

# Machining

## Level I

**Based on March 2022, Curriculum Version 1**



**Module Title: - Perform flame Cutting and welding.**

**Module code: [IND MAC1 M 07 0322](#)**

**Nominal duration: 50Hour**

**Prepared by: Ministry of Labour and Skill**

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**Addis Ababa, Ethiopia**

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## Acknowledgment

**Ministry of Labor and Skills** wish to extend thanks and appreciation to the many representatives of TVET instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

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## Introduction to the module.

Oxy-fuel welding, commonly referred to as oxy welding or gas welding is a process of joining metals by application of heat created by gas flame. The fuel gas commonly acetylene, when mixed with proper proportion of oxygen in a mixing chamber of welding torch, produces a very hot flame of about 5700-5800°F. With this flame it is possible to bring any of the metals to a molten state and cause a fusion of two pieces of like metals in such a manner that the point of fusion will very closely approach the strength of the metal fused. If more metal of like nature is added, the union is made even stronger than the original. This method is called oxy-acetylene welding.

This module is designed to meet the industry requirement under the machining particularly for the unit of competency: **Perform flame Cutting and welding.**

**This module covers the units:**

- cutting and welding operations
- Set up oxy acetylene cutting outfit and welding
- cutting and welding using Oxy acetylene
- quality and clean up

### Learning Objective of the Module

- select cutting and welding operation
- Set up oxyacetylene cutting outfit and welding
- Perform Cut materials and welding operation
- Assure quality and clean up

### 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

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## Unit one: cutting welding and operations

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

- Welding and cutting requirements
- Welding equipments and consumables
- Material preparation

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 welding and cutting requirements
- Select equipment and consumables for oxy operations
- Prepare material as required

## 1.1. Welding and cutting requirements

The oxyacetylene welding process uses a combination of oxygen and acetylene gas to provide a high temperature flame. The high temperature flame melts the metal faces of the work-pieces to be joined, causing them to flow together. A filler metal alloy is normally added and sometimes used to prevent oxidation and to facilitate the metal union.

The amount of heat applied to the metal is a function of the welding tip size, the speed of travel, and the welding position. The flame size is determined by the welding tip size and the proper tip size is determined by the metal thickness and the joint design.

### Characteristics of the oxy-acetylene welding process include:

- It uses dual oxygen and acetylene gases stored under pressure in steel cylinders;
- Its ability to switch quickly to a cutting process, by changing the welding tip to a cutting tip;
- The high temperature the gas mixture attains (~5800°F);
- The use of regulators to control gas flow and reduce pressure on both the oxygen and acetylene tanks;
- The use of double line rubber hoses to conduct the gas from the tanks to the torch;
- Melting the materials to be welded together;
- The ability to regulate temperature by adjusting gas flow.

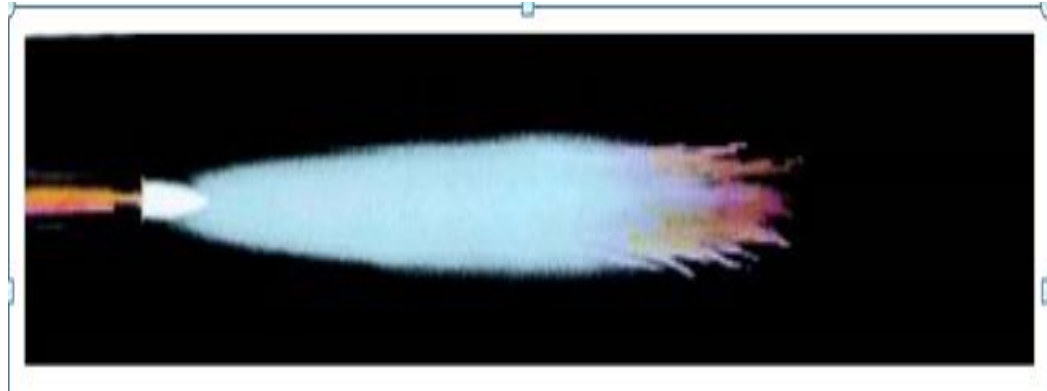
### 1.1.1. Welding and cutting Flames

In oxyacetylene welding, flame is the most important tool. All the welding equipment simply serves to maintain and control the flame. The flame must be of the proper size, shape and condition in order to operate with maximum efficiency. Three distinct types of flames are possible on adjusting the proportions of acetylene and oxygen:

- 1 Neutral Flame** (Acetylene oxygen in equal proportions)
- 2 Oxidizing Flame** (Excess of oxygen)
- 3 Reducing Flame / carburized flame** (Excess of acetylene)

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- **Neutral Flame :-** A neutral flame is produced when the ratio of oxygen to acetylene, in the mixture leaving the torch, is almost exactly one-to-one. The temperature of the neutral flame is of the order of about 5900°F.



**Figure 1. 1. Neutral flame**

- **Characteristics of Neutral flame:**
  - a) It's termed "neutral" because it will usually have no chemical effect on the metal being welded. It will not oxidize the weld metal; it will not cause an increase in the carbon content of the weld metal.
  - b) Neutral flame is obtained by gradually opening the oxygen valve to shorten the acetylene flame until a clearly defined inner cone is visible.
  - c) Neutral flame is used for most welding operations and for preheating during cutting operations. When welding steel with neutral flame, the molten metal puddle is quiet and clear; the metal flows easily without boiling, foaming, or sparking.
  - d) There are two clearly defined zones in the neutral flame. The inner zone consists of a luminous cone that is bluish-white. The inner cone is where the acetylene and the oxygen combine. Surrounding this is a light blue flame envelope or sheath. This neutral flame is obtained by starting with an excess acetylene flame in which there is a "feather" extension of the inner cone. When the flow of acetylene is decreased or the flow of oxygen increased the feather will tend to disappear. The neutral flame begins when the feather disappears.
  - e) The tip of the inner is the hottest part of the flame and is approximately 5850°F, while at the end of the outer sheath or envelope the temperature drops to approximately 2300°F. This variation within the flame permits some temperature control when making a weld. The

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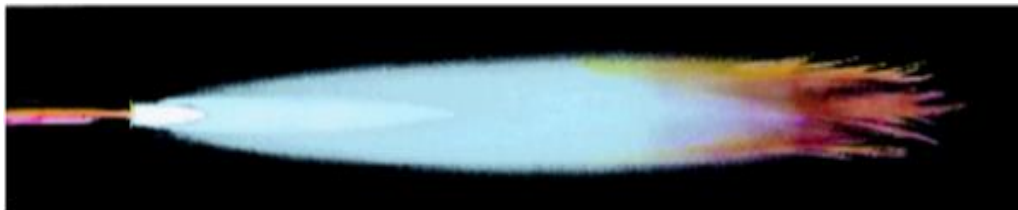
position of the flame to the molten puddle can be changed, and the heat controlled in this manner.

f) The neutral flame is commonly used for the welding of:

- Mild steel
- Stainless steel
- Cast Iron
- Copper
- Aluminum

- **Carburizing or Reducing Flame:**

If the volume of oxygen supplied to the neutral flame is reduced, the resulting flame will be a carburizing or reducing flame, i.e. rich in acetylene. A reducing flame can be recognized by acetylene feather which exists between the inner cone and the outer envelope. The outer flame envelope is longer than that of the neutral flame and is usually much brighter in color.



