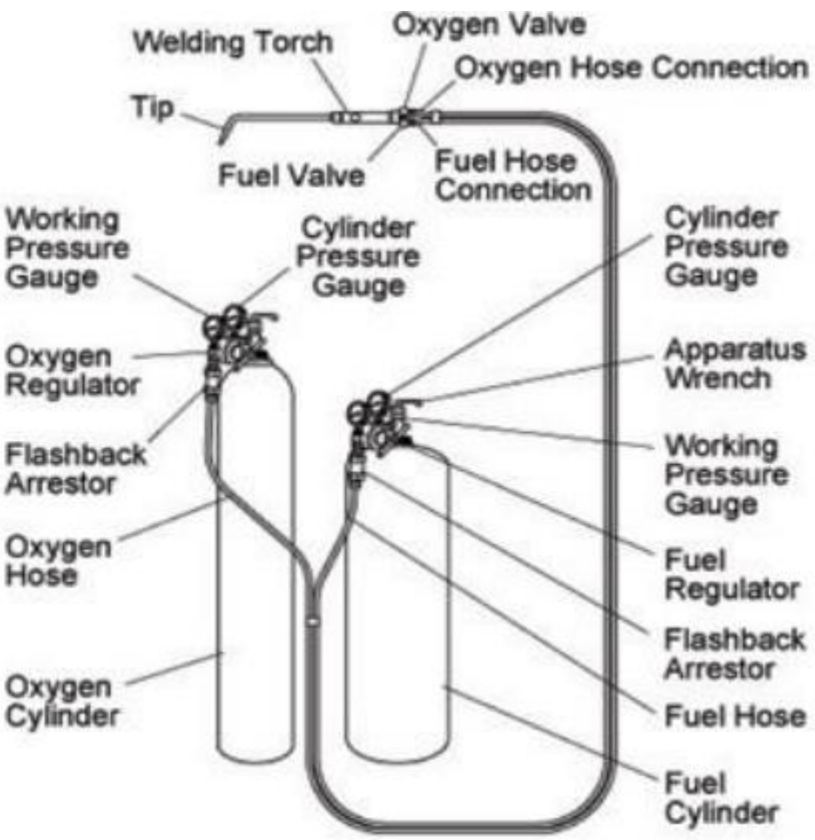
D. Accessories used in Oxy-acetylene gas welding

1) Spark lighter
2) Welding goggles
3) Tong
4) Wire brush
5) Nozzle cleaner
6) Cylinder key

7) Spanner

Content /Topic 3: Assembly of the equipment

1. Separately purge both **oxygen** and **fuel gas** lines.
2. Open **fuel gas** valve 1/2 turn.
3. Ignite flame with striker.
4. Increase **fuel gas** flow until flame leaves end of tip and no smoke is present.
5. Decrease until flame goes back to tip.
6. Open **oxygen** valve and adjust to neutral flame.
7. Depress **oxygen** lever and make necessary adjustments.



Content /Topic 4: Setting gas pressure

Regulator **Oxygen** and **Acetylene**, set until the **pressure** matching with what do you want or for **acetylene** 5 to 7 **psi** and **Oxygen** 7 to 10 **psi**. The third open valve in the torch, first **acetylene** after that you can open **oxygen** valve. If the **gas** has out from nozzle you can use lighter and light the torch**.**

LO 2.2. Identify the types of metals

Content /Topic 1: Ferrous metals

A. **Wrought iron**: Is a tough malleable form of iron suitable for forging or rolling rather than casting, obtained by puddling pig iron while molten. It is nearly pure but contains some slag in the form of filaments.
Wrought iron is an iron alloy with a very low carbon (less than 0.08%) content for cast iron (2.1% to 4%). It is a semi-fused mass of iron with fibrous slag inclusions (up to 2% by weight), which gives it a "grain" resembling wood that is visible when it is bent to the point of failure. Wrought iron is tough, malleable, ductile, corrosion resistant and easily welded. Before the development of effective methods of steelmaking and the availability of large quantities of steel, wrought iron was the most common form of malleable iron. It was given the name wrought because it was hammered, rolled or otherwise worked while hot enough to expel molten slag.

B. **Mild steel:** Mild steel contains approximately 0.05 – 0.25% carbon making it malleable and ductile. Mild steel has a relatively low tensile strength, but it is cheap and easy to form; surface hardness can be increased through carburizing.

C. **Stainless steel**: In metallurgy, stainless steel, also known as inox steel or inox from french inoxydable (inoxidizable), is a steel alloy with a minimum of 10.5% chromium content by mass. Stainless steels are notable for their corrosion resistance, which increases with increasing chromium content. Molybdenum additions increase corrosion resistance in reducing acids and against pitting attack in chloride solutions. Stainless steel differs from carbon steel due to the presence of chromium. Unprotected carbon steel rusts readily when exposed to the combination of air and moisture.

D. **Cast iron:** Cast iron is a group of iron-carbon alloys with a carbon content greater than 2%. Its usefulness derives from its relatively low melting temperature. The alloy constituents affect its color when fractured: white cast iron has carbide impurities which allow cracks to pass straight through, grey cast iron has graphite flakes which deflect a passing crack and initiate countless new cracks as the material breaks, and ductile cast iron has spherical graphite "nodules" which stop the crack from further progressing.

Content /Topic 2: Nonferrous metals.

1. **Copper**: Copper is a chemical element with symbol Cu and atomic number 29. It is a soft, malleable, and ductile metal with very high thermal and electrical conductivity. A freshly exposed surface of pure copper has a reddish-orange color.

2. **Aluminum:** Aluminum is a chemical element with symbol Al and atomic number 13. It is a silvery white, soft, nonmagnetic, ductile metal. By mass, aluminum makes up about 8% of the Earth's crust; it is the third most abundant element after oxygen and silicon and the most abundant metal in the crust. Aluminum metal is so chemically reactive that native specimens are rare and limited to extreme reducing environments. Instead, it is found combined in over 270 different minerals.

