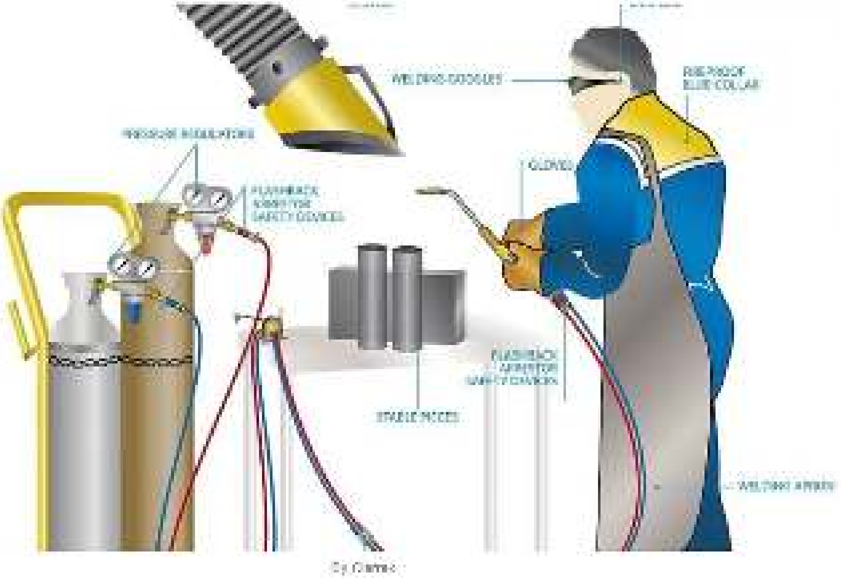
Automotive Body Repair and Paint Work
Level II
Based on March, 2022, Curriculum Version I,



Module Title: Performing Oxyacetylene Welding

Module Code: EIS BRP2 M07 0322

Nominal duration: 70 hours

Prepared By: Ministry of Lobar and Skill

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Addis Ababa, Ethiopia

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Acronyms

1) VT-Visual Inspection
2) LT - Liquid Penetrant Testing
3) MT -Magnetic Particle Testing
4) RT -Radiographic Testing

5) UT -Ultrasonic Testing
6) Eddy Current Testing – ET (not used in field inspection)
7) acoustic Emission Testing – AET (not used in field inspection)
8) Phased Array Ultrasonic – PA

Time Of Flight Diffraction – TOFD

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Introduction to the Module

Oxygen/Acetylene welding, or “Gas Welding”, is a process which relies on combustion of oxygen and acetylene. Oxy-acetylene welding is a method of joining metals by heating them to the melting point using a mixture of oxygen and acetylene gases. When mixed together in correct proportions within a hand-held torch or blowpipe, a hot flame is produced with a temperature of about 3,200°C. The chemical action of the oxy/acetylene flame can be adjusted by changing the ratio of the volume of oxygen to acetylene, using the valves on the torch or blowpipe.

This unit covers competence carrying out oxyacetylene welding. It focuses on fillet, plate and tube welding processes in repair and assembly of panels. It involves welding equipment and consumables selection, perform weld joints and correct faults.

This module covers the units:

- welding equipment and consumables
- welding materials and equipment
- weld joints
- Correct faults
- quality weld record handling

Learning Objective of the Module

- Select welding equipment and consumables
- Prepare and assemble welding materials and equipment
- Perform weld joints
- Correct faults
- Assure quality weld record handling

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the "LAP test" giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

UNIT ONE: Select Welding Equipment and Consumables

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- welding tools and equipment
- consumables material

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Select welding tools and equipment
- Select welding consumables

1.1. Welding Tools and Equipment

1.1. 1. Hand and power tools

The basic Hand tools used to carry out gas welding are:

- Open-End Wrench
- Box-End Wrench
- Combination Wrench
- Flare Nut (Line) Wrenches
- Allen Wrench
- Adjustable-End Wrench
- Sockets and Ratchets
- Torque Wrenches

1.1.2. Measuring equipment

The basic equipment's used to carry out gas welding are:

- . Oxygen gas cylinder (green)
- Acetylene gas cylinder (maroon/red)
- Oxygen pressure regulator
- Acetylene pressure regulator
- Oxygen gas hose(Blue)

1.1.3. Bench Shears and Guillotines

A bench shear, also known as a lever shear, is a bench mounted shear with a compound mechanism to increase the mechanical advantage. It is usually used for cutting rough shapes out of medium-sized pieces of sheet metal, but cannot do delicate work.

Figure.1.1. Bench Shears and Guillotines

1.2. Consumable Materials

As a rule, when welding materials that have different tensile strengths, the consumable you choose should **match the material with the lower tensile strength**. The preheat temperature you use should match what is required for the material with the higher tensile strength

Flux and filler metals together are known as welding consumables. Stick electrode, flux-cored wires, solid wires, SAW wires and fluxes are some of the welding consumables employed during the welding process.

The material added to help form the join is called filler or consumable. The form of these materials may see them referred to as **parent plate or pipe, filler wire, consumable electrode** (for arc welding), etc.

Self-check-1

INSTRUCTION ONE: -MULTIPLE CHOICES

Read each item carefully and choose the correct answer from the available four choices.

1. It is a bench mounted with a compound mechanism to increase the mechanical advantage.
   A. Consumable Materials
   B. Flux and filler metals
   C. A bench shear
   D. All
1. Flux and filler metals together are known as welding consumables
   A. welding consumables
   B. Flux
   C. filler metals
   D. None
2. Welding consumables employed during the welding process.
   A. Stick electrode
   B. flux-cored wires
   C. solid wire
   D. All

UNIT TWO: Prepare and Assemble Welding Materials and Equipment

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Prepare equipment and consumables materials
- Prepare Materials

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Prepare equipment and consumables materials
- Prepare Materials

2.1. Prepare equipment and consumables materials

2.1.1. Welding Consumables

Fuel gases

Acetylene gas

Acetylene is a fuel gas which produces a very high temperature flame with the help of oxygen because it has more amount of carbon (92.3%) than any other fuel gas. Its chemical symbol is C2 H2 and composed of: -

- Carbon 92.3% (24 parts)
- Hydrogen 7.7% (2 parts)

It is a colorless gas, lighter than air and highly inflammable and burns with a brilliant flame. Commercial acetylene has pungent odor because of certain impurities. It forms a long range of explosive mixture with air any percentage between 3 x 80 becoming explosive on ignition. It may also explode when under unduly high pressure even in absence of air, when mixed with oxygen it explodes more violently. Acetylene absorbs heat during producing and liberates heat when decomposed.

There are two type of **acetylene generators**:

1) Water – to – Carbide generators.
2) Carbide – to – Water generators.

Dissolved acetylene means compressed acetylene pumped into steel cylinder filled with porous filling material soaked in acetylene.

Oxygen gas

Oxygen is a supporter of combustion. Its chemical symbol is O2. It is a clear, colorless, odorless and tasteless gas. It is slightly soluble in water. It does not burn itself, but supports combustion of fuels. It is industrially produced by two methods: -

1) By air liquefaction.
2) By electrolysis of water.

Oxyacetylene

Oxyacetylene gas welding is commonly used to permanently join mild steel. A mixture of oxygen and acetylene, burns as an intense / focused flame, at approximately 3,500 degrees centigrade. When the flame comes in contact with steel, it melts the surface forming a molten pool, allowing welding to take place. Oxyacetylene can also be used for brazing, bronze welding, forging / shaping metal and cutting.

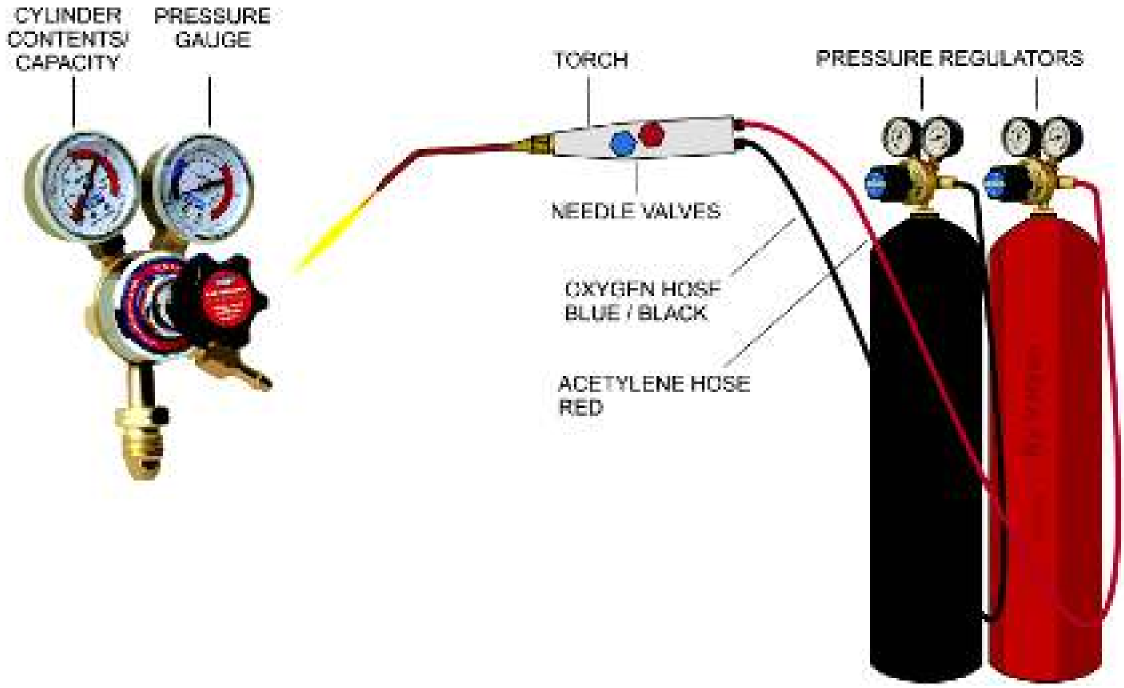


Figure.2.1.Oxyacetylene

Hydrogen

Hydrogen produces low-temperature flame and is best for aluminum. Hydrogen flame isnon-luminous, commonly used for underwater welding (can be used at higher pressure than acetylene).

Gasses suitable for cutting but NOT welding:

a) Propane
b) Methane
c) LPG

Hydrocarbon gases, such as propane, butane, city gas, and natural gas, are NOT suitable for welding ferrous materials due to their oxidizing characteristics. Although propane has a very high number of BTUs per cubic feet in its outer cone, it does not burn as hot as acetylene in its inner cone and therefore not very useful for welding operations. However with a right torch (injector style), propane can make a faster andcleaner cutting and is much more useful for heating and bending applications than acetylene. In some instances, many nonferrous and ferrous metals can be braze welded with care taken in the adjustment of flare and the use of flux.

Liquid range of filler rods

Filler Rod and its Necessity

Pieces of wires or rods of standard diameter and length used as filler metal in the joint during gas welding process are called filler rods or welding rods. These rods are made out of ferrous or non-ferrous metal.

To obtain best results, high quality filler rods should be used. The actual cost of welding rods is very small compared with cost of job, labor, gases and flux.

Good quality filler rods are necessary to:

- reduce oxidation (effect of oxygen)
- control the mechanical properties of the deposited metal
- Make up for the loss of certain elements in the weld metal caused by fusion.

While welding, a cavity or depression will be formed at the joints of thin section metals. For heavy/ thick plates a groove is prepared at the joint. This groove is necessary to get better fusion of the full thickness of the metal, so as to get a uniform strength at the joint. This groove formed has to be filled with metal. For this purpose also a filler rod is necessary. Each metal requires a suitable filler rod:**Sizes as Per IS: 1278-1972**

The size of the filler rod is determined from the diameter as: 1.00, 1.20, 1.60, 2.00, 2.50, 3.15, 4.00, 5.00 and 6.30 mm.

For leftward technique filler rods up to 4 mm dia. are used. For rightward technique up to 6.3 mm dia. is used. For cast iron welding filler rods of 6 mm dia. and above are used.

Length of filler rod are 500 mm or 1000 mm.

Filler rods above 4 mm diameter are not used often for welding of mild steel. The usual size of mild steel filler rods used are 1.6 mm and 3.15 mm diameter. All mild steel filler rods are given a thin layer of copper coating to protect them from oxidation (rusting) during storage. So these filler rods are called copper coated mild steel (C.C.M.S) filler rods.

All types of filler rods are to be stored in sealed plastic covers until they are used.

Types of Filler Rods

The following types of filler rods are classified in gas welding:

- Ferrous filler rod
- Non-ferrous filler rod
- Alloy type filler rod for ferrous metals
- Alloy type filler rod for non-ferrous metals

A ferrous type filler rod has a major % of iron.

The **ferrous type filler rod** contains iron, carbon, silicon, Sulphur and phosphorous.

The **alloy type filler rod** contains iron, carbon, silicon and any one or many of the elements such as manganese, nickel, chromium, molybdenum etc.

The **<u>non-ferrous filler rod</u>** is a filler rod which contains elements of non-ferrous metals. The composition of non-ferrous type filler rods is similar to any non-ferrous metal such as copper, aluminum.

A **<u>non-ferrous alloy type filler rod</u>** contains metal like copper, aluminum, tin etc. along with zinc, lead, nickel, manganese, silicon, etc.

Selection of the Filler Rod

Selection of the correct filler rod for a particular job is a very important step for successful welding. Composition of filler metal is chosen with special consideration to the metallurgical requirement of a weldment.

A wrong choice due to either ignorance or a false consideration of economy may lead to costly failures. IS:1278-1972 specifies requirements that should be met by filler rods for gas welding. There is another specification IS:2927-1975 which covers brazing alloys.

It is strongly recommended that filler material confirming to these specifications is used. In certain rare cases, it may be necessary to use filler rods of composition not covered by these specifications; in such cases filler rods with well-established performance should be used.

To select a filler rod in respect to the metal to be welded, the filler rod must have the same composition with respect to the base metal to be welded.

Factors to be considered for selection of filler rod are:

A. the type and composition of base metal

B. the base metal thickness

C. the type of edge preparation

D. the weld is deposited as root run, intermediate runs or final covering run

E. welding position

F. whether there is any corrosion effect or loss of material from the base metal due to welding.

<u>Care and Maintenance</u>

- Filler rods should be stored in clean, dry condition to prevent deterioration. –
- Do not mix different types of filler rods.
- Ensure that packages and their labels are in order for easy and correct selection.
- Where it is not practicable to store filler rods under heated conditions, an absorbent for moisture such as silica-gel may be used in the storage area.
- Ensure the rod is free from contamination such as rust, scale, oil, grease and moisture.
- Ensure the rod is reasonably straight to assist manipulation during welding.

Different Filler Metals and Fluxes for Gas Welding

Filler metal type	Applications	Flux
Mild steel-type S-FS1	A general purpose rod for welding mild steel where a minimum butt-weld tensile strength of 35.0 kg/mm^2 is required. (Full fusion technique with neutral flame).	Not required
Mild steel-Type S-FS2	Intended for application in which minimum butt-weld tensile strength of 44.0kg/mm^2 is required. (Full fusion technique with neutral flame).	Not required
Wear resisting alloy steel	Building up worn out crossings and other application where the steel surfaces are subject to extreme wear by shock and abrasion. (Surface fusion technique with excess acetylene flame)	Not required
3 % nickel steel Type S-FS4	These rods are intended to be used in repair and reconditioning parts which have to be subsequently hardened and tempered. (Full fusion technique with neutral flame)	special flux (If necessary)
Stainless steel decay-resistant (nobium bearing) Type S-Bo2MoNb	These rods are intended for use in the welding of corrosion-resisting steels such as those containing 18% chromium and 8% nickel. (Full fusion technique with neutral flame).	Necessary

High silicon cast iron-Type S-C11	Intended for use in the welding of cast iron where an easily achineable deposit is required. (Full fusion technique with neutral flame).	Flux necessary
Copper filler rod – Type S-C1	For welding of de-oxidized copper (Full fusion technique with neutral flame).	Flux necessary
Brass filler rod-Type S-C6	For use in the braze welding of copper and mild steel and for the fusion welding of material of the same or closely similar composition. (Oxidising flame)	Flux necessary
Manganese bronze (high tensile brass) – Type S-C8	for use in braze welding of copper, cast iron and malleable iron and for the fusion welding of materials of the same or closely similar composition (Oxidising flame)	Flux necessary

Figure.2.2.Filler rods

Fluxes

The purpose of the flux is to retard oxidation of the surfaces of the parts being welded, by generating gaseous shield around the weld zone. The flux also helps to dissolve and remove oxides and other substances from the work piece and so contributes to the formation of a stronger joint. The slag developed protects the molten metal puddles of metal against oxidation as it cools.

Characteristics of good flux

The melting point of a flux must be lower than that of either the metal or the oxides formed, so that it will be liquid. The ideal flux has exactly the right fluidity when the welding temperature has been reached. The flux will protect the molten metal from atmospheric oxidation. Such a flux will remain close to the weld area instead of flowing all over the base metal for some distance from the weld.

Composition of Fluxes

Fluxes differ in their composition according to the metals with which they are to be used. In cast iron welding, a slag forms on the surface of the puddle. The flux serves to break this up. Equal parts of a carbonate of soda and bicarbonate of soda make a good compound for this purpose. Nonferrous metals usually require a flux. Copper also requires a filler rod containing enough phosphorous to produce a metal free from oxides. Borax which has been melted and powdered is often used as a flux with copper alloys. A good flux is required with aluminum, because there is a tendency for the heavy slag formed to mix with the melted aluminum and weaken the weld. For sheet aluminum welding, it is customary to dissolve the flux in water and apply it to the rod. After welding aluminum, all traces of the flux should be removed.

Liquefied Petroleum Gas (LPG),

Liquefied petroleum gas (LPG) is a fuel providing energy that can be found in our everyday life as it is used in many household appliances for cooking, heating, and hot water.It is called liquefied gas because it is easily transformed into a liquid.

Cylinders

Oxygen gas cylinders

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

Acetylene gas cylinders

Acetylene cylinders do not contain compressed or liquefied acetylene; instead they contain acetylene gas dissolved in acetone that is absorbed onto a porous mass within the cylinder. The porous mass inhibits the decomposition reaction, providing time for emergency action in the event of a mishap.

Regulators

Figure 2.3.Regulators

Oxygen pressure regulator

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

There are two types of regulators

1) Single Stage Regulator

2) Double /Two Stage Regulator

1) Single Stage Regulator

Operation of Single Stage Oxygen Regulators

Refer the figure above, depicting a single stage oxygen regulator. As can be seen, the regulator consists of a flexible diaphragm. The diaphragm controls the needle valve between the high pressure zone and the low pressure zone. The needle valve is exposed to the high gas pressure.

A compression spring and an adjusting screw can also be seen in the figure; both these are on the opposite side of the needle valve – vented to the atmosphere. These compensate for the pressure of the gas against the flexible diaphragm.

The oxygen entering the regulator through the high pressure inlet passes through the glass wool. The function of the glass wool is to filter out the dust and dirt. As pressure is applied on the adjusting screw, it bears down on the diaphragm and presses it against the compression spring. This raises the seat from the nozzle and opens the passage through the nozzle, and permits outflow of gas to the low pressure chamber.

The oxygen passes through the regulator outlet and enters the hose. The hose transports the gas from the regulator till the oxyacetylene welding torch, where it mixes with acetylene in the mixing chamber.