**Figure 1. 2 Carburized flame**

- **Characteristics of Reducing or carburizing flame:**

- a) An excess of acetylene creates a carburizing flame. The reducing or carburizing flame is obtained when slightly less than one volume of oxygen is mixed with one volume of acetylene. This flame is obtained by first adjusting to neutral and then slowly opening the acetylene valve until an acetylene streamer or "feather" is at the end of the inner cone. The length of this excess streamer indicates the degree of flame carburization. For most welding operations, this streamer should be no more than half the length of the inner cone.
- b) The carburizing flame is characterized by three flame zones; the hot inner cone, a white-hot "acetylene feather", and the blue-colored outer cone. This is the type of

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flame observed when oxygen is first added to the burning acetylene. The feather is adjusted and made ever smaller by adding increasing amounts of oxygen to the flame. A welding feather is measured as 2X or 3X, with X being the length of the inner flame cone. This type of flare burns with a coarse rushing sound. It has a temperature of approximately 5700°F (3149°C) at the inner cone tips.

The feather is caused by incomplete combustion of the acetylene to cause an excess of carbon in the flame.

- c. The carburizing flame may add carbon to the weld metal and will tend to remove the oxygen from iron oxides which may be present, a fact which has caused the flame to be known as a “reducing flame”. With iron and steel it produces very hard, brittle substance known as iron carbide. This chemical change makes the metal unfit for many applications in which the weld may need to be bent or stretched. Metals that tend to absorb carbon should NOT be welded with reducing flame.
- d. The reducing flame is typically used for welding high carbon steel and hard facing operations or backhand pipe welding techniques. When used in silver solder and soft solder operations, only the intermediate and outer flame cones are used. They impart a low temperature soaking heat to the parts being soldered.
- e. Since this flame provides a strong reducing atmosphere in the welding zone, it is useful for those materials which are readily oxidized like oxygen free copper alloys. It is also used for high carbon steels, cast iron and hard surfacing with high speed steel and cements carbides. A reducing flame has an approximate temperature of 5500°F (which is lowest among all the three flames). A reducing flame may be distinguished from a carburizing flame by the fact that a carburizing flame contains more acetylene than a reducing flame. A carburizing flame is used in the welding of lead and for carburizing (surface hardening) purposes. A reducing flame, on the other hand, does not carburize the metal; rather it ensures the absence of the oxidizing condition. It is used for welding with low alloy steel rods and for welding those metals, (e.g. non ferrous) that do not tend to absorb carbon. This flame is very well used for welding high carbon steel.

- **Oxidizing Flame:**

The oxidizing flame is the third possible flame adjustment. It occurs when the ratio of oxygen to acetylene required for a neutral flame is changed to give an excess of oxygen. This flame type is observed when welders add more oxygen to the neutral flame.



**Figure 1. 3 Oxidized Flame**

The presence of excess oxygen in this flame creates undesirable oxides to the structural and mechanical detriment of most metals. It is useful for welding copper base alloys, zinc base alloys, cast iron, manganese steel etc.

- **Characteristics of an Oxidizing flame:**

- The oxidizing flame is produced when slightly more than one volume of oxygen is mixed with one volume of acetylene. To obtain this type of flame, the torch should first be adjusted to a neutral flame. The flow of oxygen is then increased until the inner cone is shortened to about one-tenth of its original length. When the flame is properly adjusted, the inner cone is pointed and slightly purple. An oxidizing flame can also be recognized by its distinct hissing sound. The temperature of this flame is approximately 6300°F (3482°C) at the inner cone tip.
- An oxidizing flame can be recognized by the small white cone which is shorter, much bluer in color and more pointed than that of the neutral flame. The outer flame envelope is much shorter and tends to fan out at the end on the other hand the neutral and carburizing envelopes tend to come to a sharp point.
- An oxidizing flame burns with a decided loud roar. An oxidizing flame tends to be hotter than the other two flames. This is because of excess oxygen which causes the temperature to rise as high as 6300°F and not heat up as much thermally inert carbon.