3. **Brass:** Brass is a metallic alloy that is made of copper and zinc. The proportions of zinc and copper can vary to create different types of brass alloys with varying mechanical and electrical properties.
   In contrast, bronze is an alloy of copper and tin. Both bronze and brass may include small proportions of a range of other elements including arsenic, lead, phosphorus, aluminum, manganese, and silicon. The distinction is largely historical.

   Brass is used for decoration for its bright gold-like appearance; for applications where, low friction is required such as locks, gears, bearings, door knobs, valves for plumbing, electrical applications; and extensively in brass musical instruments such as horns and bells where a combination of high workability (historically with hand tools) and durability is desired. It is also used in zippers. Brass is often used in situations in which it is important that sparks not be struck, such as in fittings and tools used near flammable or explosive materials.

4. **Bronze** is an alloy consisting primarily of copper, commonly with about 12% tin and often with the addition of other metals (such as aluminum, manganese, nickel or zinc) and sometimes non-metals or metalloids such as arsenic, phosphorus or silicon.

5. **Tin:** Tin is a chemical element with symbol Sn (from Latin: sternum) and atomic number 50. It is a post-transition metal in group 14 of the periodic table. It is obtained chiefly from the mineral cassiterite, which contains tin dioxide, $SnO2$.

6. **Zinc:** Zinc is a bluish-white, moderately hard metal. It is brittle at room temperature and at temperatures above 150°C, being workable only in the range between 100°C and 150°C. It is an active metal and will displace hydrogen even from dilute acids. The principal use of zinc is for the galvanizing of iron sheets or wires.

7. **Lead:** Lead is a bluish-white lustrous metal. It is very soft, highly malleable, ductile, and a relatively poor conductor of electricity. It is very resistant to corrosion but

tarnishes upon exposure to air. Lead pipes bearing the insignia of Roman emperors, used as drains from the baths, are still in service.

8. **Inconel and Monel:** In the most basic terms Inconel is a nickel-chromium alloy whereas Monel is a nickel-copper alloy. Both metals are commonly used in applications with extreme heat, high temperature corrosion, and generally severe conditions. Inconel 601is the metal for the job in this case.

Content /Topic 3: Composition and uses of ferrous and non-ferrous metals.

Ferrous metals contain iron. Examples are cast iron, mild steel, medium carbon steel, high carbon steel, stainless steel and high-speed steel. But **non-ferrous metals** are Generally more expensive than ferrous metals, non-ferrous metals are used because of desirable properties such as low weight (e.g. aluminium), higher conductivity (e.g. copper), non-magnetic property or resistance to corrosion (e.g. zinc). Non-ferrous metals are usually refined through electrolysis.

Application (Use) of ferrous metals	Application (Use) of non-ferrous metals
– Structural (buildings structures, concrete reinforcements). – Automotive (Chassis, engine parts, drive train, body parts). – Marine (ship hulls, structure, engines). – Defense (Tanks, weapons). – Consumer Products (appliances, recreational vehicles, toys, utensils and tools	– Residential, – Commercial, – Industrial industry – Aluminum for Aircraft Frames – Magnesium Transmissions – Titanium for Golf Clubs – Zinc in Electrical Hardware – Bronze Gears – Architectural (Aluminium windows & doors) – Automotive (Aluminium Engine blocks, copper wiring, mag wheels). – Marine (brass/bronze fitting, bearing propellers). – Defense (brass shell casings). – Consumer Products (electrical wiring, utensils, jewelry, electronics).

LO 2.3. Identify the fluxes.

Content /Topic 1: Types of brazing fluxes

1. **Rosin:** Flux is a very important part of soldering. Flux is necessary to reduce the oxides that tend to form whenever you have hot metals in contact with the air. In electronics, we use a rosin-core solder or a mild solder or water-soluble solder.
   Rosin fluxes are categorized by grades of activity: **L** for low, **M** for moderate, and **H** for high.

2. **Organic**: Fluxes with low solids, sometimes as little as 1-2%, are called low solids flux, low-residue flux, or no clean flux. They are often composed of weak organic acids, with addition of small amount of rosin or other resins. Organic fluxes are unsuitable for flame soldering and flame brazing, as they tend to char and impair solder flow.

3. **Inorganic:** contain components playing the same role as in organic fluxes. They are more often used in brazing and other high-temperature applications, where organic fluxes have insufficient thermal stability the recommended brazing flux is Silver Brazing Paste Flux.

Content /Topic 2: Properties and composition of fluxes.

1. **Activity:** the ability to dissolve existing oxides on the metal surface and promote wetting with solder. Highly active fluxes are often of acidic and/or corrosive nature.

2. **Corrosivity**: the promotion of corrosion by the flux and its residues. Most active fluxes tend to be corrosive at room temperature.
3. **Cleanability:** the difficulty of removal of flux and its residues after the soldering operation. Fluxes with higher content of solids tend to leave larger number of residues; thermal decomposition of some vehicles also leads to formation of difficult-to-clean, polymerized and possibly even charred deposits (a problem especially for hand soldering).
4. **Residue tack:** the stickiness of the surface of the flux residue. When not removed, the flux residue should have smooth, hard surface. Tacky surfaces tend to accumulate dust and particulates, which causes issues with electrical resistance; the particles themselves can be conductive or they can be hygroscopic or corrosive.
5. **Volatility:** this property has to be balanced to facilitate easy removal of solvents during the preheating phase but to not require too frequent replenishing of solvent in the process equipment.
6. **Viscosity:** especially important for solder pastes, which have to be easy to apply but also thick enough to stay in place without spreading to undesired locations. Solder pastes may also function as a temporary adhesive for keeping electronic parts in place before and during soldering. Fluxes applied by e.g. foam require low viscosity.
7. **Flammability:** relevant especially for glycol-based vehicles and for organic solvents. Flux vapors tend to have low auto ignition temperature and present a risk of a flash fire when the flux comes in contact with a hot surface.
8. **Conductivity**: some fluxes remain conductive after soldering if not cleaned properly, leading to random malfunctions on circuits with high impedances. Different types of fluxes are differently prone to cause these issues.