The pressure in the low pressure chamber is lower than the cylinder. This pressure is indicated in the low pressure gage mounted on the regulator. It is this pressure that forces the gases through the orifices of the welding torch. This pressure can be regulated by adjusting the adjusting screw.

The regulators which are used at the head of an oxygen or acetylene manifold have only gage – that is, the low pressure gage. The gage on the oxygen regulator is graduated from 0 to 200 psi (1379 kPa), while that on the acetylene regulator is graduated from 0 to 15 psi (103 kPa).

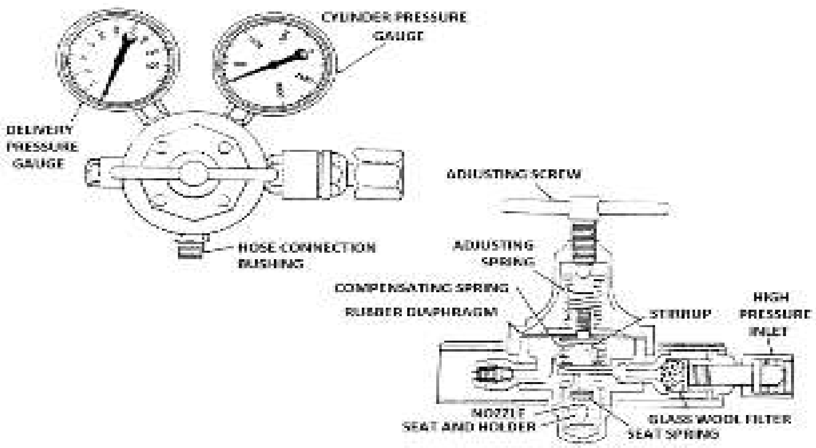


Figure.2.4. Single Stage Oxygen Regulators

2) Double/Two Stage Regulator

The two stage regulator is similar to the single stage regulator, except that it obtains the reduction in pressure in *two* stages, instead of one. The figure below shows a two-stage oxygen regulator.

First, the pressure is reduced from the high cylinder pressure to the intermediate pressure. This is on the cylinder side of the regulator. Next, the pressure is reduced from the intermediate pressure to the working pressure. This is on the torch side of the regulator.

The stage pressure helps in maintaining a constant working pressure, and periodic adjustment during the welding is not necessary.

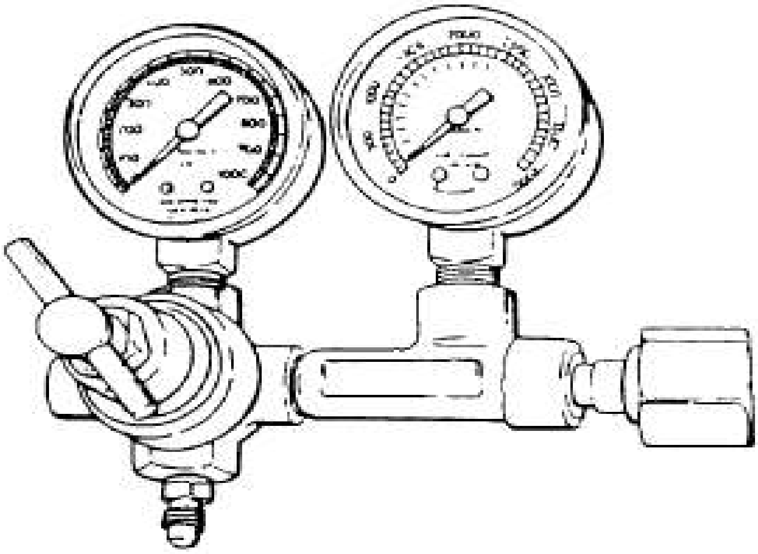


Figure. 2.5. Double/Two StageOxygen Regulators

Acetylene regulator

This is also used to reduce the cylinder gas pressure to the required working pressure and to control the flow of acetylene gas at a constant rate to the blowpipe. The threaded connections are left handed. For quickly identifying the acetylene regulator, a groove is cut at the corners of the nut.

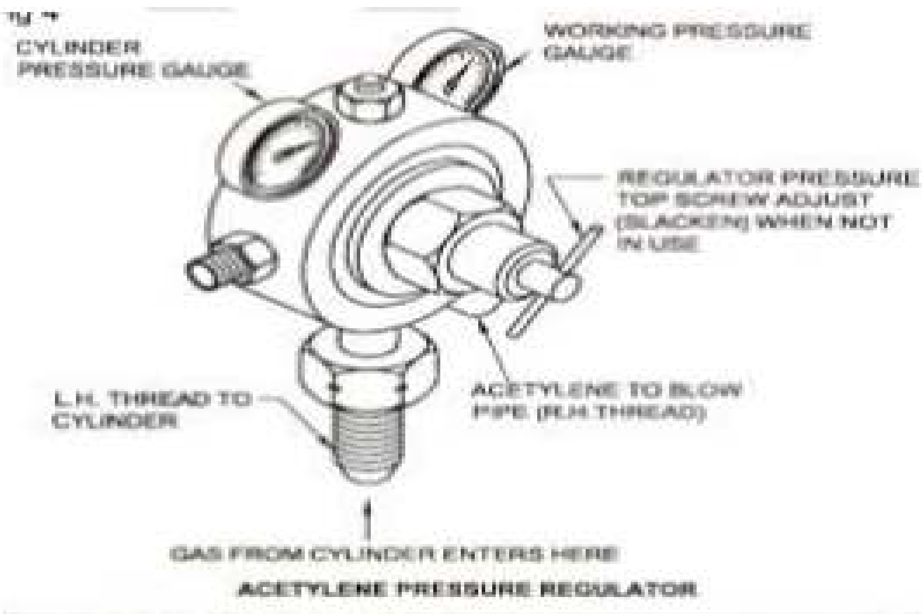


Figure.2.6Acetylene Regulators

The **acetylene regulators** are generally of same design as the oxygen regulators. Only, **they are not designed to withstand the high pressures** that the oxygen regulator is designed to do.

The high pressure gage available on the inlet side of the regulator is graduated from 0 to 500 psi (3447.5 kPa). This gage indicates the pressure available inside the acetylene cylinder.

The gage on the outlet side of the regulator, also called the low pressure gage, is graduated from 0 to 30 psi (207 kPa). This gage shows the pressure of the gas in the hose leading to the welding torch. The maximum safe working pressure for acetylene is 15 psi (103.4 kPa).

Difference between Oxygen and Acetylene Pressure Regulators

Acetylene Regulator: The cylinder and hose connections have left handed threads on the acetylene regulator.

Oxygen Regulator: There are right hand threads in this case.

Acetylene Regulator: Acetylene connection nuts have chamfers or grooves cut in them.

Oxygen Regulator: Nuts are plain, i.e., with no chamfer or grooves.

Acetylene Regulator: Color band on acetylene regulator in maroon or red.

Oxygen Regulator: It is either blue or black on the oxygen regulator.

Acetylene Regulator: The inlet or high pressure gauge on the regulator reads up to 8bar.

Oxygen Regulator: The inlet or high pressure gauge on the regulator reads up to 100bar.

Acetylene Regulator: The outlet or low pressure gauge on the regulator reads up to 1bar.

Oxygen Regulator: The outlet or low pressure gauge on the regulator reads up to 4.8bar.

Hoses

Rubber Twin Welding Hose is a premium welding hose, Green hose for Oxygen Red hose for Acetylene, Heat resistant EPDM tube and cover 2 spiral polyester yarn reinforcement, more flexible than braid reinforced hose, easier to coil and handle, Coiled coupled assemblies are available in 25 and 50 foot lengths. It can be used with most current fuel gases, including acetylene, propane, and MAPP gas.


Figure.2.7.Hoses

It is always recommended to buy and use fitted hoses. Factory fitted hose offers the customer the additional advantage of a 'gas system' which has been assembled and tested on a closely monitored production line to BS 1389.

Hoses should be fitted with the correct end connections attached by permanent clips.

Do not expose hoses to heat, traffic, slag, sparks, oil, grease, or sharp edges of metal. Test for leakage at working pressure by immersing in water; leaks may be repaired by cutting out a faulty section of hose and inserting an approved coupling. Never use copper couplings with acetylene. Doing so could permit the formation of copper acetylene. Worn ends should be cut back and re-fitted with hose connectors using permanent clips.

In general, do not fit more than two or three couplings in a length of hose. Consider replacing the hose entirely as parts are likely to be perished or damaged.

Ensure hoses are not wrapped around cylinders when stored or in use.

The hose check valve is an automatic safeguard, incorporating a spring-loaded Non-return valve. Its purpose is to inhibit oxygen and fuel gases mixing in the hoses. The hose check valve has reduced the incidence of back feeding in which oxygen contaminates fuel gas hose or vice versa. It is essential to ensure that your welding and cutting equipment is protected, as far as possible, against back feeding which may cause extensive damage to hoses and regulators in the event of a flashback.

Tips

<u>The welding nozzle or tip</u> is that portion of the torch which is located at the end of the torch and contains the opening through which the oxygen and acetylene gas mixture passes prior to ignition and combustion.

Depending upon the design of the welding torch, the interchangeable nozzles may consist of:

a) Either, a set of tips which screw onto the head of the blowpipe, or
b) As a set of gooseneck extensions fitting directly onto the mixer portion of the blowpipe.

A welding nozzle enables the welder to guide the flame and direct it with the maximum ease and efficiency. The following factors are important in the selection of appropriate welding nozzle:

a) The position of the weld
b) The type of joint
c) Job thickness and the size of welding flame required for the job
d) The metal/alloy to be welded.

To provide for different amounts of heat, to weld metals of different thicknesses, welding tips are made in various sizes. The size of a welding tip is determined by the diameter of the opening or orifice in the tip. As the orifice size increases, greater amounts of the welding gases pass through and are burnt to supply a greater amount of heat.

The choice of the proper tip size is very important to good welding. For welding thicker material large sized tip is used which will supply more combustible gases and more heat. A chart giving sizes of tips for welding various thicknesses of metal along with oxygen and acetylene pressures used is generally provided by the manufacturers.

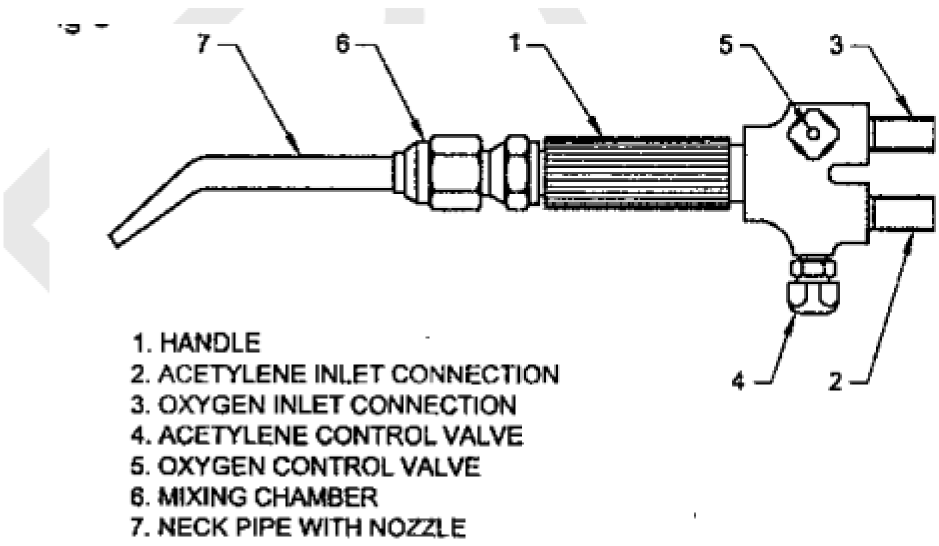


Figure.2.8.Hoses

Care of Welding tips

a) All welding tips are made of copper and may be damaged by careless handling.

b) Nozzles should never be dropped or used for moving or holding the work.

c) Nozzle seat and threads should be absolutely free from foreign matter in order to prevent any scoring when tightening on assembly.

d) Nozzle orifice should only be cleaned with tip cleaners specially designed for this purpose.

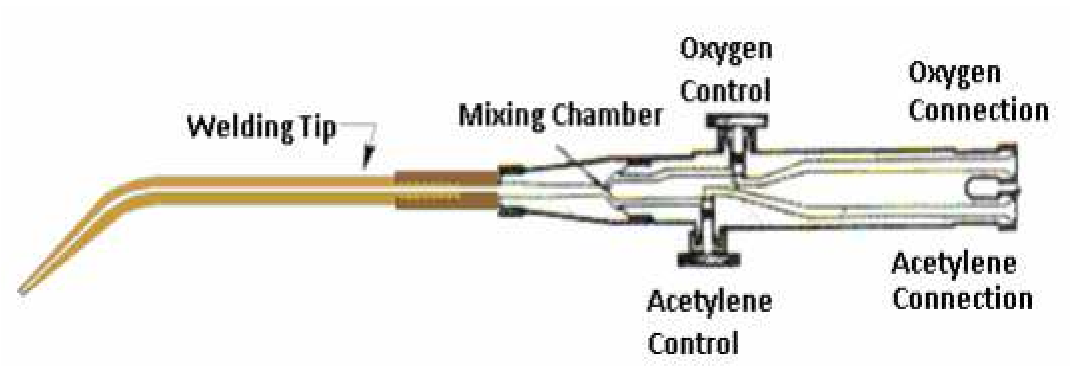


Figure.2.9.Welding torch & blow pipe

2.2. Prepare Materials

Plate

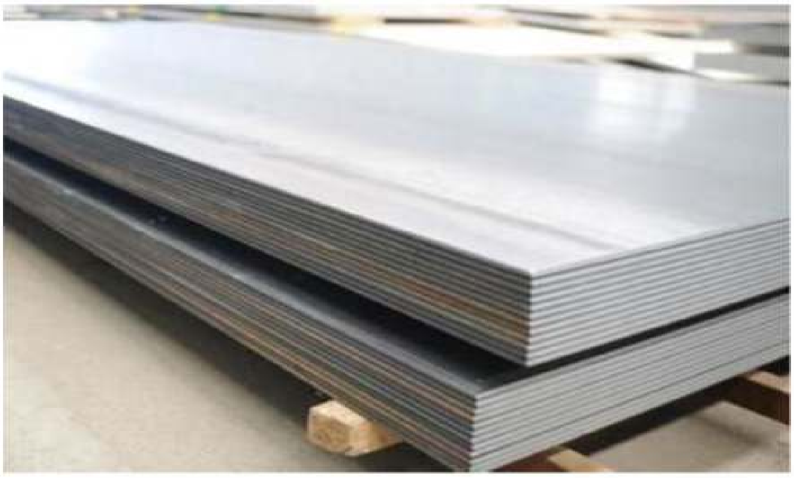


Figure.2.10.Plat

Ferrous (Low and high carbon steel/alloy steel)

Ferrous metals are those which have iron as their base. They include iron and its alloys such as steel, cast iron and alloy steels such as stainless steel etc.

Alloys

If two or more metals are chemically combined they form an alloy e.g. iron, chromium nickel and carbon form an alloy called chromium nickel steel (stainless), manganese, iron and carbon form an alloy called manganese steel, copper and zinc form an alloy called brass, copper and tin form an alloy called bronze, lead and tin form an alloy called soft solder.

Non-ferrous (copper, brass, aluminum,

Non-ferrous metals do not contain iron as base. They include copper, aluminum zinc, tin etc. and non-ferrous alloys.

Fixtures, clamps, etc.

A metal clamp is used to attach the welding hose to a nipple. There are basically two types of connections that can be used. The first is using a jubilee clip. The second option is using a crimped connector. The second option is probably safer as it is harder for this type of connection to come loose. The hoses should also be clipped together at intervals approximately 3 feet apart.

Figure.2.11. clamps

Joint preparation

What Is Joint Preparation?

Joint preparation is a more technical term used in the welding industry to describe how you prepare metal for welding.

See, when you weld something you are usually welding two pieces of metal together to form a joint. And unfortunately many welders do very little if any joint preparation. **It's very important because it's crucial to achieving a good weld.**

If you don't do any joint preparation you will end up with 'tall' welds (meaning they are sticking up more than they are getting closer to being flush with both pieces of metal), and on a more serious note you may get poor fusion.

Side Bar: Ron Covell covers a really cool Plasma cutting technique for beveling edges on thicker material in Tig Welding Basics.

Joint Basics!

As you know by now, any product you weld together must have welded joints, otherwise it's not usable. So when you weld to pieces of metal together you are welding a joint.

The joints that you weld become what is called a 'weldment'. That's a technical term you don't really need to dwell upon, but it's good know know.

And when you weld a joint together you will use your wire or rod (which is your filler metal) to fuse the joint. By the way, the base metal is your metal that you are welding together (or cut).

Figure.2.12. joints

As we have discussed, how good your joint that you are welding is depends not only on how well you weld it, but how well you prepare it.

Prepare metal well and it will reduce contraction and expansion from cooling and heating. If you do not prepare metal well heat that radiates to the base metal as you weld will be low (or lost) and your base metal will not fuse properly with your filler metal.

Conversely you do not want excessive heat either. There is a balance you are trying to achieve and joint preparation is crucial to achieving it.

The First Step to Joint Preparation:

The first step to preparing metal for welding is to remove all the impurities otherwise your weld will not be a good one. So remove rust, mill scale, and oxides. If you do not do this they will get into your weld and ruin it or make it ugly and weak.

Metal edge preparation is crucial in allowing the filler metal and metal edge walls to fuse without too much melting.

As we discussed in the article on the types of joints, there are 5 joints that you will be creating for your projects:

1. **Butt**
2. **Corner**
3. **Edge**
4. **Lap**
5. **Tee joint**

OPERATION SHEET 2.1. Butt Joint:

Operation Title: Butt Joint:

Instruction: Choose the Right Filler Material & critical step in butt joint preparation

Purpose: the purpose of this Operation Sheet is how to join metals by applying Butt Joint: Methods

Required tools and equipment:

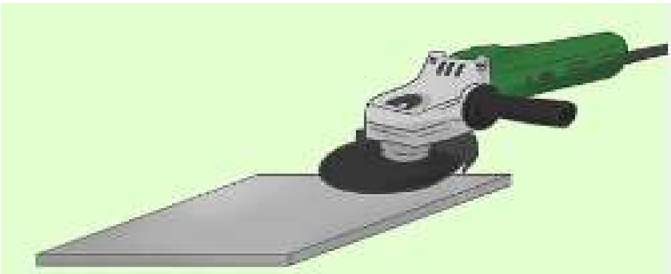
a) Oxy-acutely welding machine
b) Plates

Precautions:

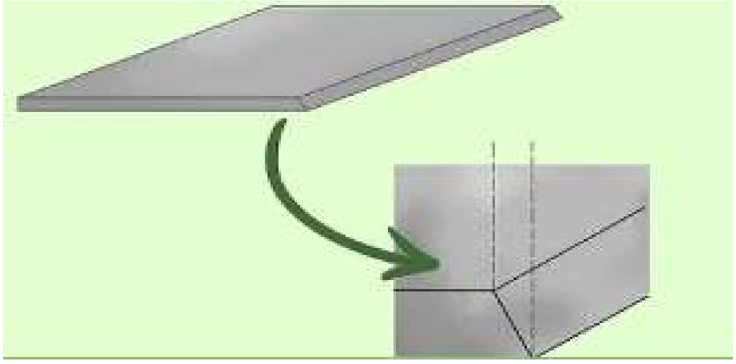
- Be sure the welder is properly installed and grounded.
- Never weld without adequate ventilation.
- Take proper precautions to prevent fires.
- Protect your entire body with fire retardant clothing, shoes, and gloves.
- Wear eye protection at all times.
- Weld only in a fire safe area.