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- d) When applied to steel, an oxidizing flame especially at high temperatures tends to combine with many metals to form hard, brittle, low strength oxides. This indicates that the excess oxygen is combining with the steel and burning it. Moreover, an excess of oxygen causes the weld bead and the surrounding area to have a scummy or dirty appearance. This flame will ruin most metals and should be avoided, except as noted below.
- e) An oxidizing flame is of limited use in welding. It is not used in the welding of steel. A slightly oxidizing flame is helpful when welding most
- Copper base metals
  - Zinc base metals, and
  - A few types of ferrous metals, such as manganese steel and cast iron

A stronger oxidizing flame is used in the welding of brass or bronze. The oxidizing atmosphere, in these cases, creates a base metal oxide that protects the base metal. For example, in welding brass, the zinc has a tendency to separate and fume away. The formation of a covering copper oxide prevents the zinc from dissipating. To conclude, for most welding operations the Neutral Flame is correct, but the other types of flames are sometimes needed for special welds, e.g., non-ferrous alloys and high carbon steels may require a reducing flame, whilst zinc bearing alloys may need an oxidizing flame for welding purposes.

The basic equipments used to carry out gas welding are:

**Table 1. 1oxyacetylene flame adjustment**

**Flame Adjustment for Oxy-acetylene Welding**

<b>Metal</b>	<b>Flame</b>
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

## 1.2. Welding equipments and consumables

### 1. CYLINDERS:

The oxygen and acetylene cylinders are designed to hold high-pressure gases. There are some important things to remember when using these cylinders:

- Cylinders must always be stood upright and be secured by a chain
- When not in use (regulator mounted) they must always have a valve protection cap in place
- Cylinders should be stored in a cool dry place away from direct sunlight or extreme cold

#### Oxygen Cylinders

- Usually smaller in diameter and taller than Acetylene
- 2500 PSI when full
- The cylinder valve must be opened fully
- You should not run an oxygen tank completely empty (no pressure)

#### OXYGEN GAS CYLINDER

Oxygen is stored within cylinders at a pressure of 2200 psi when filled @70°F and is capable of retaining a pressure of almost twice the fill pressure.

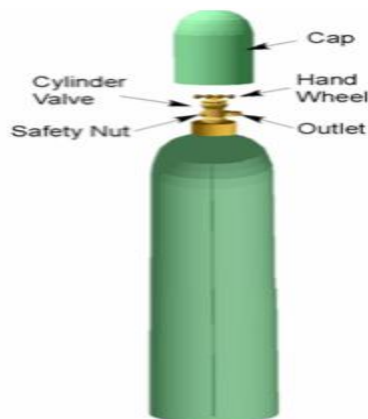


Figure 1.4 Oxygen cylinder

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## Acetylene Cylinders

- Usually large in diameter and short • 250 PSI when full • The cylinder valve should only be opened 3/4 of a turn.
- The acetylene cylinder should never be laid down as this will result in the gas becoming unstable.
- You should not run an acetylene completely empty (no pressure)

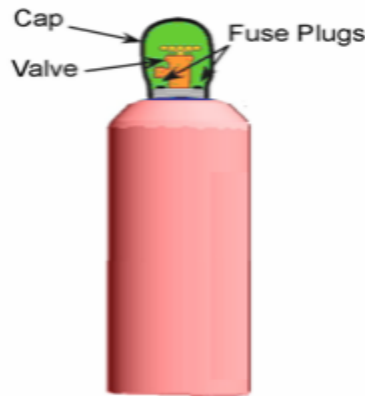


Figure 1. 5Acetylen cylender

## 2. PRESSURE REGULATORS

The pressure of the gases obtained from cylinders is considerably higher than the gas pressure used to operate the welding torch. The purpose of using a gas pressure regulator is:

- To reduce the high pressure of the gas in the cylinder to a suitable working pressure,
- To produce a steady flow of gas under varying cylinder pressures.

A pressure regulator is connected between the cylinder/generator and the hose leading to welding torch. Desired pressure at the welding torch may be somewhere up to 35 psig for oxygen and 15 psig for acetylene.

A pressure regulator is fitted with two pressure gauges. One indicates the gas pressure in the cylinder and the other shows the reduced pressure at which the gas is going out.