A. Organic fluxes typically consist of four major components (composition):

i. **Activators:** chemicals disrupting/dissolving the metal oxides. Their role is to expose unoxidized, easily wettable metal surface and aid soldering by other means, e.g. by exchange reactions with the base metals.
   - Highly active fluxes contain chemicals that are corrosive at room temperature.
   - Milder activators begin to react with oxides only at elevated temperature.

ii. **Vehicles:** high-temperature tolerant chemicals in the form of non-volatile liquids or solids with suitable melting point; they are generally liquid at soldering temperatures. Their role is to act as an oxygen barrier to protect the hot metal surface against oxidation, to dissolve the reaction products of activators and oxides and carry them away from the metal surface, and to facilitate heat transfer.

iii. **Solvents:** added to facilitate processing and deposition to the joint. Solvents are typically dried out during preheating before the soldering operation; incomplete solvent removal may lead to boiling off and spattering of solder paste particles or molten solder.

iv. **Additives:** numerous other chemicals modifying the flux properties.

Content /Topic 2: Form of fluxes.

A. **Liquid:** The liquid flux removes oxidation buildup in copper and solder. Liquid flux also reduces surface tension which allows the solder to flow free and evenly along the surface of the application. Apply liquid flux when soldering for sturdy and clean solder joints.

B. **Solid/powder:** Solids flux, solids flux theory, Settling. The terms "settling", "sedimentation" is used in practice for several theoretically different facets of the processes (free and hindered settling, thickening). In activated sludge samples, settling can be observed as movement of liquid-solid interface downwards in time.

C. **Paste:** A solder paste is essentially powder metal solder suspended in a thick medium called flux. Flux is added to act as a temporary adhesive, holding the components until the soldering process melts the solder and fuses the parts together. The paste is a gray, putty-like material.

Content /Topic 3: Functions of fluxes.

Brazing requires flux to stop any oxides or similar contaminants from forming during the process, and flux increases both the flow of the filler metal and its ability to stick to the base metal. Flux helps form a strong joint by bringing the filler metal into immediate contact with the adjoining base metals and permitting the filler to penetrate the pores of the metal. Carefully select the flux for each brazing operation; read the manufacturer's label for the type of metal than can be brazed with the flux. Consider the following three factors:

- Base metal or metals.
- Brazing filler metal.
- Source of heat.

In high-temperature metal joining processes (welding, brazing and soldering), the primary purpose of flux is to prevent oxidation of the base and filler materials. for example, tin-lead solder attaches very well to copper, but poorly to the various oxides of copper, which form quickly at soldering temperatures.

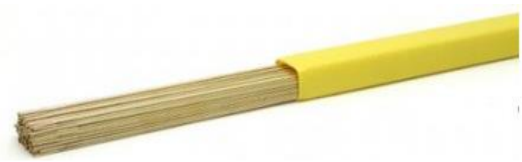
LO 2.4 Identify the brazing rods.

Content /Topic 1: Properties, compositions, and use of the brazing rod.

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. Brazing filler metals (rods) include the following composition elements:

i. Aluminum-silicon
ii. Copper
iii. Copper-phosphorus
iv. Magnesium
v. Silver
vi. Nickel alloys
vii. Gold alloys

A.1. Plain Silicon Bronze Brazing Rods – (2.5KG Pack): Is Original multi-purpose, low temperature rod for brazing and bronze welding of steels, cast iron, copper and its alloys. Ideally suited for general mild steel work, galvanized steel and dissimilar metal applications.



A.2. Fluxed Silicon Bronze Brazing Rods – (2.5KG Pack): This rod is Free flowing flux impregnated brazing rod and is Ideal for brazing clean mild steel.

A.3. Coated Silicon Bronze Brazing Rods (2.5 kg pack): This rod is Sif Bronze No.1 with a full flux coating providing the added benefit of faster, continuous brazing through not having to flux-dip and is ideally suited for general mild steel work, galvanized steel and dissimilar metal applications.

A.4. Plain Ni Bronze Brazing Rods – (2.5KG Pack): This Brazing rod containing 9 nickel, for use on cast iron, copper alloys, stainless and alloy steels and Excellent wearing properties and high strength making it ideal for tubular structures, brazing cutting tips and as a general maintenance alloy.

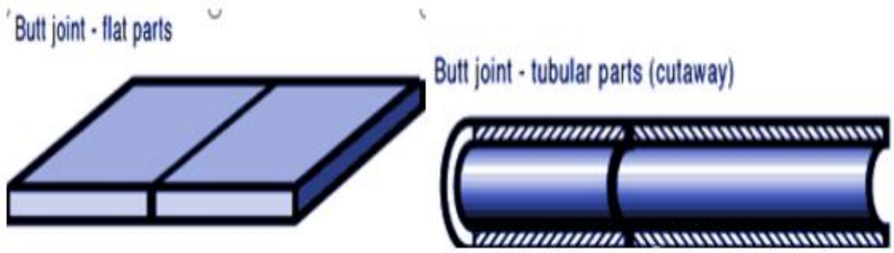
Learning unit 3 – Perform brazed joint.

LO 3.1. Perform the work pieces' preparation

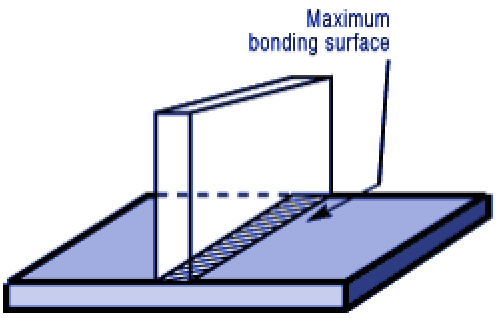
Content /Topic 1: Brazing joint design

Brazing has become an indispensable tool of the metal fabrication engineer, one of the main advantages of this production method being its versatility associated with the large variety of the brazing materials and techniques available to the prospective user.