Procedure

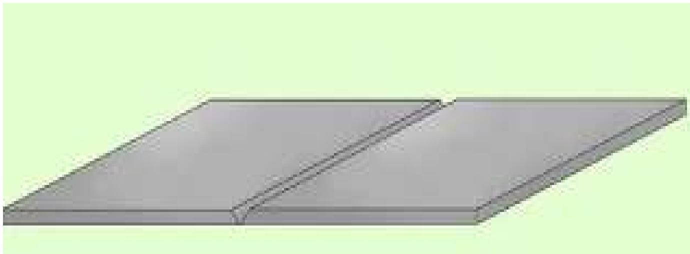
Step 1. Obtain all necessary equipment. This should be a welding machine, electrode and workpiece clamps (and their leads), a welding helmet darker than shade 10, welding gloves, and appropriate safety clothing.



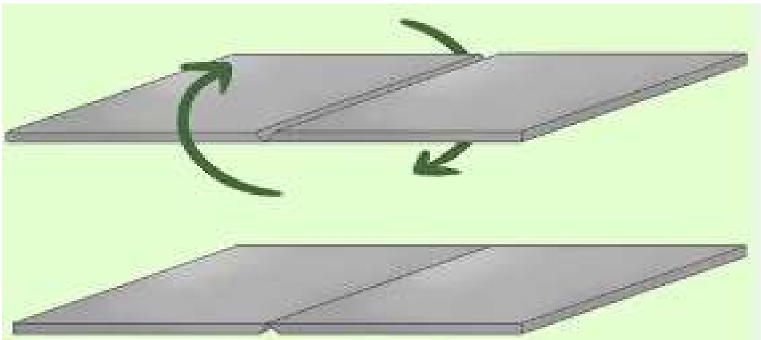
Step 2.Prepare the metal to be welded. This includes grinding down rough edges and cleaning the areas to be welded.



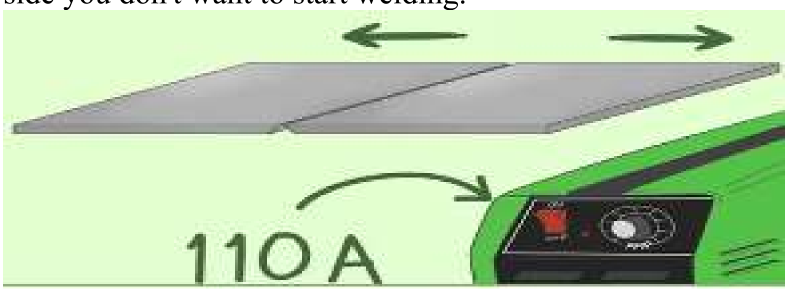
Step 3.Bevel the edge of the metal if it is thicker than ¼ inch (0.6 cm). Beveling allows for better penetration of the root pass and subsequent passes. Beveling can be done with an oxy-fuel torch or a plasma arc cutter, but isn't necessary on thinner metal.



Step 4.Align your metal to make sure the edges line up well. They should be smooth and align cleanly.



Step 5.Turn your pieces over. This should be the flat side if on or more pieces are beveled, or the side you don't want to start welding.

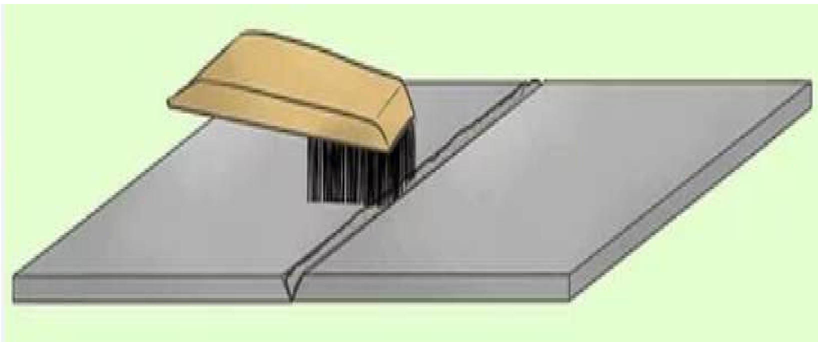


Step 6.Separate the pieces a little bit and set the amperage on your machine about 10 percent higher than the level you intend to use welding the metal. So, if you are going to use 100 amps to make your weld(s), set your amperage at 110 amps.

Step 7.Make tack welds. These will hold the metal together and prevent it from warping or bending inward when the weld is finished. To make a tack weld, strike an arc and let it sit for a few seconds. A few tack welds are usually needed and you should be able to break them with a hammer or wrench.

Step 8.Flip your metal over to be welded.

Step 9.Strike an arc and create your root pass. This is going to be the first and deepest pass on your weld, and if the metal is thick enough, the only pass you'll need. If you beveled the steel start at the bottom for your root pass. You need to ensure the root pass penetrates deeply enough, and for this reason 6010 electrodes are frequently used for this purpose.



Step 10.Clean the weld with a hammer and wire brush and make subsequent passes if needed. These passes should strengthen the weld and fill it in. Make sure to clean each pass before you start a new one.

Quality criteria:

The basic conditions of welding quality to achieve products of such high quality includes the following:

a) No cracks or holes found in the bead.

b) The bead has uniform waves, width and height.

c) The finished product satisfies the design dimensions and has almost no distortion.

OPERATION SHEET 2.2 Lap Joint:

Operation Title: How to Prepare **Lap** Joint:

Instruction: Choose the Right Filler Material & critical step in **Lap** joint preparation

Purpose: the purpose of this Operation Sheet is how to join metals by applying Butt Joint: Methods

Required tools and equipment:

1. Welding power supply
2. Flat file
3. Welding rod
4. Chipping hammer
5. Electrode holder
6. Wire brush
7. Gloves and apron
8. Earthling clamps
9. Shield and goggles

Precautions:

- Be sure the welder is properly installed and grounded.
- Never weld without adequate ventilation.
- Take proper precautions to prevent fires.
- Protect your entire body with fire retardant clothing, shoes, and gloves.
- Wear eye protection at all times.
- Weld only in a fire safe area.

Procedure

Step 1. The given workpieces are thoroughly cleaned, i.e. rust, scales are removed and the edges are filed.

Step 2. The electrode is held in an electrode holder and ground clamp is clamped to the welding plates and the power is supplied.

Step 3. The workpieces are positioned on the table to form a "Lab joint".

Step 4. The tag weld is done on the both the ends of joining plates to avoid the movement of workpieces during welding.

Step 5. The welding is carried throughout the length of the workpieces on both sides by maintaining 3mm gap between plates and the welding rod.

Step 6. The welded plates are allowed for air cooling after the slags are removed.

Step 7. The weld joint portions are cleaned by wire brush.

Quality criteria:

- your joint will be your base metal overlapping one another

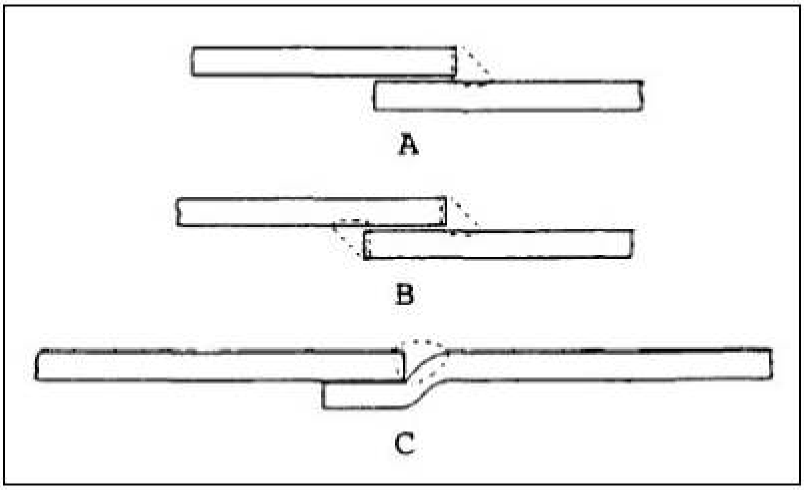


Figure.2.15. **Lap Joint:**

As the name implies, your joint will be your base metal overlapping one another:

- Image A is an example of a one sided weld (fillet weld) of a single lap joint.
- Image B shows you a weld on both sides which will make it much stronger.
- Image C is what is called an offset lap joint. Your weld will be done in the natural seem made by the offset. It is usually a stronger weld than a single lap joint, but it can be more a more challenging joint preparation.

OPERATION SHEET 2.3 Tee Joint:

Operation Title: How to Prepare Tee joint:

Instruction: Choose the Right Filler Material & critical step in Tee joint preparation

Purpose: the purpose of this Operation Sheet is how to join metals by applying Tee joint:

Required tools and equipment:

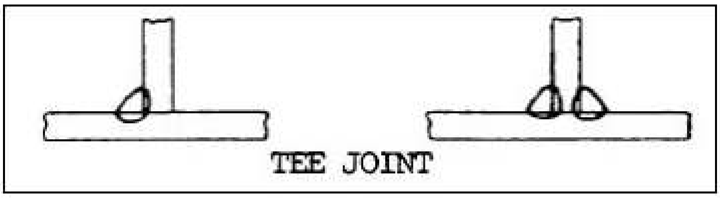
1. Welding power supply
2. Flat file
3. Welding rod
4. Chipping hammer

5. Electrode holder
6. Wire brush
7. Gloves and apron
8. Earthling clamps
9. Shield and goggles

Precautions:

- Be sure the welder is properly installed and grounded.
- Never weld without adequate ventilation.
- Take proper precautions to prevent fires.
- Protect your entire body with fire retardant clothing, shoes, and gloves.
- Wear eye protection at all times.
- Weld only in a fire safe area.

Procedure



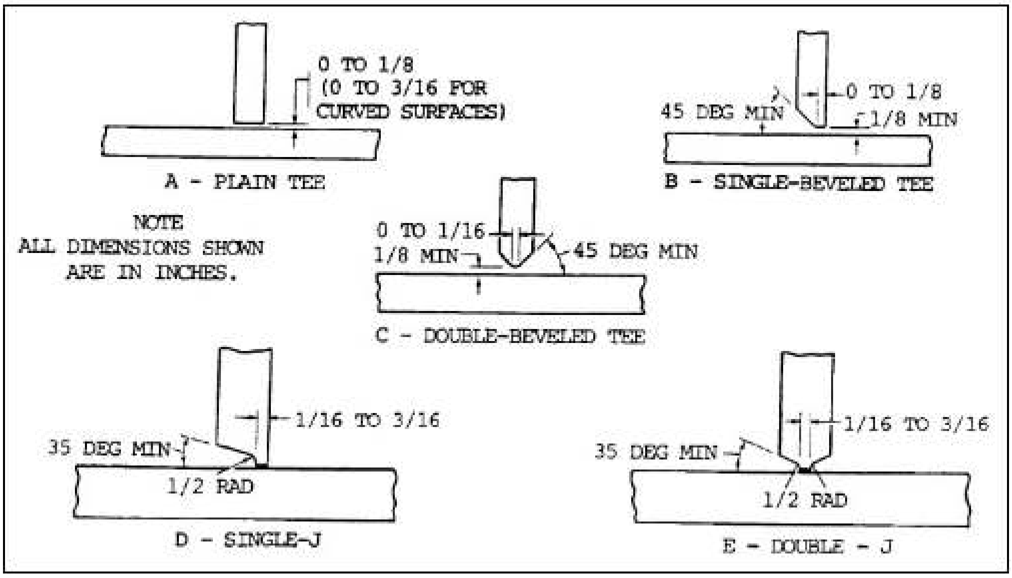
A Tee joint is another joint that looks the way it sounds. If you look at it from a cross sectional view it looks like the letter 'T'.

So it basically where two pieces of flat bar, plate, or whatever are at a right angle but not on the edge. If it was on the edge you would be making more of a corner joint.

As you can see in right hand side image above there is weld on either side of it. To prepare this Tee Joint you will bevel the edges, tack weld it on both sides, and then lay a bead on either side. But there are occasions where you will only weld one side as you can see in the left hand image.

Note that the beveled edges on either a single side or double side weld will be at an angle that is about 50% of what you would do on a Butt joint.

Joint Preparation for Tee Joints Part 2:



Step 1 A regular Tee joint is seen in Image A above. This is a Tee joint that does not require any prep. Of course, you will clean the base metal (both pieces).

Step 2 Image B shows a single joint bevel. This will be used on heavier sections and you will be welding both sides.

Step 3 Image C is a joint that has been beveled on both sides, and both sides are welded as well. This type of preparation is for thick plates.

Step 4 Image D is what is called a sing J joint. You will weld both sides of this material but only bevel one side of the joint.

Step 5 Image E is to be used on even heavier or thicker material and it is called a double j joint.

It is very important that you get good penetration. You want penetration to the root of your weld.

LAP Test 2	**Practical Demonstration**

Name: ___________________________ Date: _____________

Time started: ____________________ Time finished: ________________

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within 10 hours.

Task 1. Select the tools and equipment to Butt Joint

Task 2. Write the steps for Butt Joint

UNIT THREE: Perform Weld Joints

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Welding materials in all position
- Interpreting instructions, symbols, and specifications

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Weld materials in all position
- Interpret instructions, symbols, and specifications

3.1. Weld Materials in All Position

Safety Precautions in Handling Oxy-Acetylene Gas Welding Plant

One must observe safety rules in day-to-day working to avoid accident. "Accident starts when safety ends."

Oxy-acetylene equipment is safe if it is properly handled, but it may become a great destructive power if handled carelessly. It is important that the operator be familiar with all the safety rules before handling gas cylinders.

In gas welding, the welder must follow certain safety precautions while handling gas welding plants in order to prevent accidents to others and him. Observing the following precautions will help the gas welder to avoid accidents to a great extent.

General safety precautions

- Never use oil or grease in any part or assembly of a gas welding plant as it may cause an explosion.
- All inflammable materials should be kept away from the welding area.
- Always wear goggles with filter glasses during welding.
- Wear fire-resistant clothes, asbestos gloves and an apron while welding.
- Never wear nylon or greasy clothes while welding.
- Rectify the gas leakages noticed immediately as even a small leakage can lead to serious accidents.
- Always keep fire extinguishing devices handy and in working order.
- While leaving the work area, make sure the place is free from any form of fire

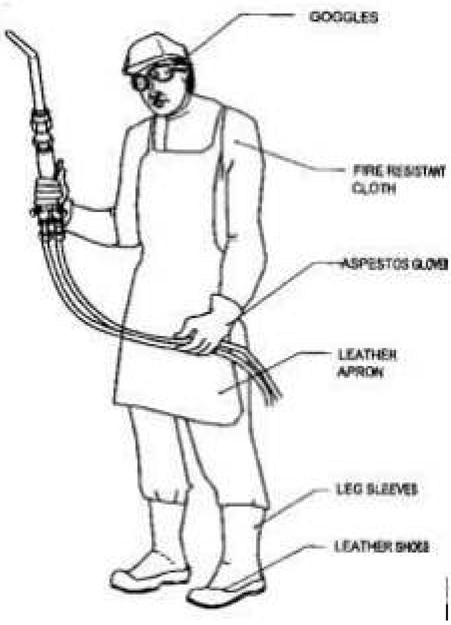


Figure.3.1. fire-resistant clothes

Safety concerning gas cylinders

- Do not roll gas cylinders for shifting. Always use a trolley to carry cylinders.
- Do not drop the gas cylinders.
- Close the cylinder valves when not in use or empty.
- Keep the empty cylinders and full cylinders separately.
- Always open the cylinder valves slowly and not more than one and a half turn.
- Use always the correct size cylinder keys.
- Stand aside when opening the cylinders.
- Do not remove the cylinder keys from the cylinders during welding. It will help to close the cylinders quickly in case of an emergency.
- Always keep the cylinders in an upright position keeping in view safety and ease in handling.

Figure.3.2. Safety concerning gas cylinders

- Always crack the cylinder valves to clean the valve socket before attaching the regulators.
- Never fall or trip over gas cylinders.
- A valve broken in the oxygen cylinder will cause it to become a rocket with tremendous force.
- Keep the gas cylinders away from exposure to high temperature.
- Remember the pressure in the gas cylinders increases with the temperature
- Mark the empty cylinders (MT/EMPTY) with chalk.
- Put on the valve protection caps when the cylinders are not in use or they are being moved.

Figure.3.3. Safety concerning gas cylinders

- Close the cylinder valves both when they are full and empty.
- Never remove the valve protection cap while lifting cylinders.
- Avoid exposing the cylinders to furnace heat, open fire or sparks from the torch.
- Smoking or naked lights should be strictly prohibited near gas cylinders.
- Never strike an arc of direct gas flame on a gas cylinder.

Safety of rubber hose-pipes

- Use only the type of hose recommended for use in gas welding.
- Use only black colored hoses for oxygen and maroon colored ones for acetylene gas.
- Avoid damage to the hose-pipes caused by rubbing against hard or sharp edges.
- Ensure that the hoses do not cross the gangways.
- Do not add bits of hose together to make up the length.
- Blow out the hose-pipes before connecting to the blowpipe to remove dirt or dust.
- Protect the regulators from water, dust, oil etc.

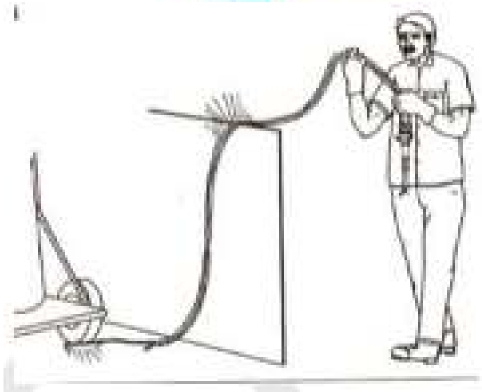


Figure.3.4. Safety of rubber hose-pipes

- Never attempt to interchange oxygen and acetylene regulators while fitting as it can damage the threads.
- Always remember the oxygen connection is right-hand threaded and the acetylene connections have left hand threads.
- In the event of backfire shut both the blowpipe valves (oxygen first) quickly and dip the blowpipe in water.
- While igniting the flame, point the blowpipe nozzle in a safe direction and use the spark lighter to ignite the flame to avoid fire hazards.

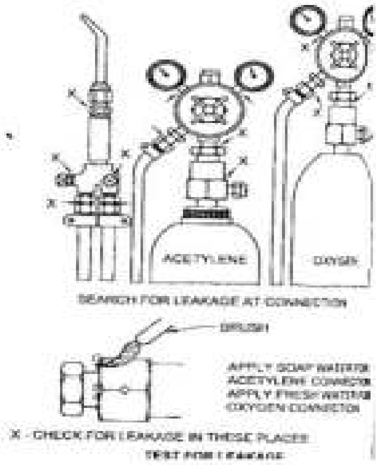


Figure.3.4. Safety of rubber hose-pipes

- While extinguishing the flame, shut off the acetylene valve first and then the oxygen to avoid backfire.
- Check for leakage before using oxyacetylene welding equipment

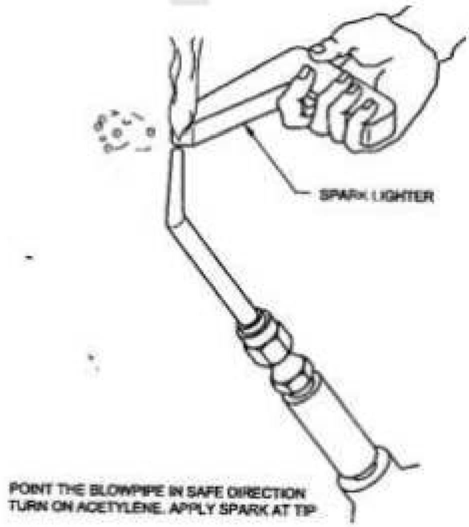


Figure.3.4. Check for leakage before using oxyacetylene welding equipment

- Toxic and poisonous fumes given out during welding of some materials should be collected and cleared so as to be prevented from inhaling. For this an exhaust ducting and a respirator may be used.

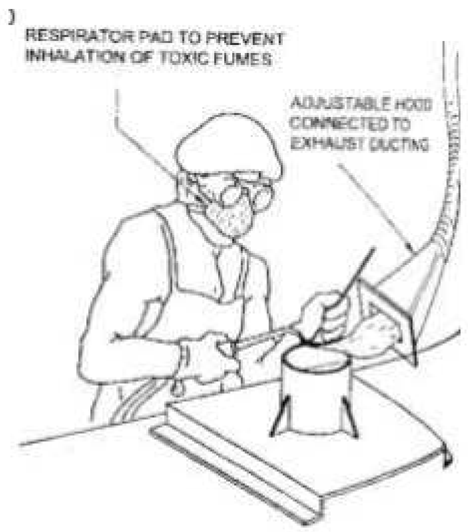


Figure.3.5. Containers used for the storage of flammable materials

- Containers used for the storage of flammable materials should not be welded without thorough cleaning as otherwise the containers may explode.

Trouble with Blow Pipe & Cylinders

Backfire

At certain times during ignition in gas welding a small explosion of the flame occurs at the torch tip. The flame may or may not go off. This is known as 'backfire'.

Causes: A backfire is caused when:

- the gas pressure setting is low
- the nozzle is overheated
- the nozzle orifice is blocked by carbon or spark deposits
- the nozzle touches the molten pool
- there is leakage near the nozzle Eliminate the causes before proceeding further to avoid backfire.

Flashback

Sometimes during backfire, the flame goes off and the burning acetylene gas travels backward in the blowpipe, towards the regulator or cylinders. This is known as 'flashback'.

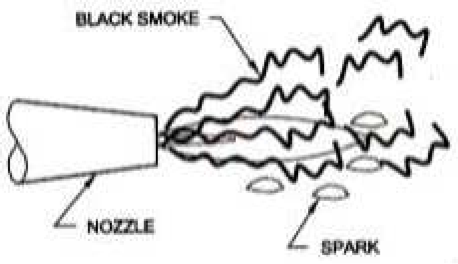


Figure.3.6. Flashback

Indications of flashback:

- A sharp squealing sound inside the blowpipe may be heard.
- Heavy black smoke and sparks come out of the nozzle.
- The blowpipe handle starts heating.

Immediate steps:

- Close the blowpipe valves (oxygen first) •
- Immerse the blowpipe in water and close the cylinder valves. If the backfire or flashback is not checked in time, it may cause serious accidents to men and machines.

Cylinder catches fire

If the cylinder catches fire externally due to the leakage of gas at the connection:

- close the cylinder valve immediately (wearing asbestos gloves as a safety measure)

- Use carbon dioxide fire extinguisher to extinguish the fire.
- Rectify the leakage thoroughly before putting into further use. If the cylinder becomes overheated due to internal or external fire:
- close the cylinder valve
- detach the regulator from the cylinder
- Remove the cylinder to an open space, away from smoking or naked light.
- Cool the cylinder by spraying with water
- Inform the gas cylinder supplier immediately
- Never keep such defective cylinders with the other cylinders.

Types of Oxy-Acetylene Flames

The oxy-acetylene gas flame has following features which make it useful for gas welding:

- it has a well-controlled flame with high temperature
- the flame can be easily manipulated for proper melting of the base metal
- It does not change the chemical composition of the base metal/ weld.

Three different types of oxy-acetylene flames as given below can be set:

- Neutral flame
- Oxidizing flame
- Carburizing flam

Neutral Flame

Oxygen and acetylene are mixed in equal proportion in the blowpipe and complete combustion takes place in this flame. This flame does not have a bad effect on the metal/ weld i.e. the metal is not oxidized and no carbon is available for reacting with the metal.

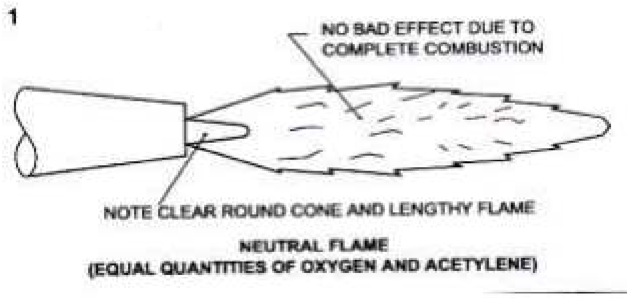


Figure.3.8. Neutral Flame

It is used to weld most of the common metals, i.e. mild steel, cast iron, stainless steel, copper and aluminum.

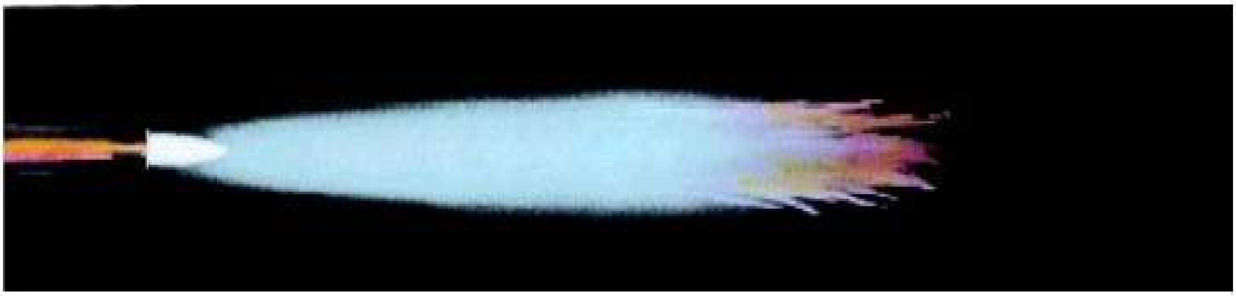
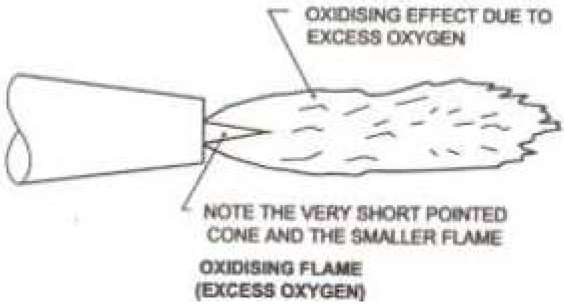


Figure.3.9. Neutral Flame(5850°F).

Oxidizing Flame

It contains an excess of oxygen over acetylene as the gases come out of the nozzle. The flame has an oxidizing effect on metals which prevents evaporation of zinc/ tin in brass welding/ brazing.



It is used for welding of brass and for brazing of ferrous metals.

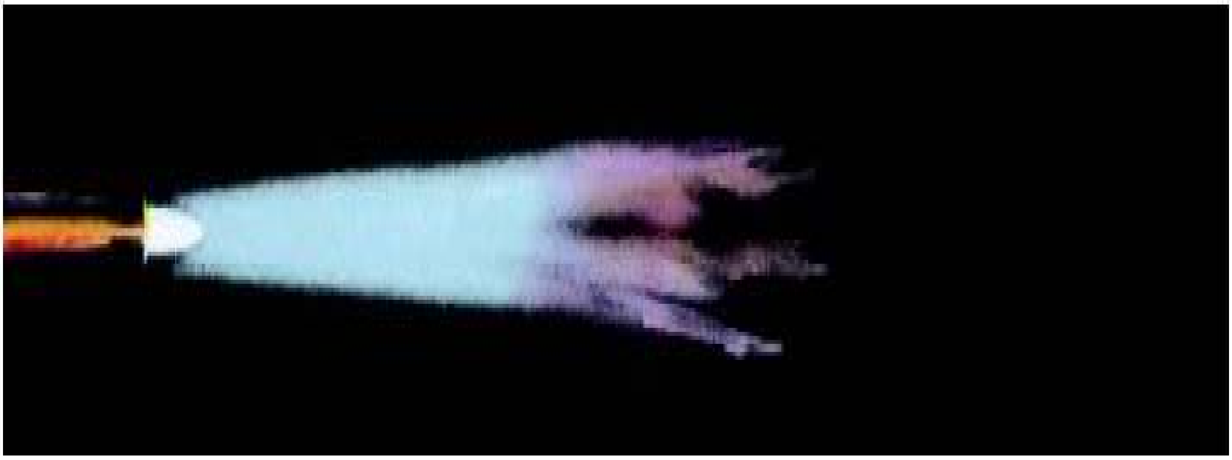
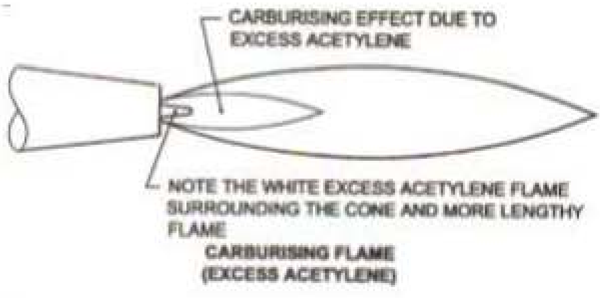


Figure.3.10. Oxidizing Flame (Acetylene and excess oxygen, 6300°F)

Carburizing Flame

It receives an excess of acetylene over oxygen from the blowpipe. The flame has a carburizing
effect on steel, causing hard, brittle and weak weld.



It is Useful for stellateing (hard facing), 'Linde' welding of steel pipes, and flame cleaning.

The selection of the flame is based on the metal to be welded. The neutral flame is the most commonly used flame. Metals and flame to be used are as given below:

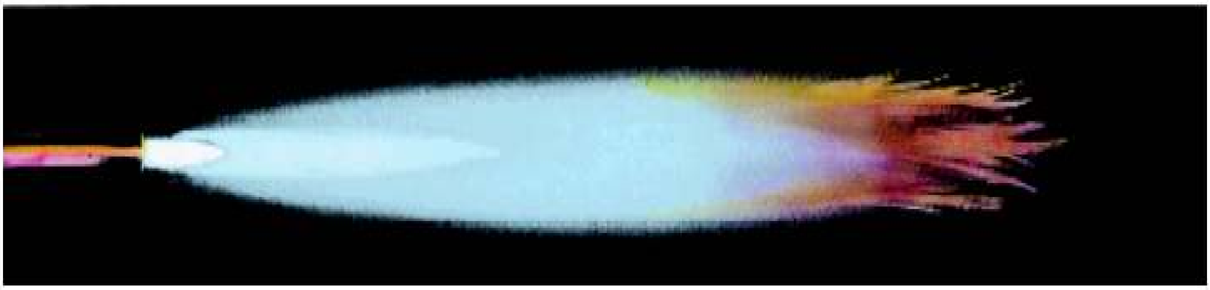


Figure.3.11. Carburizing Flame (Excess acetylene with oxygen, 5700°F)

Metal. **Flame**

- Mild steel Neutral
- Copper (de-oxidized) Neutral
- Brass Oxidizing
- Cast iron Neutral
- Stainless steel Neutral
- Aluminum (pure) Neutral
- Satellite Carburizing

Chemistry of Oxy-acetylene Flame

Oxy-acetylene flame is produced by the combustion of a mixture of oxygen and acetylene in various proportions. The temperature and characteristics of the flame depend on the ratio of the two gases in the mixture.

Features of neutral flame

Oxy-acetylene flame consists of the following features by appearance: -

- Inner core
- Inner reducing zone
- Outer zone or envelope

Welding Techniques of Oxy-Acetylene Welding

There are following two welding techniques used in oxy-acetylene welding process:

1. Leftward welding technique (Forehand technique)
2. Rightward welding technique (Backhand technique)

Leftward Welding Technique

It is the most widely used oxy-acetylene gas welding technique in which the welding commences at the right hand edge of the welding job and proceeds towards the left. It is also called forward or forehand technique.

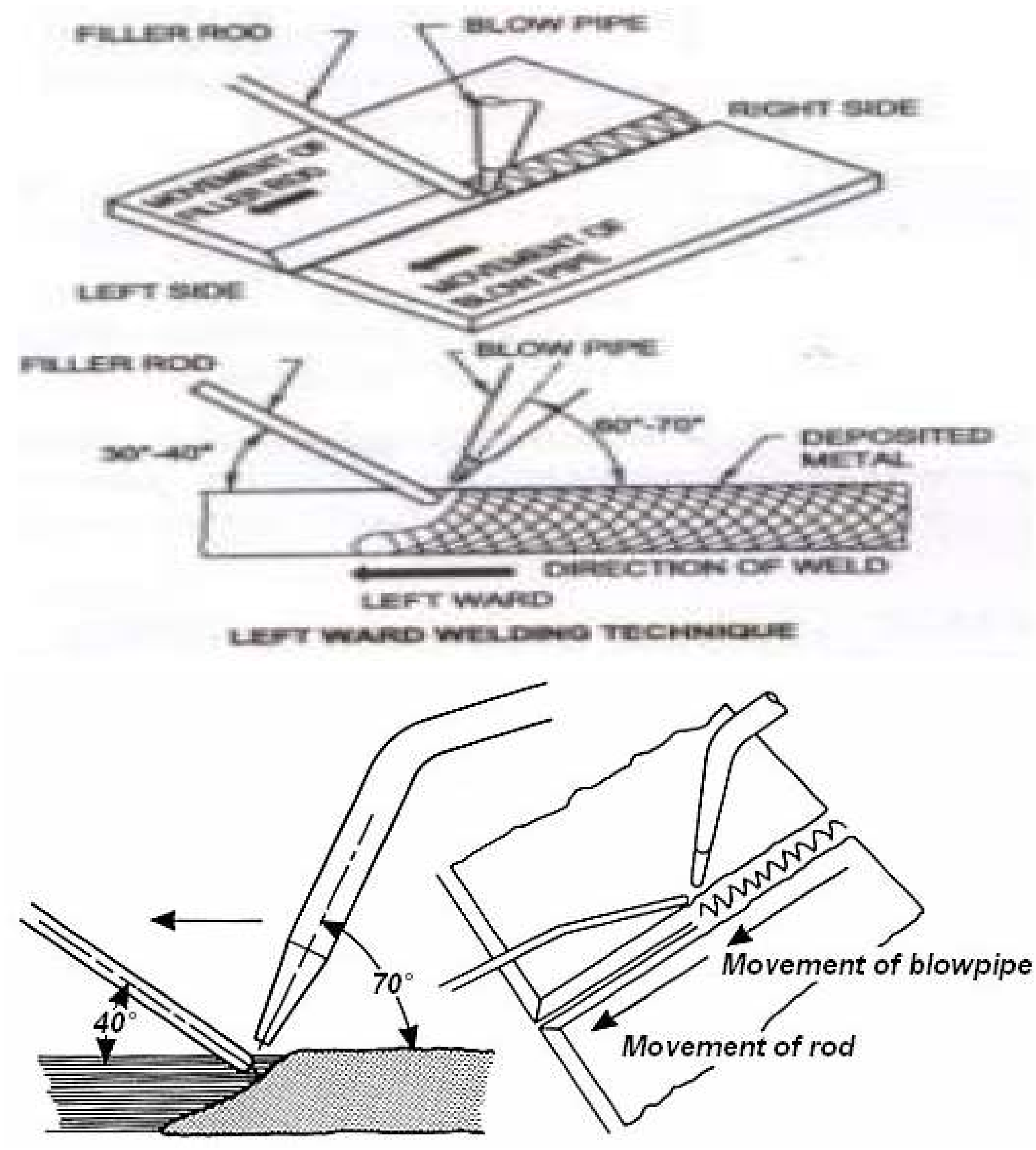


Figure.3.12. leftward welding

The blowpipe is held at an angle of 60 ° - 70° with the welding line. The filler rod is held at an angle of 30°-40° with the welding line. The welding blowpipe follows the filler rod. The welding flame is directed away from the deposited weld metal.

The blowpipe is given a circular or side-to-side motion to obtain even fusion on each side of the joint. The filler rod is added in the (weld) molten pool by a piston like motion and not melted off by the flame itself.

If the flame is used to melt the filler rod it-self into the pool, the temperature of the molten pool will be reduced and consequently good fusion cannot be obtained.

Edge preparation for leftward technique

- For fillet joints square edge preparation is done.
- For butt joints the edges are prepared as shown in figure given below.

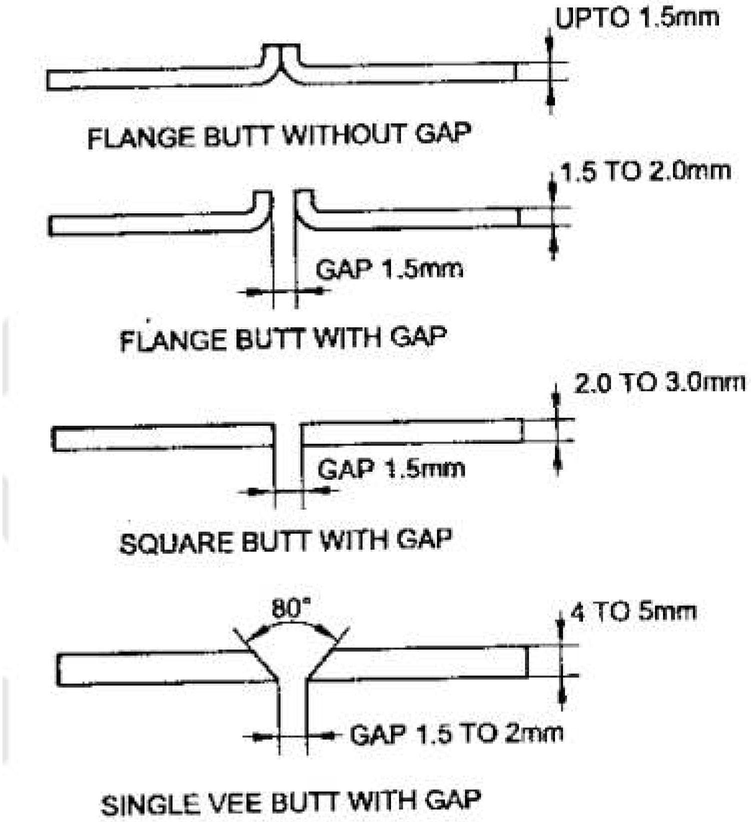


Figure.3.13: Edge preparation for leftward technique

The table given below shows the details for welding mild steel by leftward technique (for butt joint)

metal thickness in mm	C.C.M.S. filler rod diameter in mm	Blow pipe nozzle size	edge preparation	root gap in mm	flux to be used
0.8	1.6	1	flange	Nil	
1.6 to 2.0	1.6	3	square	2	for gas welding of mild steel no flux is required to be used
2.5	2	5	square	2	
3.15	2.5	7	square	3	
4.0	3.15	7	80°Vee	3	
5.0	3.15	13	80°Vee	3	

For fillet joints one size larger nozzle is to be used.