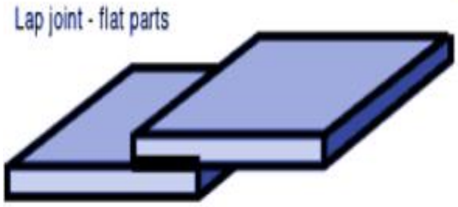
There are many kinds of joints. But our problem is simplified by the fact that there are only two basic types - the butt and the lap. The rest are essentially modifications of these two. Let's look first at the butt joint, both for flat and tubular parts.

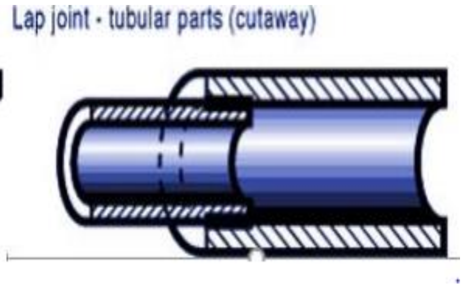


As you can see, the butt joint gives you the advantage of a single thickness at the joint. Preparation of this type of joint is usually simple, and the joint will have sufficient tensile strength for a good many applications. However, the strength of the butt joint does have limitations. It depends, in part, on the amount of bonding surface, and in a butt joint the bonding area can't be any larger than the cross-section of the thinner member.

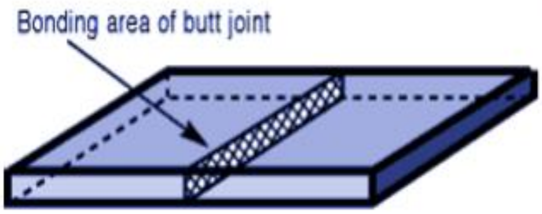


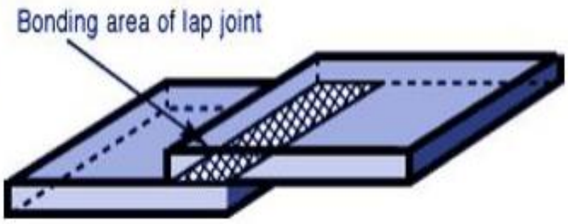
Now let's compare this with the lap joint, both for flat and tubular parts.



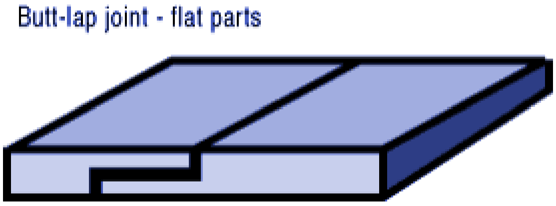


The first thing you'll notice is that, for a given thickness of base metals, the bonding area of the lap joint can be larger than that of the butt joint and usually is. With larger bonding areas, lap joints can usually carry larger loads.



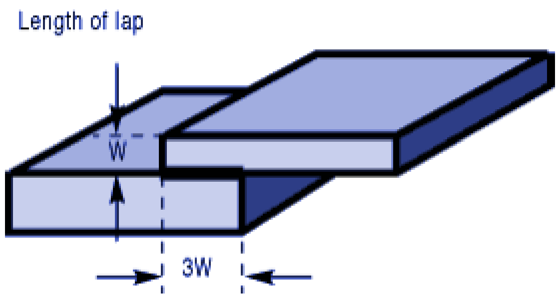


The lap joint gives you a double thickness at the joint, but in many applications (plumbing connections, for example) the double thickness is not objectionable. And the lap joint is generally self-supporting during the brazing process. Resting one flat member on the other is usually enough to maintain a uniform joint clearance. And, in tubular joints, nesting one tube inside the other holds them in proper alignment for brazing. However, suppose you want a joint that has the advantages of both types; single thickness at the joint combined with maximum tensile strength. You can get this combination by designing the joint as a butt-lap joint.



True, the butt-lap is usually a little more work to prepare than straight butt or lap, but the extra work can pay off. You wind up with a single thickness joint of maximum strength. And the joint is usually self-supporting when assembled for brazing. Figuring the proper length of lap Obviously, you don't have to calculate the bonding area of a butt joint. It will be the cross-section of the thinner member and that's that. But lap joints are often variable. Their length can be increased or decreased.

How long should a lap joint be? The rule of thumb is to design the lap joint to be three times as long as the thickness of the thinner joint member.

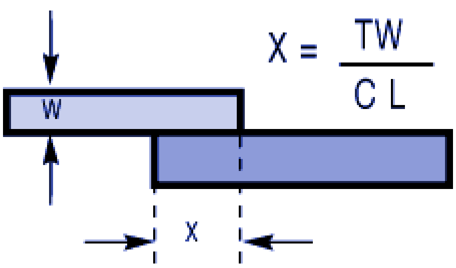


A longer lap may waste brazing filler metal and use more base metal material than is really needed, without a corresponding increase in joint strength. And a shorter lap will lower the strength of the joint. For most applications, you're on safe ground with the "rule of three." More specifically, if you know the approximate tensile strengths of the base members, the lap length required for optimum joint strength in a silver brazed joint is as follows:

Tensile strength of weakest member	Lap length(X) = factor(C) x W
35,000 psi - 241.3 MPa	2 x W
60,000 psi - 413.7 MPa	3 x W
100,000 psi - 689.5 MPa	5 x W
130,000 psi - 896.3 MPa	6 x W
175,000 psi - 1,206.6 MPa	8 x W
Note: ksi x 6.8948 = 1 MPa **Unit of stress:** SI unit: N / m2 (Pa, Pascal), N / mm2 (MPa) 1 MPa = 10^6 Pa, 1 GPa = 10^9 Pa USCS: lb / in^2 (psi), kip / in^2 (ksi), 1 ksi = 10^3 psi 1 psi = 6,895 Pa ,1 ksi = 6.895 MPa	

If you have a great many identical assemblies to braze, or if the joint strength is critical, it will help to figure the length of lap more exactly, to gain maximum strength with minimum use of brazing materials. The formulas given below will help you calculate the optimum lap length for flat and for tubular joints

Figuring length of lap for flat joints examples



X = Length of lap

T = Tensile strength of weakest member

W = Thickness of weakest member

C = Joint integrity factor of 0.8

L = Shear strength of brazed filler metal

Problem: What length of lap do you need to join 1.27 mm annealed Monel sheet to a metal of equal or greater strength?

Solution:

C = 0.8

T = 482.63 MPa (annealed Monel sheet)

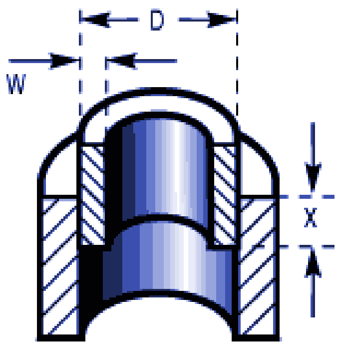
W = 1.27 cm

L = 172.37 MPa (Typical shear strength for silver brazing filler metals)

X = (482.63 x 1.27) / (0.8 x 172.37)

X = 4.5 mm (length of lap)

Figuring length of lap for tubular joints Example.



$$X = \frac{W\ (D-W)\ T}{C\ L\ D}$$

X = Length of lap area

W = Wall thickness of weakest member

D = Diameter of lap area

T = Tensile strength of weakest member

L = Shear strength of brazed filler metal

C = Joint integrity factor of 0.8

Again, an example will serve to illustrate the use of this formula.

Problem: What length of lap do you need to join 19.05 mm O.D. copper tubing (wall thickness 1.626 mm] to 19.05 mm I.D. steel tubing?

Solution:

W = 1.626 mm

D = 19.05 mm

C = 0.8

T = 227.53 MPa (annealed copper)

L = 172.37 MPa (a typical value)

X = (1.626 x (19.05 - 1.626) x 227.53)/ (.8 x 19.05 x 172.37)

X = 2.45 mm (length of lap)

Content /Topic 2: Pre-cleaning

Although a proper flux will remove and exclude light oxidation during heating, foreign matter such as grease, oil, paint, cutting fluids, etc. should be cleaned away before the part reaches the assembly point. If not removed, such materials may inhibit proper capillary attraction during heating and/or prevent the flux itself from acting directly on the metals being joined.

A. **Pre-cleaning:** this cleaning methods may be performed into the two ways,
    1. **Chemically**: Cleaning with solvents, acid or pickling baths compatible with the contaminants and the metals used. Such procedures should always be followed by thorough rinsing. Fusion offers the following pre-cleaner:

- **Fuze Clean AB** – An alkaline cleaner that removes heavy deposits of oil, grease, and soils from aluminum and brass surfaces.

2. **Mechanically:** Removal of exceptionally heavy deposits via brushing, grinding or blasting with an abrasive agent. In the case of blasting, care must be taken that the abrasive itself is not left to contaminate the joint area. It is suggested that soldering or brazing be performed as soon as possible after any pre-cleaning operation.

B. **Post-cleaning (Flux Residues):** A significant benefit of the Fusion Paste Process is that type and amount of flux may be carefully controlled, yielding minimal flux residues. Nonetheless, flux residues of a corrosive nature must be removed to prevent damage to the joint over an extended period. The following additional guidelines are offered.

1. **Rosin Type Flux Residues:** Generally, these are non-corrosive and may be left on the part without damage to the joint area. If residue removal is desired, it may be removed using alcohols or chlorinated hydrocarbon solvents or combinations of both families.
2. **Activated Rosin Fluxes**: Some rosin activators will cause corrosion under unusually hot or humid conditions. Most may be removed using alcohols or chlorinated hydrocarbon solvents or combinations of both families.
3. **Oily or Greasy Flux Residues:** Generally, may be removed with an alkaline cleaner such as Fuze-Clean S.
4. **Intermediate and Corrosive Solder Fluxes (Halides):** These fluxes leave a fused residue which absorbs airborne moisture, causing a slow chemical reaction at the joint. Removal is generally accomplished by thorough washing in warm detergent water, or in hot water containing dilute hydrochloric acid, followed by hot water rinse.
5. **Low-Temperature Brazing Fluxes:** These residues may be removed with hot water – alone or with detergents, alkaline cleaners, or acid cleaners. The most effective method is largely dependent on the base metals involved.
6. **High-Temperature Brazing Fluxes (Borates):** These hard, glass-like deposits are insoluble in many cleaners. They may be cracked off, however, by quenching the hot assembly in water immediately after brazing. A solution of dilute hydrochloric acid may also be helpful. Fusion offers an all-purpose brazing post cleaner:
7. **Fuze-Clean FS:** Quickly and effectively dissolve residues and heat scale on both ferrous and non-ferrous metals. This material will dissolve the glasslike flux buildup normally found after brazing or soldering, permitting effective part cleaning directly on the production line. Fuze-Clean FS eliminates the problems

associated with using strong acids or abrasive processes. In addition, it will remove rust, mill, and heat scale. For Fuze-Clean FS to be most effective, heat is required. The most efficient method is to add the material to a water solution in a heated tank, separate from the brazing or soldering machine.