Above 5.0 mm thickness, the rightward technique should be used.

Application - This technique is used for the welding of:

- Mild steel up to 5mm thickness
- All metals both ferrous and non-ferrous

Rightward welding technique

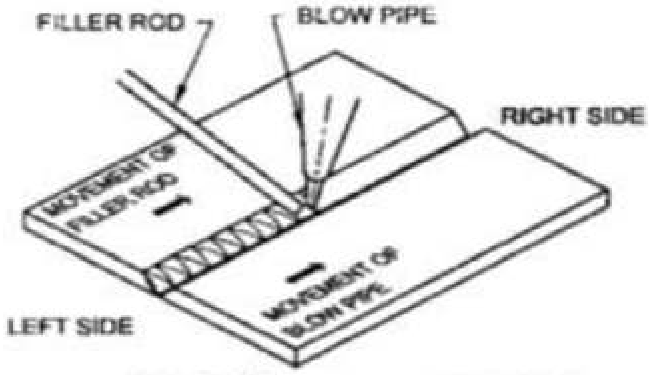


Figure.3.14. Edge preparation for leftward technique

This technique was developed to assist the production work on thick steel plates (above 5mm) so as to produce economic welds of good quality. It is also called backward or backhand technique.

The blowpipe is held at an angle of 40°-50° with the welding line. The filler rod is held at an angle of 30°-40° with the welding line. The filler rod follows the welding blowpipe. The welding flame is directed towards the deposited weld metals.

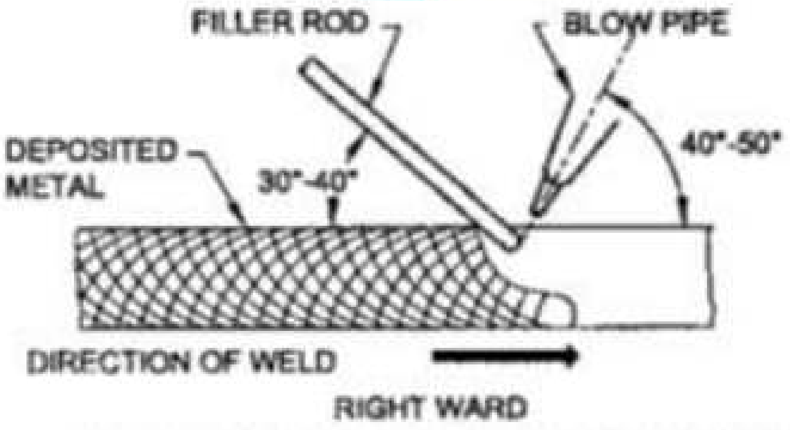


Figure.3.15.:Feature of rightward welding technique

The filler rod is given a rotational or circular loop motion in the forward direction. The blowpipe moves back in a straight line steadily towards the right. This technique generates more heat for fusion, which makes it economical for thick steel plate welding.

Edge preparation for rightward technique

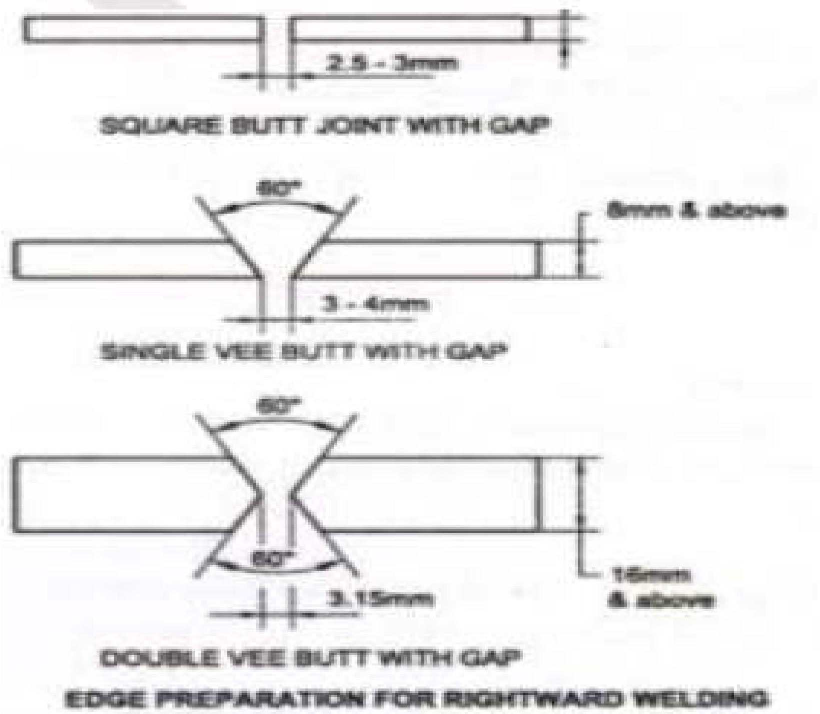


Figure.3.16:Edge preparation for rightward technique

For butt joints the edges are prepared as shown in figure:

The table given below gives the details for welding mild steel by rightward technique for butt joint:

Metal thickness in mm	C.C.M.S filler rod diameter in mm	Blow pipe nozzle size	Edge preparation	root gas in mm	flux to be used
5	3.15	10	square	2.5	for gas welding of mild steel no flux is required to be used
6.3	4.0	13	square	3.0	
8	5.0	18	60°Vee	3.0	
10 to 16	6.3	18	60°Vee	4.0	
above 16	6.3	25	60° double Vee	3.0	

Application:

This technique is used for the welding of steel above 5mm thickness and 'LINDE' welding process of steel pipes.

Advantages:

Less cost per length run of the weld due to less bevel angle, less filler rod being used and increased speed. Welds are made much faster.

Welding Of Low Carbon Steel and Medium Carbon Steel

A plain carbon steel is one in which carbon is the only alloying element. The amount of carbon in the steel controls its hardness, strength and ductility. The higher the carbon content, lesser the ductility of the steel.

Carbon steels are classified accordingly to the percentage of carbon they contain. They are referred to as low, medium and high carbon steels.

Low carbon steels

Steels with a carbon range of 0.05 to 0.30 percent are called low carbon steel or mild steel. Steels in this class are tough, ductile and easily machine able and quite easy to weld.

Welding technique: Up to 6 mm, leftward technique is a suitable one. Above 6 mm rightward technique is preferable.

Type of flame: Neutral flame to be used.

Application of flux: No flux is required.

After treatment: Most of them do not respond to any heat treatment process. Therefore except cleaning no post-heat treatment is required.

Medium carbon steel

These steels have a carbon range from 0.30 to 0.6 percent. They are strong and hard but can not be welded as easily as low carbon steels due to the higher carbon content. They can be heat treated. It needs greater care to prevent formation of cracks around the weld area, or gas pockets in the bead, all of which weaken the weld.

Welding procedure: Most medium carbon steels can be welded in the same way as mild steel successfully without too much difficulty but the metal should be preheated slightly to 160°C to 320°C (to dull red heat). After completion of welding, the metal requires post-heating to the same preheating temperature and allowed to cool slowly. After cooling the weld is to be cleaned and inspected for surface defects and alignment. The plate edge preparation depends on the thickness of the material to be welded.

High carbon steels

These steels have a carbon range from 0.6 to 1.2 percent. This type of steel is not weldable by gas welding process because it is difficult to avoid cracking of base metal and the weld.

Vertical Welding

Vertical welding may be used on unbeveled steel plate up to 3mm (1/8in) thickness and up to 15mm (5/8in) when two welders are employed working on both sides of the joint; welding starts at the bottom and proceeds vertically. See Fig. 5 and 6 for methods of blowpipe and welding rod manipulation for single-operator techniques.

When the two-operator method is used, the two welders must be trained to work in harmony.

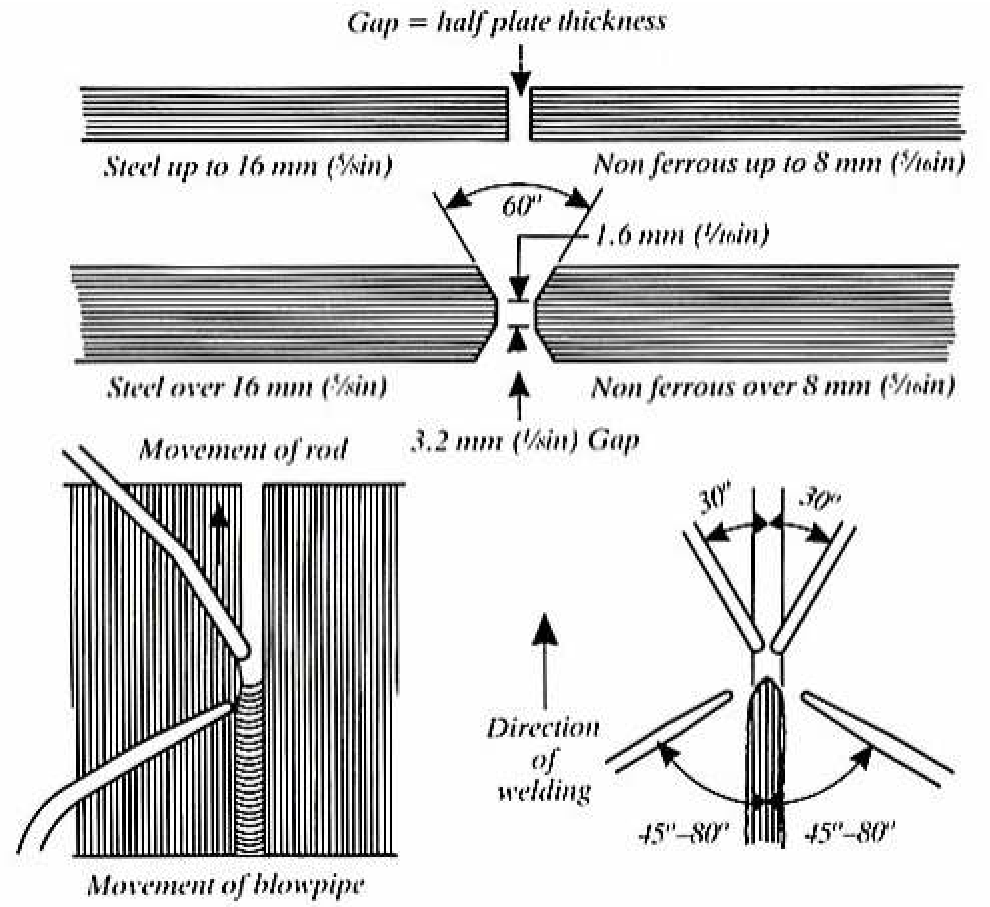


Fig.3.17: Vertical welding, two operators for plates thicker than 5.0mm (3/16in)

3.2. Interpret Instructions, Symbols, and Specifications

Step – By – Step Instruction

Check equipment

First, make sure that the gas flow from both the oxygen and the acetylene cylinders is turned off tightly. The two cylinders are secured in an upright position. This is usually on a wheeled trolley. Look at the hose pressure and cylinder pressure gauges on top of each cylinder. Both gauges on each cylinder should read zero. If both gauges do not read zero, turn the main cylinder valve on the top of the cylinder clockwise, to close it completely. Then you must purge the system of any gas.

Purge the system

It is recommended that you purge the gas lines before use to ensure that no oxygen is in the acetylene line and vice versa. Ensure that you have adequate ventilation.

To purge the system, make sure the main cylinder valve is closed tightly. Pick up the torch handle and note that it has two hoses attached. One hose supplies acetylene, the other oxygen. Turn the oxygen regulator under the gauges clockwise, and open the oxygen valve on the handle. This will purge any gas that may still be in the system and the gauges should both drop back to zero. For a 20 foot hose, open the torch valve for 5 seconds to allow oxygen to bleed from the line acetylene line. For a longer hose, consult a welding reference. Repeat this procedure with the acetylene cylinder.

Install the torch handle

The torch handle is the connection between the hoses and the working tips. It consists of a body and two taps. It's used for both welding and heating. Different attachments are connected to the handle to enable welding, heating or cutting. Examine the connections. One connection is marked "OX", and is for the oxygen hose. The other is marked "AC", and is for the acetylene hose.

Connect the hoses

As a further safety precaution, you'll find the oxygen connector is right hand thread and the acetylene connector is a left hand thread.

Install the correct tip

Welding tips come in sizes that are stamped with a number. Number one is the smallest tip. The relation between the tip number and the diameter of the orifice may vary with different manufacturers. However, the smaller number always indicates the smaller diameter. For the approximate relation between the tip number and the required oxygen and acetylene pressures, see tables below.

Low Pressure or Injector Type Torch

The choice of the tip size depends on the thickness of the metal to be joined. Larger torch tip sizes cause higher amount of oxygen and fuel to flow out causing the release of more heat.

Notes:

1. Tips are provided by a number of manufacturers, and sizes may vary slightly.

2. Oxygen pressures are approximately the same as acetylene pressures in the balanced pressure type torch. Pressures for specific types of mixing heads and tips are specified by the manufacturer.

Adjust the pressure of the gas flow

You are now ready to adjust the gas pressure for heating. Look at the two valves on the torch handle. The valve next to the oxygen hose controls the flow of oxygen to the tip. Close it tightly clockwise. The valve next to the acetylene hose controls the flow of acetylene to the tip. Also, close it tightly clockwise.

Turn on the gases

Now that you're ready to use the torch, turn the main valve on the top of each cylinder counter-clockwise half a turn to open the valve. The oxygen tank valve is a backstop valve and should be opened all the way in order to completely seal. The acetylene valve should only be opened 1/4 to 1/3 of a turn. The needle on the cylinder pressure gauge will rise to show you the pressure in the cylinder. Turn the oxygen regulator handle clockwise until the needle in the gauge registers 10 psi. Turn the acetylene regulator handle clockwise until the needle in the gauge registers 5 psi. This is your working pressure for heating.

Make sure the valves are easily accessible in case emergency shutdown is necessary

Check the area

Before you light the torch, check the area you're working in to make sure there are no flammable materials or fluids nearby. Workmates should also be clear of the area. The welding flame is not only extremely hot; it also produces dangerous ultra violet rays, which will damage your eyes. It is absolutely vital that you are wearing the right safety gear: gloves and tinted goggles or face mask. So put them on and adjust them comfortably.

Ignite the torch

Now you are ready to ignite the torch with the striker. The tip of the torch must be pointing downwards away from your body and away from the gas cylinders.

1) Hold the striker against the tip of the torch with the lighter cup between the torch and you. Flick the striker to create the spark while opening the acetylene valve slightly (1/4 turn). This will ignite the gas at the tip of the torch.
2) Once the flame is lit, open the acetylene valve just until the flame stops smoking. You should get a flame about 8 inches long with a toothy splintering end.
3) Now introduce oxygen into the flame by opening the oxygen valve on the torch.
4) Adjust the two valves (cutting torch oxygen and acetylene) until you obtain a short, bright blue flame at the torch tip with no yellow.

5) Adjust the acetylene regulator to approximately 10 psi. Turn the screw in to increase the pressure and out to decrease it.

6) Adjust the oxygen regulator in the same manner to a pressure between 40 and 60 psi.

7) Adjust the acetylene and oxygen valves as necessary to maintain the correct flame. The actual adjustment of the flame depends on the type of material to be joined

Table:Flame Adjustment for Oxy-acetylene Welding

Metal	Flame
Mild Steel	Neutral
High Carbon Steel	Reducing
Grey Cast Iron	Neutral, Slightly Oxidizing
Alloy Steel	Neutral
Lead	Neutral
Aluminum	Slightly Carburizing
Brass	Slightly Oxidizing
Copper, Bronze	Neutral, Slightly Oxidizing
Nickel Alloy	Slightly Carburizing

Caution

- Check all connections before lighting the torch.
- NEVER use a match or butane lighter to light the flame. Always use a flint and steel spark lighter to light the oxygen acetylene flame.
- BEFORE LIGHTING TORCH, be positive that hose, tanks, or any inflammable material will not be exposed to heat, flame, or sparks.
- Never stand directly in front of or behind a regulator when opening the cylinder valve.
- Turn both cylinders off immediately when the torch flashes back or is burning on the inside: first oxygen and then acetylene.
- Never open both fuel (acetylene) and oxygen valves before lighting the preheat flame. ALWAYS turn the oxygen cylinder valve all the way open.
- Open the acetylene cylinder valve not more than one turn. One-half turn is preferred.

Adjust the flame

As you open the oxygen valve, you will see the color of the flame change. The pure acetylene flame is yellow, and it will change to blue as you add the oxygen. Continue to open the oxygen valve until you can observe a small, sharp blue cone in the center of the torch flame. This is the “neutral” flame you need for general heating. 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. Too low a gas flow for a given tip size will result in a soft, ineffective flame sensitive to backfiring. Too high a gas flow will result in a harsh, high velocity flame that is hard to handle and will blow the molten metal from the puddle. The chemical action of the flame on a molten pool of metal can be altered by changing the ratio of the volume of oxygen to acetylene issuing from the tip. 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.

Using the Torch

The torch tip should be positioned above the metal plate so that the white cone is at a distance of 1.5 to 3.0 mm from the plate. The torch should be held at an angle of 45 to 60° from the horizontal plane.

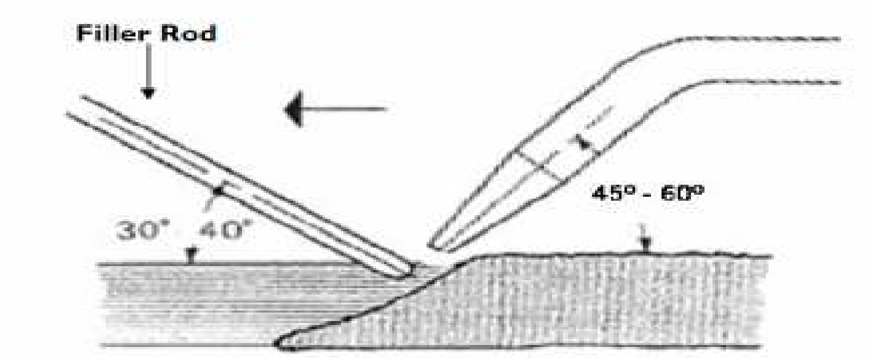


Fig.3.18: Vertical welding, two operators for plates thicker than 5.0mm (3/16in)

The torch movement along the joint should be either oscillating or circular. In forehand welding, the torch is moved in the direction of the tip. This tends to preheat before the white cone of the tip melts it. In backhand welding the torch moves backwards. The outer blue flames are directed on the already welded joint. This allows the joint to be continuously annealed relieving the welding stresses. This welding allows a better penetration as well as form bigger weld. Backhand welding is generally used for thicker materials.

When the welding rod is used to provide filler material, it is necessary to hold it at a distance of 10 mm from the flame and 1.5 to 3.0 mm from the surface of the weld metal pool or puddle. This way the rod gets preheated and when dipped into the puddle would readily get melted.

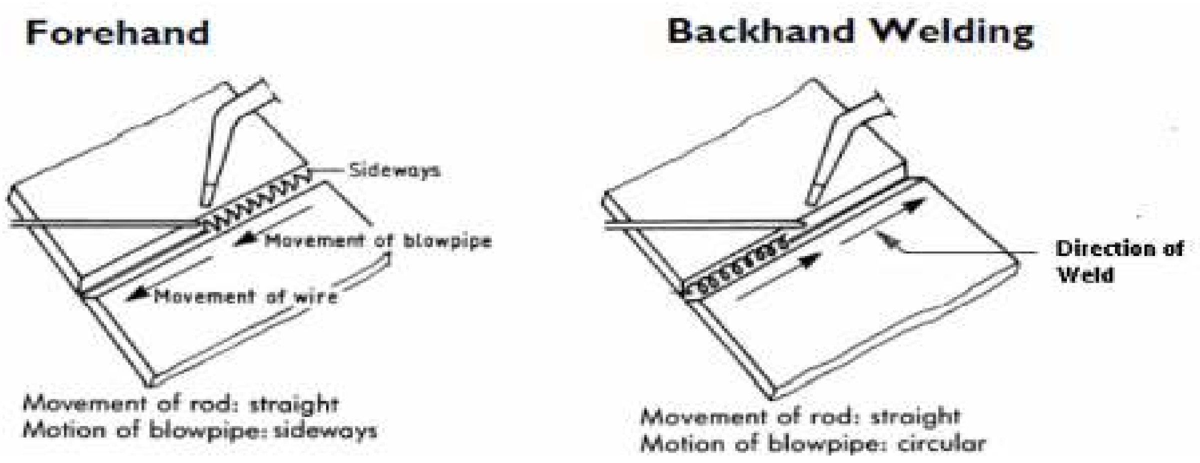


Fig.3.19: Backhand welding

Oxy-fuel welding can be used for all the types of joints in all positions. Overhead usage requires additional skill to safeguard the welder. The various butt joint edge preparations are shown in the adjacent figure.

Thicker plates require more than one pass of the gas torch along the length to complete the joint. In multi pass welding, the first pass (root pass) is very critical in any welding operation.

Weld Appearances

Welding gas pressures are set in accordance with the manufacturer's recommendations. The welder will modify the speed of welding travel to maintain a uniform bead width. Trained welders are taught to keep the bead the same size at the beginning of the weld as at the end. If the bead gets too wide, the welder increases the speed of welding travel. If the bead gets too narrow or if the weld puddle is lost, the welder slows down the speed of travel. Welding in the vertical or overhead positions is typically slower than welding in the flat or horizontal positions.

The welder must add the filler rod to the molten puddle. The welder must also keep the filler metal in the hot outer flame zone when not adding it to the puddle to protect filler metal from oxidation. Do not let the welding flame burn off the filler metal. The metal will not wet into the base metal and will look like a series of cold dots on the base metal. There is very little strength in a cold weld. When the filler metal is properly added to the molten puddle, the resulting weld will be stronger than the original base metal.

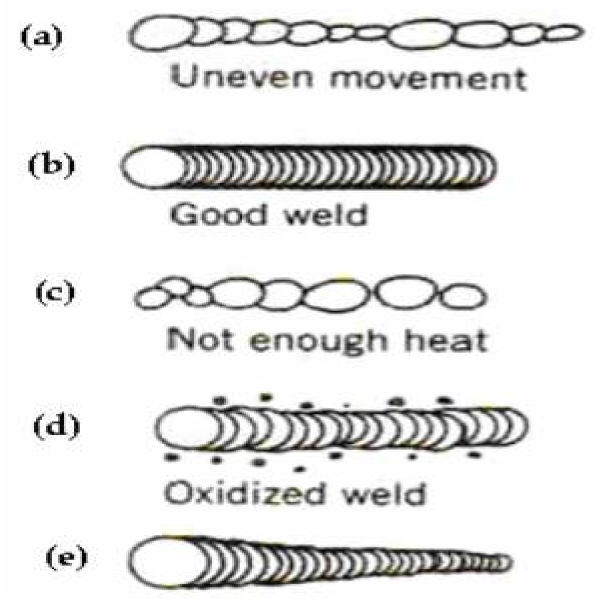


Figure3.20: improper heat control

Weld Appearances

To Extinguish the Flame and Stop Welding

1) When the welding or cutting operation is finished, close the torch acetylene valve first and then turn off the torch oxygen valve.
2) Close the oxygen cylinder valve.
3) Release the pressure in the hose and regulator by opening the oxygen control valve on the torch.
4) Release the pressure on the oxygen regulator diaphragm by turning the regulator to the minimum pressure position.
5) Close the oxygen control valve on the torch.
6) Repeat the same procedure for purging acetylene.

Caution

- ALWAYS weld at least 5 feet from the cylinders o
- ALWAYS place the welding tip so that it points to the side of the torch to which the acetylene hose is attached
- DO NOT use any oil or grease on any oxygen or acetylene connections o NEVER hammer on oxygen or acetylene regulators or stuck valves
- BEWARE OF HIGH ACETYLENE PRESSURE. NEVER USE ACETYLENE GAS WHEN THE PRESSURE IS GREATER THAN 15 POUNDS PER SQ. IN. (acetylene

gas when compressed to more than 15 pounds per sq. in. become a very high explosive.)

- DO NOT hold welding or cutting tip too close to your work

Perfecting the Weld

There are several factors that impact on the quality of weld. These factors include:

- Tip size
- Rod size
- Flame size
- Preparation of metal
- Torch or rod angle
- Distance between torch and work
- Speed and method of torch movement
- Maintenance of equipment

Tip and rod size

You need to select the proper tip size for the job to get the correct heat for the metal being welded. Some general guidelines include:

- Tips need to be selected to match the size of filler rod used and the thickness of the gauge metal being welded. The larger the filler rod, the thicker the metal, the higher the number of tip to be used.
- As a basic rule of thumb, choose a rod size that is the same thickness as the metal that you are welding.
- Tip sizes 3, 5 and 7 are common sizes to use for steel between 1/16" and 1/8" thick.

Flame Size

If the puddle is not moving properly, it may be because of incorrect tip size or it may mean you need to adjust your torch valve setting slightly. Remember that you also need to have the torch set for the correct flame type – usually neutral.

Preparation of Metal

Metal should be free of rust, grease, oil and paint. Use a grinder or wire brush to remove rust or paint. Anything that has had oil or grease on it should be avoided as it is potentially toxic and flammable when heated.

Torch or Rod Angle

The angle between the torch flame and the steel helps you to move the weld puddle where you want it. Change the angle that you are working until you find the angle that works best, usually 45 to 60 degrees.

Distance between torch and work

The close you hold the torch to your work, the more heat is created. The greater heat increases the depth of penetration of the weld and makes the weld puddle narrower.

Speed and method of torch movement

Slower speed will make a wider weld with a deeper penetration. The object is to get a flat weld. To achieve that you may need some slight back and forth or oval motions with the torch. A steady, even speed and movement is important to achieving a quality weld.

Maintenance of equipment

If your tip becomes plugged, the flame will go sideways and splutter or go out. You need to be sure that your tips are kept clean with a tip cleaner. The tip wears, becomes blackened, and pitted as you work with it. The tip cleaning tools has a flat file you can use to file the tip flat again. The cleaning tool has tip cleaners for each size of the tip. Be sue to use the right size of cleaner for the tip you are cleaning as you may damage it. Be very careful when using these cleaners as they can break off inside the tip.

Advantages of Gas Welding

1) Welder has considerable control over the rate of heat input, the temperature of the weld zone, and the oxidizing or reducing potential of the welding atmosphere;
2) As the source of heat and filler metal are separated, the metal deposition can be easily controlled and heat properly adjusted giving rise to a satisfactory weld;
3) Welding equipment is portable and can be operated at remote places. Besides gas welding, the equipment can be used for preheating, post heating, braze welding, torch brazing and it is readily converted to oxygen cutting;
4) Weld bead size and shape and weld puddle viscosity are also controlled in the welding process because the filler metal is added independently of the welding heat source;
5) Gas welding is ideally suited to the welding of thin sheet, tubes, and small diameter pipe. It is also used for repair welding. Thick section welds, except for repair work, are not economical.

Limitations of gas welding:

1) Gas flame takes a long time to heat up the metal than an arc;
2) Flame temperature is less than the temperature of the arc;
3) Slower speed of welding compared electric arc welding;

4) Heavy sections cannot be joined efficiently;
5) For heavy sections proper penetration may not be achieved;
6) Refractory metals (e.g., tungsten, molybdenum, tantalum, etc.) and reactive metals (e.g., titanium and zirconium) cannot be gas welded;
7) Flux used in the filler metal provides fumes which are irritating to the eyes, nose, throat and lungs;
8) More safety is recommended in gas welding;
9) Acetylene and oxygen are expensive gases;
10) Prolonged heating of the joint may results in large HAZ. This often leads to increased grain growth, more distortion and, in some cases, loss of corrosion resistance.

Applications of Gas Welding

1) For joining of thin materials. The process is used extensively for soldering copper tubing;
2) For joining materials in whose case excessively high temperatures or rapid heating and cooling of the job would produce unwanted or harmful changes in the metal;
3) For joining materials in whose case extremely high temperatures would cause certain elements in the metal to escape into the atmosphere;
4) For joining most ferrous and nonferrous metals, e.g., carbon steels, alloy steels, cast iron, aluminum, copper, nickel, magnesium and its alloys, etc;
5) In automotive and aircraft industries. In sheet metal fabricating plants, etc.

3.2.1. Welding Symbols

Welding symbols are used on drawings to indicate the type and specifications of the weld. The figure shows the American Welding Society (AWS) standard welding symbol. The most important features of the welding symbol are illustrated below:

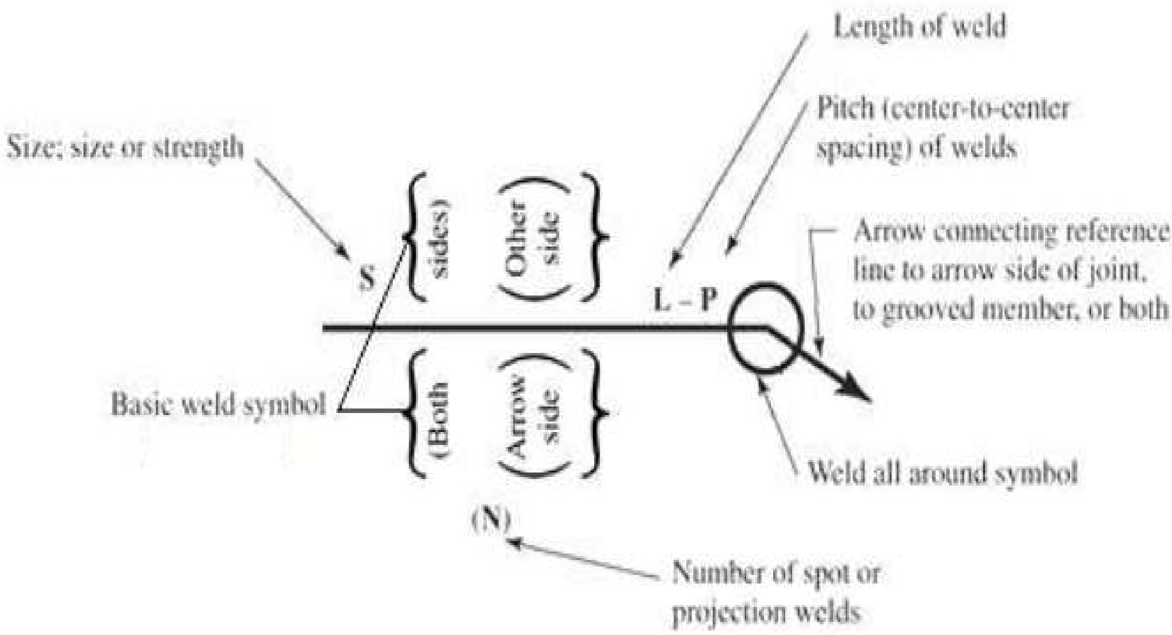
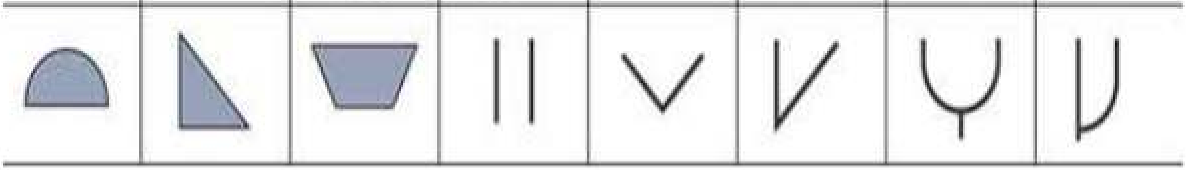


Figure: 3.21: Welding Symbols

The table shows the Basic weld symbol for the different types of welds.

Type of weld							
Bead	Fillet	Plug or slot	Groove				
			Square	V	Bevel	U	J



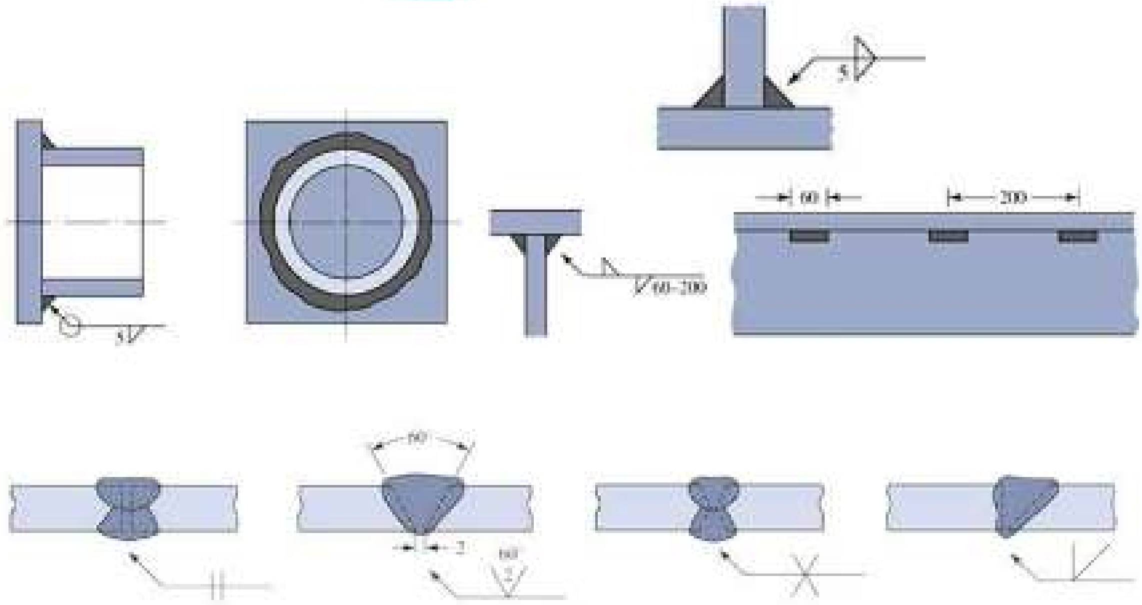


Figure: 3.22: examples for the use of welding symbols.

Self-Check-3

INSTRUCTION ONE: -<u>MULTIPLE CHOICES</u>

<u>Read each item carefully and choose the correct answer from the available four choices.</u>

1.______are used on drawings to indicate the type and specifications of the weld.

A.Welding symbols

B. Joining

C.joining materials

D.all

2.The angle between the torch flame and the steel

A.Torch

B. Rod Angle

C.joining materials

D.a&b

INSTRUCTION TWO: - SHORT ANSWER (2pts each)

Write the short answer on the space provided

1. --------------It is an oxy-acetylene gas welding technique, in which the welding is begun at the left hand edge of the welding job and it proceeds towards the right.
2. ------------ is produced by the combustion of a mixture of oxygen and acetylene in various proportions.
3. ------------It receives an excess of acetylene over oxygen from the blowpipe.
4. -------------It contains an excess of oxygen over acetylene as the gases come out of the nozzle.
5. ------------Oxygen and acetylene are mixed in equal proportion in the blowpipe and complete combustion takes place in this flame.

UNIT FOUR: Correct faults

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Identifying weld defects
- Removing defects

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify weld defects
- Remove defects

4.1. Identifying weld defects

4.1.1. Weld Defects & Types

A defect or fault is one which does not allow the finished joint to withstand or carry the required load.

Weld defects may be considered under two heads.

1) **External defects**
2) **Internal defects**

The defects which can be seen with bare eyes or with a lens on the top of the weld bead, or on the base metal surface or on the root side of the joint are called external defects.

Those defects, which are hidden inside the weld bead or inside the base metal surface and which cannot be seen with bare eyes or lens are called internal defects.

Some of the weld defects are external defects, some are internal defects and some defects like crack, blow hole and porosity, slag inclusion, lack of root penetration in fillet joints, etc. will occur both as external and internal defects.

External defects

1) Undercut
2) Cracks
3) Blow hole and porosity
4) Slag inclusions
5) Edge of plate melted off
6) Excessive convexity/ oversized weld/ excessive reinforcement
7) Excessive concavity/ insufficient throat thickness/ insufficient fill
8) Incomplete root penetration/ lack of penetration
9) Excessive root penetration
10) Overlap
11) Mismatch
12) Uneven/ irregular bead appearance
13) Spatters

Internal defects

1) Cracks
2) Blow hole and porosity
3) Slag inclusions
4) Lack of fusion
5) Lack of root penetration
6) Internal stresses or locked-up stresses or restrained joint.

4.1.2. Types of Faults in Gas Welding

A fault is an imperfection in the weld which may result in failure of the welded joint while in service. The following faults occur commonly in gas welding:

Undercut

A groove of channel formed along the toe of the weld on one side or on both sides.

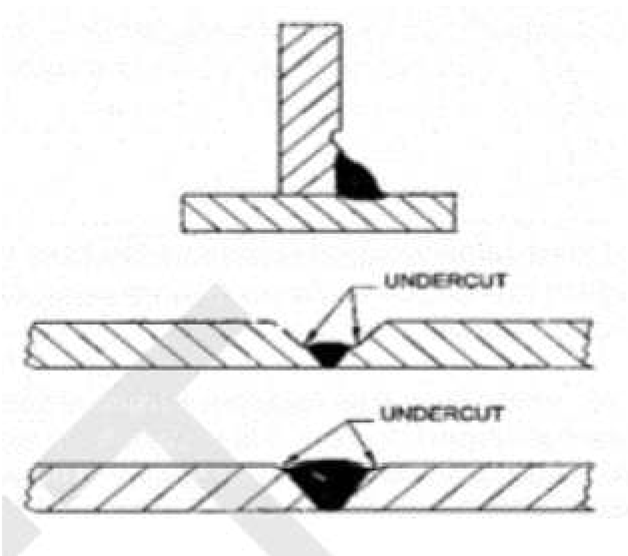


Figure: 4.1: Undercut

Excessive convexity

Too much weld metal added to the joint so that there is excessive weld reinforcement.