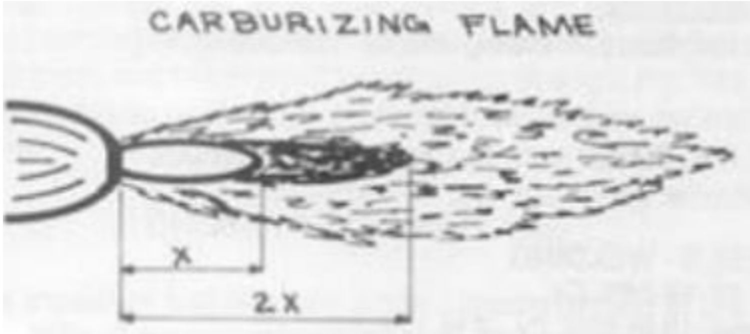
LO 3.2. Set up the flame.

Content /Topic 1: Types of flames and their applications

A. **Neutral flame**: It is a flame produced by mixing equal proportion of oxygen and acetylene gases, it is having a temperature of 32000 c at its hottest point. It is used for welding of mild steel, copper, stainless steel, cast Iron. The neutral flame has advantage over other flames because it doesn't add or change any properties of metals.

B. **Carburizing flame:** The flame receives an excess amount of acetylene over oxygen gases. The flame has an effect on steel, causing hard, brittle and weak weld, because of excess acetylene which increases the carbon on the metals. The temperature is around 2900^0c. It used for hard facing process. The gas welding is used to join metal having small thickness up to 3mm otherwise the pieces must be beveled.

C. **Oxidizing flame:** It is a flame contained an excess amount of oxygen over acetylene gases. The temperature is approximately 3300^0c. The flame has an oxidizing effect on metals which prevents evaporation of zinc and tin. It is used in Brazing process.



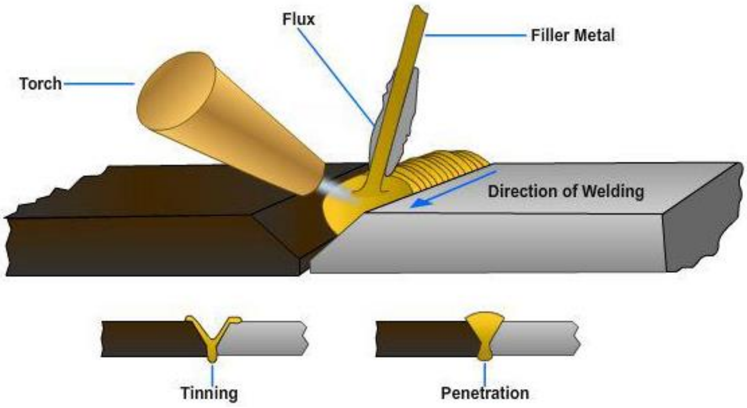
LO 3.3. Perform brazing.

Edge preparation is essential in braze welding. You can bevel the edges of thick parts by grinding, machining, or filing, but it is not necessary to bevel thin parts (1/4-inch or less). You need to make the piece bright and clean on the underside as well as on the top of the joint. If you clean with a file, steel wool, or abrasive paper, it will remove most of the foreign matter such as oils, greases, and oxides, and using the proper flux will complete the process to permit the tinning to bond. After you prepare the work's edges, use the following steps to braze weld:

- Align parts and hold in position with clamps, tack welds, or both.
- Preheat assembly to reduce expansion and contraction during welding.
- Adjust flame to slightly oxidizing flame.
- Flux joint.

Note: More flux during the tinning process produces stronger welds.

- Apply heat to base metal until it begins to turn red.
- Melt some brazing rod onto surface and allow spreading along entire joint.
- Complete tinning entire joint.

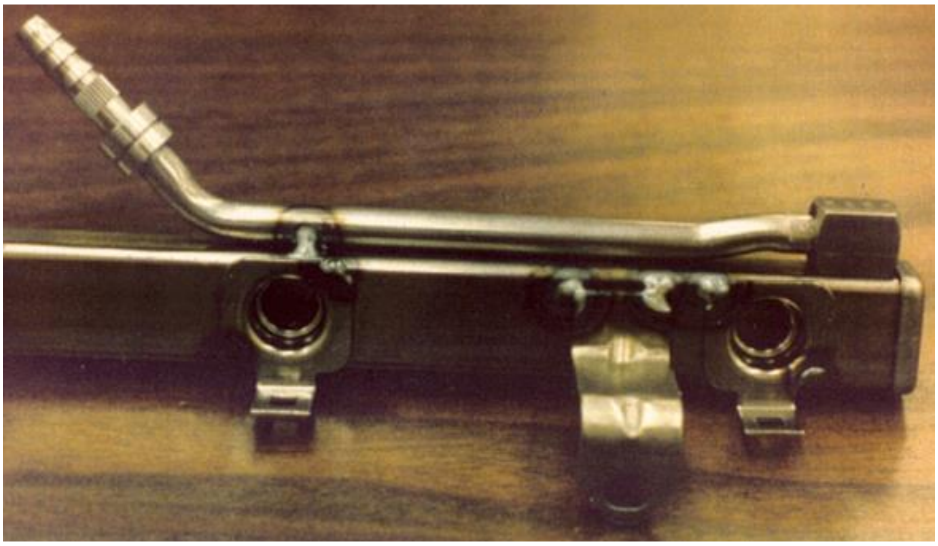


Content /Topic 1: Method of fluxing and brazing rods.

- Begin adding beads of filler metal to fill joint.
- Use a slight circular motion with the torch and run the beads as in regular fusion welding.
- Continue adding flux.
- If the weld requires several passes, ensure each layer fuses with the previous one.
- Upon completion of fill, heat area around joint on both sides for several inches to ensure even rate of cooling.
- When joint is cold, remove any excess flux or other particles with stiff wire brush or steel wool.

Content /Topic 2: Tacking method.

Highly complex assemblies, for a variety of end-use applications in such diverse fields as automotive, aerospace, medical, electronics, and tooling (just to name a few), can be effectively made via brazing.