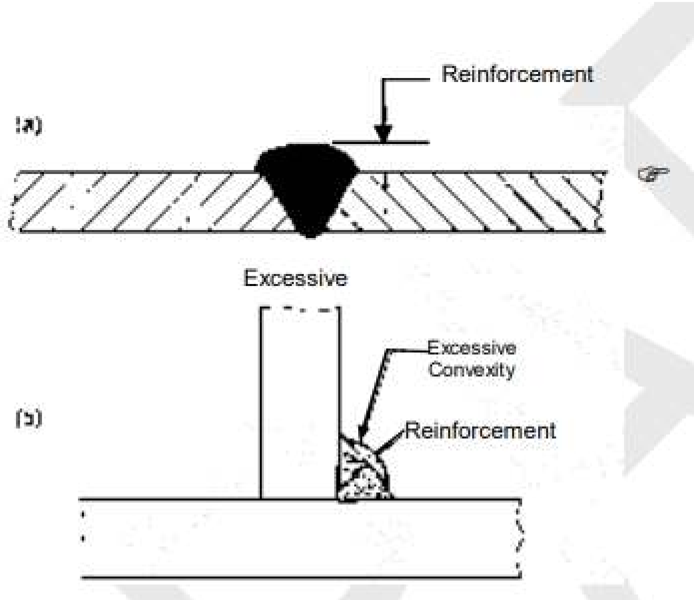


Figure: 4.2: Excessive convexity

Overlap

Metal flowing into the surface of the base metal without fusing it.

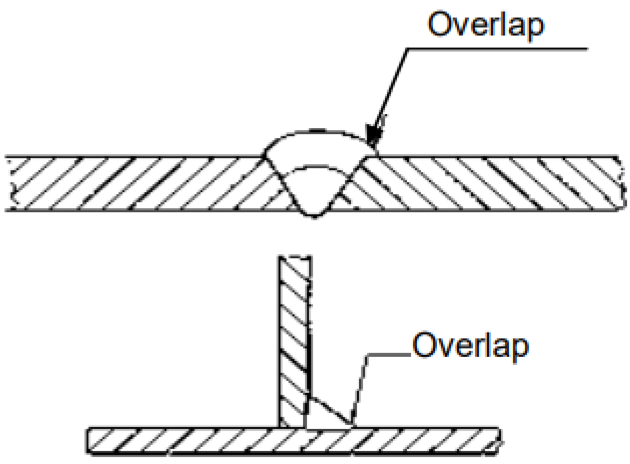


Figure: 4.3: Overlap

Depth of fusion at the root of the grooved joint is more than the required amount.

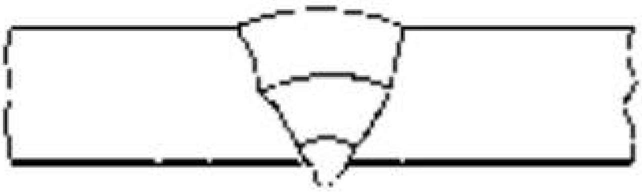


Figure: 4.4: Excess Weld Metal at the Root

Lack of penetration

Required amount of penetration is not achieved i.e. fusion does not take place upto the root of the weld.

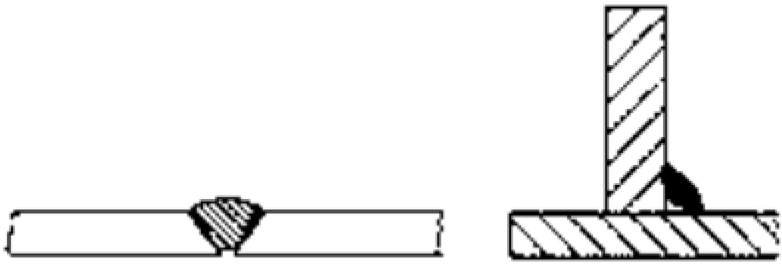


Figure: 4.5: Lack of Penetration

Lack of fusion

If there is no melting of the edges of the base metal at the root face or on the side face or between the weld runs, then it is called lack of fusion.

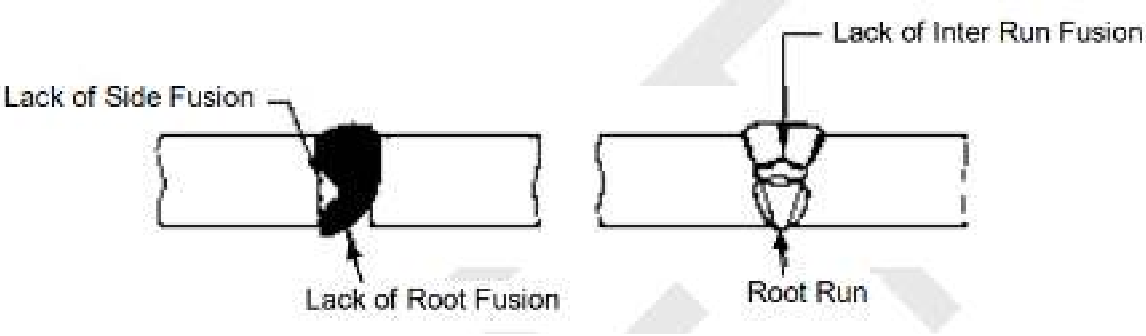


Figure: 4.6: Lack of fusion

Porosity

Number of pinholes formed on the surface of the deposited metal.

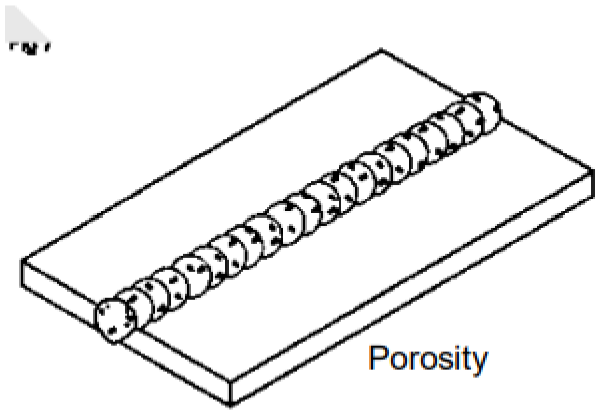


Figure: 4.7: Porosity

Blow-holes

These are similar to pinholes but have a greater diameter.

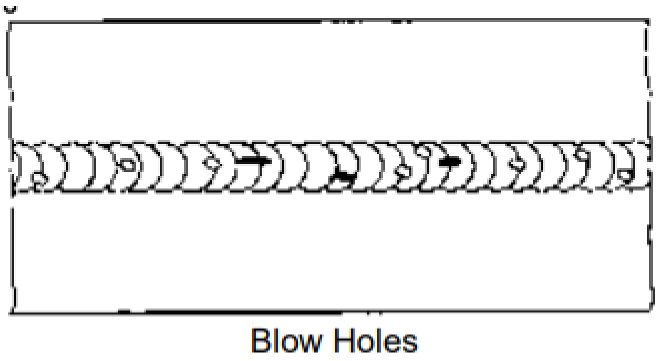


Figure: 4.8: Blow-holes

Cracks

A discontinuity in the base metal or weld metal or both.

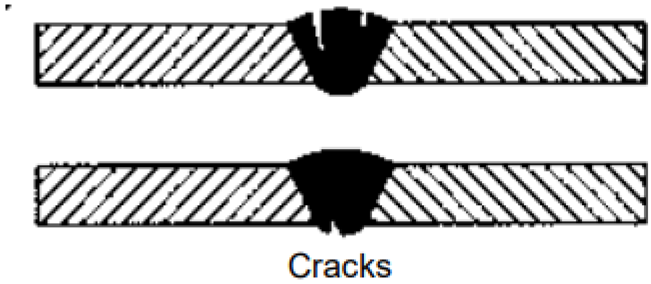


Figure: 4.9: Cracks

Unfilled crater

A depression formed at the end of the weld.

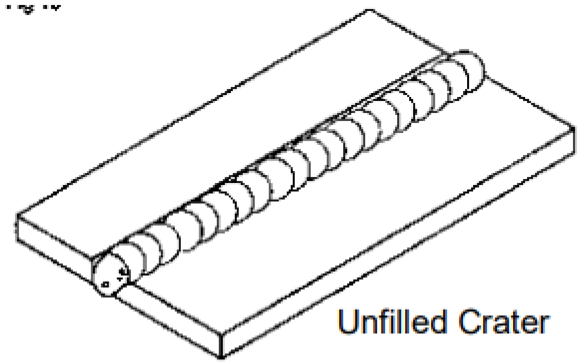


Figure: 4.10: Unfilled crater

Excessive concavity/ insufficient throat thickness

Enough weld metal is not added to the joint so that there is insufficient throat thickness.

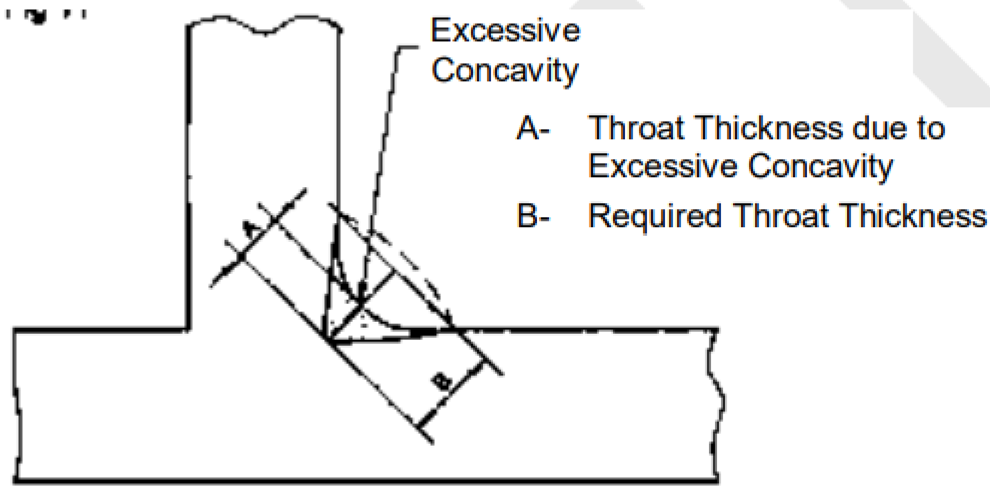


Figure: 4.11:Excessive concavity/ insufficient throat thickness

Burn through

A collapse of the molten pool due to excessive penetration, resulting in a hole in the weld run.

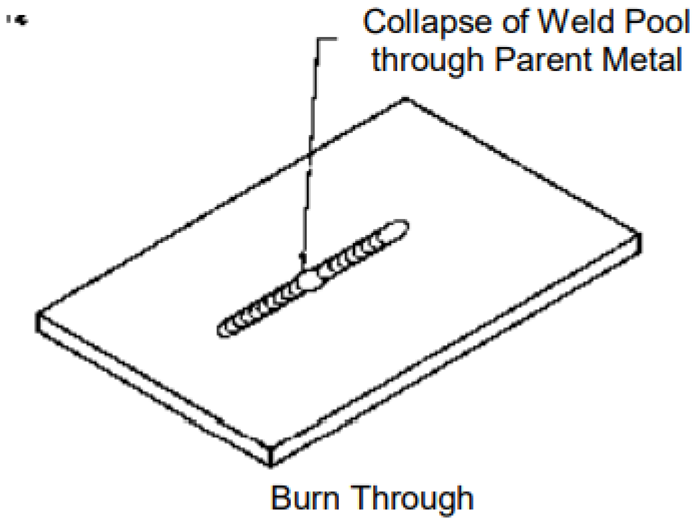


Figure: 4.11: Burn through

4.2. Removing Defects

What Is A Weld Defect?

In short, a weld defect is any flaw or imperfection that compromises the intended use of a weldment. These are classified according to ISO 6520.

This also implies a flaw or imperfection may not compromise the weld, and a weld is said to have a discontinuity when this occurs. So, a weld can have a discontinuity and not be considered defective. These acceptable limits are specified in ISO 5817 and ISO 10042.

However, if enough discontinuities exist (i.e., they exceed a limit as defined in an applicable code or specification), then the discontinuities become classified as defects, and the weld is rejected.

A weld must be strong enough for the intended purpose at the most basic level, and many defects can weaken a joint. But in some cases, your weld must be aesthetically pleasing, too. So, most defects either weaken a weld or make it look ragged and unpresentable.

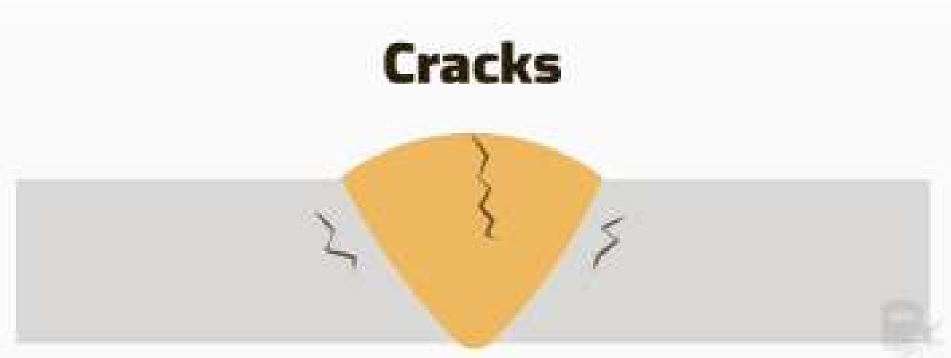
We all want to avoid having our welds fail or be rejected. So, you need to know the types of defects that can occur and how to avoid them.

Common Types of Weld Defects

1. Cracks
2. Inclusions
3. Lack of fusion
4. Porosity
5. Undercut
6. Poor penetration
7. Burn through
8. Under-fill
9. Excess reinforcement
10. Spatter
11. Over-roll/Overlap
12. Whiskers
13. Mechanical damage

Irregular welds include too wide or too narrow, those with an excessively convex or concave surface, and those with coarse, irregular ripples. These characteristics may be caused by poor torch manipulation, a speed of travel that is too slow, current that is too high or low, improper arc voltage, improper stick out, or improper shielding gas.

1. Cracks



We may as well start with one of the most obvious and serious defects in a weld – cracks. These weaken a weld, and even worse, cracks tend to grow at a rapid rate making the problem worse.

So, it goes without saying you do not want any cracks in your welds. But it can be a challenge, and there are three main types of cracks:

- Longitudinal cracks run along, or are parallel, to the length of the weld.
- Transverse cracks run across the width of a bead.
- Crater cracks usually occur at the end of a weld when the arc is terminated. They are often star-shaped and form when a dent or "crater" is formed at the end of a weld.

Cracks can further be categorized as hot or cold cracks.

Welds can be heated to over 10,000°C, and hot cracks occur as the weld cools and transitions from the liquid to the solid phase. Hot cracks tend to occur when the wrong alloy filler material is used.

Cold cracks occur after the weld has cooled. They can occur hours or days after the joint is made. This defect usually occurs when welding steel and is often caused by deformities in the base metal.

How to prevent cracks

- Use the correct alloy filler material for the metal being welded.
- Avoid welding high sulfur and carbon steel.
- Preheat your joint.
- Ensure the joint is filled and avoid a convex-shaped bead.
- Use sound, defect-free base metal.
- Avoid low currents coupled with high travel speeds.
- Do not use hydrogen shielding gas with ferrous metals.
- Keep a good depth to width ratio for your joint.
- Avoid craters at weld termination by placing adequate filler material when ending a bead.
- Allow for expansion and contraction of a weld joint during the weld and cool down.

2. Inclusions

Impurities can become trapped inside a weld, and these are referred to as inclusions. Contaminants trapped inside a weld dramatically weaken the joint.

Slag often forms when flux is used, such as brazing and stick, flux-cored, and submerged arc welding. The slag must be allowed to float to the top of the puddle and not become trapped inside the bead. That means the molten pool should not be allowed to cool too fast.

But it can occur with MIG welding as well. Bits of rust and even tungsten can be counted as slag and can cause contamination in your welds. So, MIG and TIG welding is not immune to inclusions.

How to prevent inclusions in your welds

- Prep and clean the base metal well.
- Avoid low amperage settings (prevent the weld pool from cooling too fast).
- Keep a proper torch speed (the welding and slag pools should not mix).
- Maintain a proper torch angle.
- Clean slag from previous welds between passes.

3. Lack of Fusion

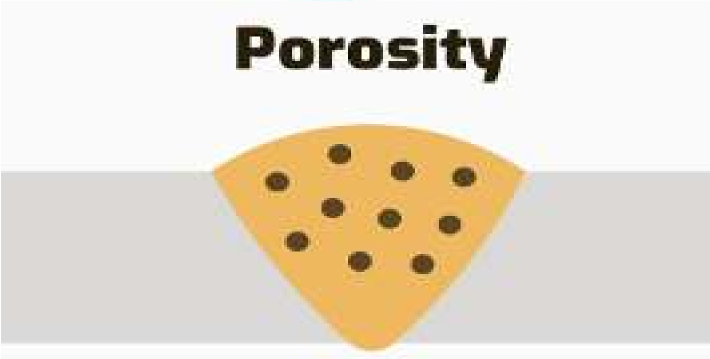
It may seem obvious, but the filler material must be well bonded to the base metal on both sides and to welds underneath during multiple passes.

If there are voids, gaps, or poor adhesion, the joint will be structurally impaired.

How to prevent a lack of fusion

- Clean your base metal well and remove all impurities.
- Use the correct size electrode.
- Select the right electrode alloy for the metal being welded.
- Don't move the torch too fast.
- Prevent the arc from getting too short.
- Keep the amperage high enough for the job.

4. Porosity



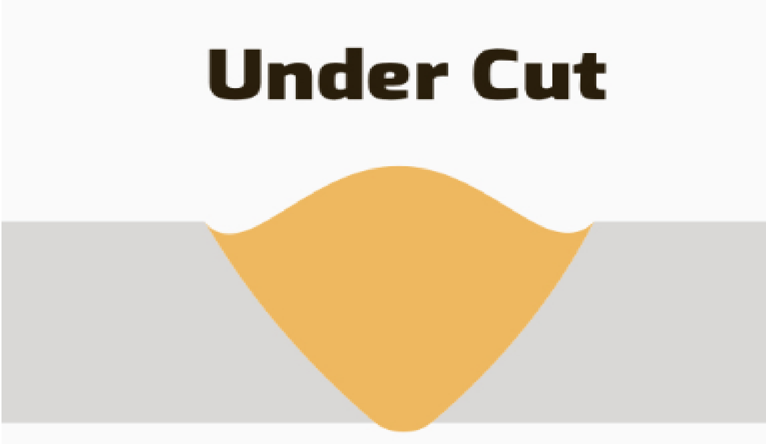
Weld porosity (also known as wormhole weld) is where gas bubbles accumulate and get trapped inside a weld. This is also said to be porous. A cross-section of a porous weld bead will resemble a sponge with all the air bubbles trapped inside.

As you weld, gases like steam, hydrogen, and carbon dioxide can be generated, and they normally bubble out of the molten bead. But if the gas bubbles are trapped, they can weaken your joint, and the work is ruined.

How to avoid porous welds

- Properly clean and prepare the base metal.
- Make sure the joint is dry.
- If used, set your shielding gas flow correctly (too low or high can create issues).
- Keep the amperage from getting too high (i.e., too “hot”).
- Use the correct electrode alloy for the job.
- Ensure the electrode coating is not damaged if it has one.
- Move your torch slow enough to keep a molten puddle, allowing the gas to bubble out.
- Avoid a long arc.
- Use low hydrogen electrodes.