For this to happen, however, each of the individual components in these complex assemblies must be able to be held together in proper alignment, have the appropriate brazing filler metal (BFM) applied to it, and this assembly then moved into a brazing-furnace, where it can be heated until the BFM melts and flows into the joints by capillary action, thereby permanently joining the components together to make a complex assembly.

An essential part of this process is the specialized braze-fixturing techniques needed to hold all the component parts of the assembly in proper alignment until the applied BFM has melted, flowed, and solidified.

Tack-welding is one fixturing method that has found broad use in the brazing industry to "temporarily" hold component-parts together in proper alignment until brazing can be completed.

The proper way to use fusion-welding for "braze-fixturing" is to be sure that the welds are extremely small, leaving no noticeable oxidation whatsoever to the naked eye around the weld.

Remember: Any weld-fixturing is ONLY supposed to lightly hold the assembly together in alignment until it can be placed into the furnace for brazing. The braze is what is supposed to create the permanent bond, not the fixture-weld!

Tack-welding can be used quite nicely as a fixturing technique to hold complex assemblies together prior to brazing, as long as certain criteria are closely observed during its use, the weld should be small, just enough to hold the parts together until it can put into the brazing furnace for subsequent brazing. In that way, the following benefits accrue:

1. Damaging oxidation is prevented, and the parts can be successfully brazed without fear of any "leakers" occurring due to any excessive weld-oxidation that can easily occur when using large welds to fixture components together prior to brazing.

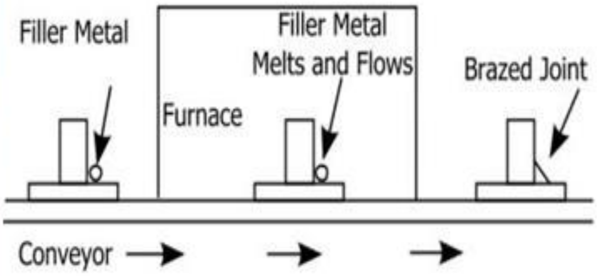
2. Distortion of the component parts of the assembly can be effectively prevented, because the larger the weld, the greater the tendency for the metal in the weld-area to distort. Keeping the tack-weld as tiny as possible (very easy with the small Unitek and Soudax equipment) not only eliminates oxidation problems but also eliminates any issues with distortion of the assembly being fixtured for brazing.
3. Basically, it can be used to fill a hole or build up a small area of no stress, but it has very little strength, and worse for your purpose it will cause contamination of the weld when they go to finish weld it. I wouldn't advise, if you are going to tack it and get somebody to weld it properly, use a MIG to do the tacking as the welder can then just weld over the top or clean out your tack if needs be and finish it off.

Content /Topic 3: Advantages and limitation of brazing.

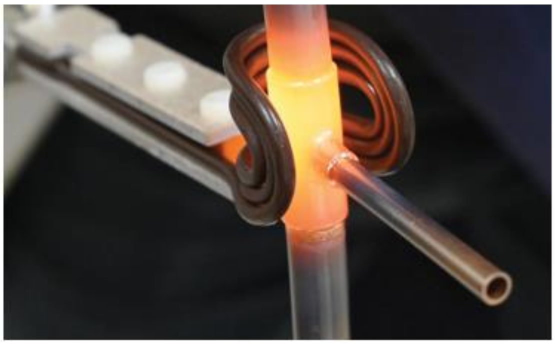
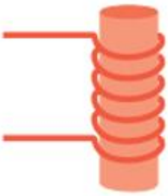
Advantages	**Limitation**
i. Brazing is used to join a large variety of dissimilar metals. ii. Properly brazed joints are pressure tight. iii. Pieces having great difference in cross-sectional areas can be brazed. iv. Thin sheets, pipes and gauges that can't be joined by welding can be joined by brazing. v. Complex assemblies can be fabricated by this method. vi. A brazed component has ability to preserve protective metal coating. vii. Brazing can be done on cast and wrought materials. viii. Corrosion resistance joints can be produced by this method. ix. Brazing preserves metallurgical characteristics of a material better than welding. x. After brazing a component maintains more precision tolerances than welding. xi. Brazing processes can be automated for bulk production. xii. Non-metals can be joined to metals.	i. lack of joint strength as compared to a welded joint due to the softer filler metals used. ii. This method of joining has less strength. iii. This method of joining metal cannot work under high temperature, they may get damaged. iv. This is not useful at long welding. v. The joints are not effective at higher temperatures. Because the low melting point of filler material. vi. The color of the joint is often different from that of the base metal that create an aesthetic disadvantage. vii. Metal to join must very close to ensure capillary action of molten filler metal. viii. Need a flux during brazing and flux residue must be removed. ix. The job size is limited - large plates of metal can't braze.

Content /Topic 4: Other brazing processes.

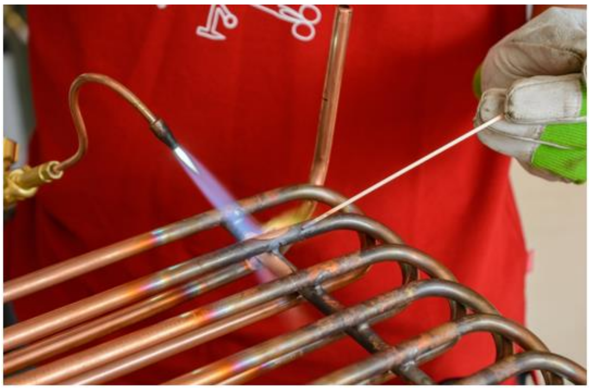
1. **Furnace brazing**: a high production method where fixtured parts preloaded with filler metals and, when needed, flux is put in a furnace. The furnace may be either a single batch model or a conveyor model for continuous brazing.

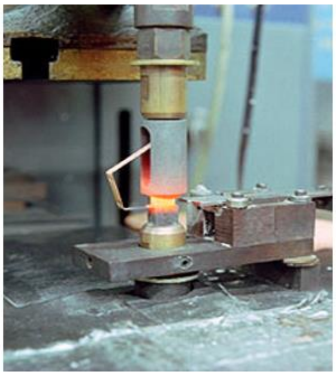
2. **Induction brazing:** a process that uses inductor coils to induce an alternating current into and around a pre-assembled part. The electrical resistance of the part generates the heat to melt the filler metal.

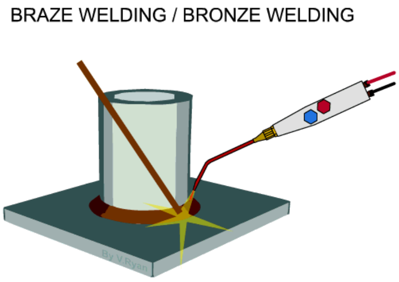
3. **Dip brazing**: assembled parts are typically dipped in a heated chemical bath which serve as both fluxing agent and heat source to melt pre-applied filler material.



4. **Resistance brazing:** involves passing electric current through the work pieces, resulting in resistance heating which melts the filler alloy and joins the work pieces.

5. **Braze welding:** is a process of almost equal importance to the user of an oxy-acetylene welding outfit. It closely resembles fusion welding in several important respects. It is used to produce joints of excellent strength in steel, in cast iron, and in copper and some copper alloys.



Content /Topic 5 Application of brazing

Brazing is a widely used joining process because it can join almost all metal except aluminum and magnesium. It is used for electrical components, pipe fittings. Metals having uneven thickness can be joined by **brazing**.

When it comes to joining two pieces of metal, tradespeople have a wide selection: mechanical fasteners, adhesives, soldering, welding and brazing. The first three options produce weaker joints, which are preferable in certain circumstances. Consider an assembly in which a pump must be connected to pipes. Because the pump has a finite lifetime and will eventually need replacement, it makes little sense to use a permanent joining technique. Instead, metalworkers would opt for a mechanical fastener, which could be easily disassembled when the pump failed.

Content /Topic 6: Cleaning up the brazed joints.

After the brazed joint has cooled the flux residue should be removed with a clean cloth, brush or swab using warm water. Remove all flux residue to avoid the risk of the hardened flux temporarily retaining pressure and masking an imperfectly **brazed joint**.

Learning unit 4 - Perform housekeeping.

LO 4.1. Clean tools, equipment and workplace.

Content /Topic 1: Cleaning tools and equipment

1. **Brush:** It is used for cleaning the working surface prior to welding and general cleaning of the weldment.

2. **Cloth rug:** is the process of cleaning workplace (area) by using a rag, A rug is a small carpet made of old pieces of cloth stitched or woven together.

3. **Mop:** a tool for cleaning floors made of a bundle of cloth or yarn or a sponge fastened to a long handle, something that looks like a cloth or yarn mop. a mop of hair.

4. **Soapy water:** A metallic salt of a fatty acid, as of aluminum or iron, that is not water soluble and may be used as a lubricant, thickener, or in various coating applications, ointments, or disinfectants. 3. Slang Money, especially that which is used for bribery.
5. **Compressed air:** Compressed air is a concentrated stream of air at high pressure and high speed that can cause serious injury to the operator and the people around him. First, compressed air is itself is a serious hazard. It has been known for compressed air to enter the blood stream through a break in the skin or through a body opening. An air bubble in the blood stream is known medically as an embolism, a dangerous medical condition in which a blood vessel is blocked, in this case, by an air bubble.

An embolism of an artery can cause coma, paralysis or death depending upon its size, duration and location. While air embolisms are usually associated with incorrect scuba-diving procedures, they are possible with compressed air due to high pressures. This may all seem to be improbable, but the consequences of even a small quantity of air or other gas in the blood can quickly be fatal so it needs to be taken seriously.

A. Potential dangers

Unfortunately, horseplay has been a cause of some serious workplace accidents caused by individuals not aware of the hazards of compressed air, or proper work procedures.

i. Compressed air accidentally blown into the mouth can rupture the lungs, stomach or intestines.
ii. Compressed air can enter the navel, even though a layer of clothing, and inflate and rupture the intestines.
iii. Compressed air can enter the bloodstream, and death is possible if it makes its way to blood vessels in the brain. Upon reaching the brain, pockets of air may lead to a stroke.
iv. Direct contact with compressed air can lead to serious medical conditions and even death. Even safety nozzles which regulate compressed air pressure below 30 psi should not be used to clean the human body. If an air pocket reaches the heart, it causes symptoms similar to a heart attack.
v. As little as 12 pounds of compressed air pressure can blow an eye out of its socket.

Content /Topic 2: Methods of cleaning:

1. **Dusting:** is the process of removing unwanted materials to the workplace by putting it the dust bin.
2. **Removal of dirt:** Before starting any welding project, make sure the work piece is as clean as possible. Use a clean cloth, wire brush, or sandpaper to remove rust, dirt, paint, grease, oil, or any other contaminant.
3. **Chemical spraying:** Good for industrial painting interior decoration chemical production chemical pesticide spraying and other operations produce toxic gas odor protection. The following is a chemical spraying mask which can be used for,

LO 4.2. Care for and store brazing equipment

Content /Topic 1: Care and storage procedures of tools, equipment and materials:

- Equipment has to be cleaned and maintained in accordance with manufacturers specifications and/or local instructions to ensure correct functionality of equipment.
- Any unserviceable tools are repaired, replaced or reported to relevant personnel to ensure correct functionality.
- Tools are transported in a safe, secure, efficient manner to minimize risk of injury to personnel and damage to equipment.
- Tools are stored and secured according to manufacturers or workplace procedures to prevent damage to, and losses of, equipment.

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