5. Undercut



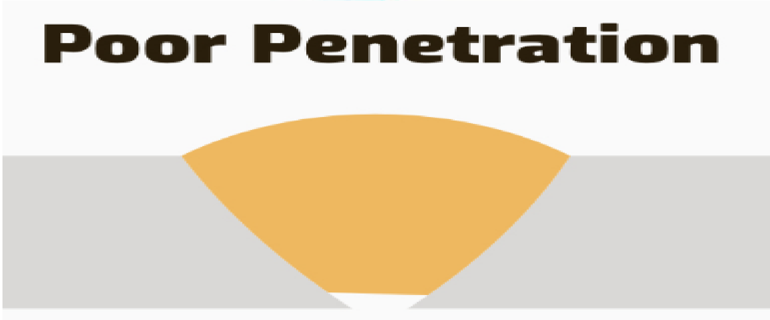
When the welding process results in spots or sections being less than the original base metal, the defect is referred to as an undercut. This will often appear as a "notch" at the edge of a weld, either on the top or bottom of the weld.

A loss in thickness reduces the strength of the weldment and makes the joint susceptible to fatigue. This defect is often the result of too high a current or moving the torch too fast.

How to prevent undercutting

- Do not move the torch too quickly.
- Use the proper amperage and avoid too high a setting.
- Keep the torch at the correct angle (and angle the heat to thicker areas when possible).
- Use a correctly sized electrode.
- Keep a shorter arc.
- Ensure you have the right shielding gas flowing at the correct rate.
- Use proper welding techniques.
- Employ multiple passes.

6. Poor Penetration



When the bead does not fill a butt joint all the way to the bottom, the weld achieves poor penetration. It is also referred to sometimes as incomplete penetration. Whatever you call it, this form of defect also compromises the integrity of a joint.

How to get good penetration

- Use a properly sized electrode for the weld (avoid an oversized electrode).
- Don't move the puddle too fast.
- Prepare V grooves for butt joints with 60 to 70 degree sloped sides.
- Align the workpieces, so there are no large or irregular gaps to fill.
- Keep your amperage, or heat, at an optimum setting and avoid too low a current setting.

7. Burn Through

If too much heat is applied during the weld, you can actually blow a hole through the metal. This defect is referred to as burn through, but sometimes it is also called melt through. Of course, creating a hole defeats the purpose of a weld and destroys the joint.

This type of defect is usually encountered with thin stock, material less than 1/4 inch thick. But it can occur with thicker stock if your welder settings are too high, if the gap between pieces is large, and/or you are moving the torch too slow.

How to prevent burn through

- Do not let the current get too high.
- Avoid excessive gaps between plates.

- Ensure your travel speed is not too slow.
- Stay away from large bevel angles.
- Ensure the nose is not too small.
- Use the correct wire size; too small accentuates the problem.
- Provide adequate metal hold-down and/or clamping.

Self-Check-4

INSTRUCTION ONE: - SHORT ANSWER

Write the short answer on the space provided

1 write the way to prevent undercutting

A. --

B. --
C. --
D. --
E. --

2. Write the way to prevent burn through

A. --
B. --
C. --
D. --
E. --

3. Write the way to prevent burn through

A. --
B. --
C. --
D. --
E. --

Unit Five: Assure quality weld record handling

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Inspecting welding joints
- Filling weld records
- Maintaining weld records

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Inspect welding joints
- Fill weld records
- Maintain weld records

5.1. Inspect Welding Joints

Welding Inspection Procedures:

<u>1. First Inspection Verification:</u>

The main job of Weld Inspectors is to judge the quality, integrity, properties, testing, dimensions procedures and recording of welding operations. All welding's must be done by a certified welder. When a welder is qualified a certificate is issued showing the types of welds which the operator is qualified to perform. Inspectors should verify and record the welder's certificate:

- Certificate number,
- Date issued, and
- Qualified positions on the Log of Piling form.

Certificates are good for one year and must be renewed annually, except requalification that will be only be required every two years for field welder who have successfully passed their qualification tests without failure for three consecutive years. Welding and repairs shall be done in accordance with Welding Procedure Specifications (WPS) but, only Shielded Metal Arc Welding (SMAW) and/or Flux Cored Arc Welding (FCAW) will be permitted for welding steel piles. Filler metal shall be in accordance with the requirements of AWS Specifications. For SMAW, low hydrogen electrodes shall be used. The welding electrode must be on the approved list published by the Office of Materials semi-annually or be specifically approved by the Office of Materials.

Weld Defects Inspection:

The most important considerations in inspection are to point out the difference between a weld defect and a weld discontinuity. However, some welding instructors, specification books or codes may allow for a certain amount of discontinuities without calling the weld defective.

A defective weld in a manufacturing situation would have to be ground out and replaced or the entire base metal structure would be rejected. When one or more discontinuities cause a weld to fail a particular weld test, this type of discontinuity would then be termed as a defect.

It is quite easy to encounter many kinds of discontinuities and defects when first learning the GMAW process. Discontinuities and defects can be caused by many factors, including:

- Improper welding techniques;
- Improper shielding gas or equipment problems;
- Improperly prepared or contaminated base metal;
- Dirty or contaminated electrode wire;
- Improper secondary circuit;

The most common weld defects are:

- Lack of Penetration;
- Incomplete Fusion;
- Porosity;
- Undercutting;
- Cracking;
- Excessive Spatter

Inspection and Non Destructive Testing (NDT)

Personnel Qualification

The NDT operators shall be qualified according to EN 473 level II or to an equivalent scheme. Visual inspectors shall be qualified in accordance with NS 477 or equivalent. The responsible person for the NDT system shall be qualified to EN 473 level III or equivalent.

Acceptance Criteria

The defect acceptance level shall be in accordance with ASME B31.3, Chapter VI, Normal Fluid Service and Chapter IX, High Pressure Service, for pipe classes with rating above 2500psi.

If radiographic testing is replaced by ultrasonic the acceptance criteria for ultrasonic shall be in accordance with ASME VIII,

For dye penetrant and magnetic particle testing the acceptance criteria shall be in accordance with ASME VIII,

Weld zones in stainless steels, Nickel and Titanium alloys shall be examined on the inside and outside and fulfill the criteria stated below.

a) The oxidation levels showing light brown to brown color are acceptable.

b) Oxidation levels showing a narrow band of dark browncolor and intermittent spots of blue color are acceptable.

Radiographic Testing

The radiographic film sensitivity shall be as given in table 7.1.

Table 7.1 - Radiographic Film Sensitivity

Technique	Nominal wall thickness	Sensitivity
X-ray	> 3 mm £ 3 mm	2,0 % 3,0 %
Gamma ray	> 5 mm £ 5 mm	2,0 % 3,0 %

NONDESTRUCTIVE TESTING (NDT):

The NDT (nondestructive testing) methods are:

1) Visual Inspection - VT
2) Liquid Penetrant Testing - LT
3) Magnetic Particle Testing - MT
4) Radiographic Testing - RT
5) Ultrasonic Testing – UT
6) Eddy Current Testing – ET (not used in field inspection)
7) Acoustic Emission Testing – AET (not used in field inspection)

Operation Sheet 5.1

Operation Title: **Visual Inspection – VT**

Instruction: Welds must be cleaned from slag to make inspection for surface flaws possible. A 10x magnifying glass is helpful in detecting fine cracks and other faults.

Purpose: Visual inspection are one of the oldest and most trusted ways to evaluate the condition of an

Asset as part of the overall maintenance process. The goal of a visual inspection is to find

. Anything that might be wrong with the asset which could require maintenance.

Required tools and equipment:

Precautions:

Step 1.

Visual inspection after welding is very useful in evaluating quality, even if other testing methods are to be employed. As welding progresses, surface flaws such as cracks, porosity, and unfilled craters can be detected only by Visual Inspections, leading to repairs or rejection of the work.

As indicated before, a borescope and dental mirrors, are useful for inspection inside vessels, pipe, or confined areas.

Figure. Visual inspection

Visual inspection is the most popular and the most widely used of the non-destructive inspection techniques. Completed welds should be checked according to the plans and the specifications.

The most common welds that need to be inspected in the field are fillet welds. Fillet welds are designed based on their leg sizes. If the leg is under the specified dimension, then the strength required is less than what the joint was designed for. The throat of the weld should be checked also.

Inspector visual requirements: Performed with or without corrective lenses, to prove near vision acuity on Jaeger J2 at not less than 12 inches and a color perception test. The objective of visual inspection at this stage is not only to detect non permissible faults, but all procedure details.

If the plans show a fillet weld at 5/16 inches then each leg of the weld needs to measure to that dimension. A fillet weld gauge is the standard tool to check weld sizes. The fillet weld gauge has two corners for checking leg sizes and two corners for checking throats of the weld. An explanation of how to use the fillet weld gauge is shown below:

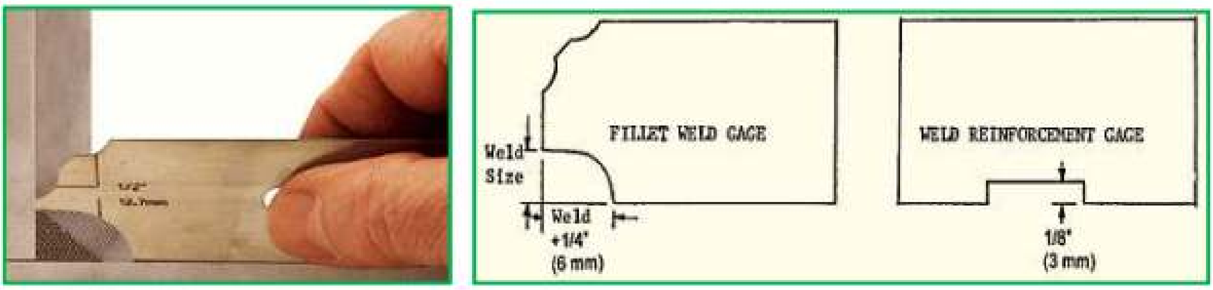


Figure. Visual inspection

Welds should be first visually inspected. The initial procedures taken by the Welding Inspector are:

Step 2. <u>Details to Check before the Welding</u>:

1) The materials to be welded and the related standards (ASME, ASTM, etc.);
2) Welder Qualification Certificate, drawings and related documents;
3) Welder equipment and electrodes, including storage and drying systems;
4) Welding edge preparations and correct bevels;
5) Root openings;
6) Clearance of backing strip or ring;
7) Overall alignment and fit up;
8) Welding procedures during the welding.

Step 3. <u>Details to Check during the Welding</u>:

1) Preheat and interposing temperature;
2) Cleaning, chipping, grinding or gouging;
3) Structural defects and discontinuities;
4) Post heating temperature, when specified.

Step 4. <u>Details to Check after the Welding</u>:

1) Dimensional accuracy of the weldment, using fillet weld gages or rulers, as shown above;
2) Conformity to drawing and procedure requirements;
3) Acceptability of welds with regard to appearance and fabrication quality;
4) The presence of any unfilled craters, undercuts, cracks, overlaps;

5) Post heating temperature, when specified.

Step 5. <u>Weld Joint Preparation</u>:

The first step in making a sound weld is to make sure the joint is correctly cleaned using a stiff wire brush or a grinder for cleaning the base metals. The portion of the base metal to which the ground clamp will be attached must also be cleaned. Poor contact with the ground clamp will create resistance in the welding circuit and could result in poor weld quality.

Preheat prior to welding should be taken according to procedures. All unpainted surfaces have to be free from all loose or thick scale, slag, rust, moisture, grease, or other foreign material.

5.2. Fill Weld Records

WELDER AND WELDING OPERATOR QUALIFICATION RECORD

Welder/Welding Operator's Name: Identification No.:

Welding process Manual ☐ Semi-automatic ☐ Machine ☐

Position:
(Flat, horizontal, overhead or vertical – if vertical, state whether upward or downward)

In Accordance with Procedure Specification No.:

Material specification:

If Pipe - Diameter and Wall Thickness: Qualifies for thickness range below:
Otherwise - Joint Thickness:

FILLER METAL

Specification No: Classification: F-No:

Describe filler metal: (if not covered by AWS specification)

Is backing used? Yes ☐ No ☐
Filler metal diameter and trade name:

FLUX for Submerged Arc or Flux Cored Arc Welding / GAS for Gas Metal Arc:

VISUAL INSPECTION (9.21.1)

Appearance: Undercut: Piping porosity:

Guided Bent Test Results

Type	Result	Type	Result

Test Conducted by: Laboratory Test No.:

Per: Test Date:

FILLET TEST RESULTS

Appearance: Fillet size:

Fracture Test Root Penetration: Macrotech:
(Describe the location, nature, and size of any crack or tearing of the specimen)

Test Conducted by: Laboratory Test No.:

Per: Test date:

RADIOGRAPHIC TEST RESULTS

Film Identification	Results	Remarks	Film Identification	Results	Remarks

Test witnessed by: Test No:

Per:

We, the undersigned, certify that the statements in this record are correct and that the welds were prepared and tested in accordance with the requirements of the current AASHTO/AWS D1.5 Bridge Welding Code.

Manufacturer or Contractor:

Authorized by: Date:

Lap test 5.1.

Name: ___________________________ Date: _____________

Time started: _____________________ Time finished: ________________

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within 10 hours.

Task 1. Select the tools and equipment to Visual Inspection

Task 2. Write the steps for Visual Inspection

Annexure – 1

Terminology

1) **Acetone:** A flammable liquid used in acetylene cylinders to dissolve and store acetylene.

2) **Acetylene:** A colorless, flammable gas that is used in oxyfuel welding. Acetylene is the most commonly used gas for mixing with oxygen to fuel oxyfuel torches.
3) **Airtight:** Not allowing any gases or air to penetrate. An airtight joint will not leak any gas.
4) **Aluminum:** A silvery white metal that is soft, light, and has a high strength-toweight ratio. Aluminum is one of the most difficult metals to weld.
5) **Arc welding:** A joining process that uses electricity to generate the heat needed to melt the base metals.
6) **Braze pool:** The pool formed by the melted filler metal during braze welding. The temperature to melt the filler metal is low enough that the pieces being joined do not melt.
7) **Braze welding:** A process in which a filler metal is melted at a temperature above 840° F (450° C), but below the melting point of the base metals to fill in a gap between two base metals. Braze welding differs from brazing because the filler metal is used to fill a gap.
8) **Brazing:** A joining process that is used to combine dissimilar metals at temperatures lower than welding.
9) **Butt joint:** A joint formed by joining two pieces of metal edge to edge.
10) **Capillary action:** The ability of a substance to draw a liquid upwards against the force of gravity. In brazing, capillary action causes a filler metal to be drawn into the space between work pieces.
11) **Copper:** A reddish metal that is very ductile, thermally and electrically conductive, and corrosion resistant. Copper can be welded using limited methods.
12) **Cutting:** The use of an ox fuel torch to separate metal from a workpiece. Oxy-fuel cutting uses an additional high-pressure stream of oxygen to cut metal.
13) **Cylinder:** A container for compressed gases. Each gas is stored in a unique type of cylinder.
14) **Die:** A reusable mold that holds heated liquid metal and imparts its shape as the metal cools. Oxygen cylinders are shaped in dies.
15) **Distillation:** The process by which oxygen is extracted from the air to be stored in a cylinder.
16) **Ductility:** The ability of a metal to be drawn, stretched, or formed without breaking.
17) **Edge joint**: A joint formed by joining the edges of two pieces of metal that are parallel to each other.

18) **Ferrous metal:** A metal that contains iron. Ferrous metals are the most common type of welded metal.
19) **Filler metal:** A type of metal sometimes added to the joint in fusion welding. Filler metal adds to the strength and mass of the welded joint.
20) **Flashback:** A torch malfunction in which the flame briefly or continually moves up into the torch and hoses. If a flame reaches the hoses, an explosion can occur.
21) **Flashback arrestor:** A part of an oxyfuel outfit that is installed between the hoses and the torch. A flashback arrestor reduces the chances of flashback occurring while a torch is used.
22) **Flux:** A non-metallic material used to protect the weld puddle and solid metal from atmospheric contamination.
23) **Hose connector:** The part of an oxyfuel torch where the flashback arrestor is attached to the torch.
24) **Impurities:** Any elements contained in an oxyfuel weld that are not the metal being joined or the filler metal.
25) **Injector:** The part of an injector torch that pulls low-pressure acetylene into the torch and mixes it with oxygen.
26) **Injector torch:** A type of torch that uses lower-pressure acetylene and features an internal injector that pulls the acetylene into the torch.
27) **In-tip mixer:** A welding tip that contains a mixing chamber as part of the tip.
28) **Joining:** Bringing two separate materials together through some type of forming. Joining is one of the main ways metals can be formed.
29) **Lap joint:** A joint formed by two overlapping pieces of metal.
30) **Low-carbon steel:** Carbon steels that contain less than 0.3% carbon. Also referred to as mild steel, low-carbon steel is the most commonly welded metal.
31) **MAPP gas:** Also called methylacetylene-propadiene gas. A liquefied petroleum gas that can be used in oxyfuel processes. The main disadvantage of MAPP gass is that it costs much more than acetylene.
32) **Metal:** A hard, crystalline solid that conducts electricity and heat. It is shiny when polished, and it can be hammered, bent, formed, and machined.
33) **Mixing chamber:** A part of an oxyfuel outfit that is connected to the tip of the torch, or is part of the tip. The mixing chamber is where the two gases are combined before being burned by the flame.

34) **Non-ferrous metal:** A metal that does not contain iron. Nonferrous metals are more difficult to weld than ferrous metals.
35) **Orifice:** The hole or holes at the end of a torch tip. The shape and number of holes determine the use of the tip.
36) **Outside corner joint:** A joint formed by the edges of two metal pieces being welded together at an angle of around 90 degrees. The weld is done on the outside of the corner.
37) **Oxide:** A chemical compound containing oxygen and one other element. Oxides form during oxyfuel welding is harmful to the weld.
38) **Oxy-fuel welding:** A joining process that uses a mix of gases to fuel a torch to join two metal parts.
39) **Oxygen:** A nonmetallic element that is colorless, odorless, and tasteless. Oxygen is one of the two gases used in oxyfuel welding.
40) **Porous:** Full of holes that allow the material to absorb liquids. The material inside an acetylene cylinder is porous, enabling it to hold acetone.
41) **Positive pressure torch**: A torch that uses equal pressures of oxygen and acetylene and does not have an injector.
42) **Propylene**: Also known as propane. A flammable gas that can be used in oxyfuel welding instead of acetylene.
43) **Soldering**: A joining process in which a filler metal is melted at temperatures below 840° (450° C) to form a joint between two base metals. Soldering is often used for delicate projects such as jewelry and electronics.
44) **Stainless steel**: A type of steel that contains more than 15% chromium and exhibits excellent corrosion resistance. Stainless steel can be welded using many methods.
45) **T-joint**: A joint formed when the edge of one piece is welded to the surface of another piece at a 90° angle.
46) **Torch**: A tool used to generate the flame for oxyfuel welding by mixing oxygen and a fuel gas, usually acetylene.
47) **Torch body**: Also called the handle. The part of the torch held by the welder. Inside the torch body are hoses which direct the flow of gases to the mixing chamber.
48) **Unstable**: Highly reactive and dangerous, possibly explosive. Unstable chemicals require careful handling to ensure safety.
49) **Valve**: The part of the torch used to regulate the amount of oxygen and fuel gas flowing into the torch.

50) **Watertight**: Not allowing any liquids to penetrate. A watertight joint will not leak any liquids at all.

51) **Welding rod**: Also known as a filler metal. Filler metals come in rods that are used during the welding process.

52) **Welding tip**: The end of the torch where the flame is ignited. Tips are usually interchangeable, and are made of solid copper.