**Gas Regulator**

**Figure 1. 6Gas pressure regulator**

Gas pressure regulators may be classified as:

- a) Single stage Regulator
- b) Two stage Regulator

In single stage regulator, reduction of pressure from the cylinder pressure to the welding pressures takes place in single stage. A single stage regulator is all that actually is needed for both oxygen regulation and acetylene regulation for oxyacetylene welding. However, a single stage regulator tends to freeze in cold weather. This is because a sudden expansion and resulting drop in initial pressure causes rapid cooling of the gas involved. The moisture present in the gas, thus, results in the formation of ice on or near the regulator nozzle which causes irregular seating of the seat on the nozzle and therefore substantial pressure fluctuations.

The principle of pressure reduction in a two stage regulator is exactly the same as in a single stage regulator, but here the pressure is reduced in two stages instead of one, using two diaphragms and two control valves, so that the pressure reduction ratio is less abrupt.

Good regulators are essential to ensure the even flow of gas to the blowpipe. Acetylene regulators are constructed much more sensitively than the oxygen regulators, to take care of the lower pressure of gas. Acetylene regulators cannot be

interchanged with oxygen regulators for they will not stand the pressure demanded in the first place, and in the second if a small quantity of acetylene gas left in the regulator and oxygen introduced, an inflammable mixture would be formed which is not advisable on account of its explosiveness.

### **Difference between Oxygen and Acetylene Pressure Regulators -**

<b>Acetylene Regulator</b>	<b>Oxygen Regulator</b>
<ul style="list-style-type: none"> <li>The cylinder and hose connections have left handed threads on the acetylene regulator</li> </ul>	<ul style="list-style-type: none"> <li>. There are right hand threads in this case</li> </ul>
<ul style="list-style-type: none"> <li>connection nuts have chamfers or grooves cut in them</li> </ul>	<ul style="list-style-type: none"> <li>Nuts are plain, i.e., with no chamfer or grooves.</li> </ul>
<ul style="list-style-type: none"> <li>Color band on acetylene regulator in maroon or red.</li> </ul>	<ul style="list-style-type: none"> <li>It is either blue or black on the oxygen regulator.</li> </ul>
<ul style="list-style-type: none"> <li>The inlet or high pressure gauge on the regulator reads up to 8bar</li> </ul>	<ul style="list-style-type: none"> <li>The inlet or high pressure gauge on the regulator reads up to 100bar.</li> </ul>
<ul style="list-style-type: none"> <li>The outlet or low pressure gauge on the regulator reads up to 1bar.</li> </ul>	<ul style="list-style-type: none"> <li>The outlet or low pressure gauge on the regulator reads up to 4.8bar.</li> </ul>

### **Caution**

- NEVER use oxygen or fuel gas from a cylinder except through an approved pressure-reducing regulator.
- NEVER attempt to use a regulator except for the gas and service for which it is designed.
- Oil or other petroleum products must never be used around oxygen regulators because these products will either cause a regulator explosion or fire.



### 3. GAS HOSES & CLAMPS:

The hoses used to make the connections between the torch and the regulators must be strong, nonporous, light, and flexible enough to make torch movements easy. The most common type of cutting and welding hose is the twin or double hose that consists of the fuel hose and the oxygen hose joined together side by side.



**Rubber flexible hose**

**Figure 1. 7 gas hoses**

Oxygen hoses are green in color and have right hand thread. Acetylene hoses are red in color with left hand thread. The nut on the acetylene connection has a notch that runs around the center, distinguishing it from the nut on the oxygen connection. This is a safety precaution to prevent hoses from being hooked up the wrong way.

**Some precautions are to be taken when using reinforced rubber hoses:**

- Only one gas should be used in a hose. For example, using an oxygen hose to carry acetylene could cause a serious accident.
- The hose should never be patched or repaired.
- Hot metal (job) should never be placed on the hose.

### 4. Hose Clamps:

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

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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 1.8 clamp

## 5. Check Valve

A check valve lets gas flow in one direction only and is positioned at the torch inlet, and at the regulator outlet. The purpose of check valve is to prevent flame or oxygen-fuel mixture being pushed back into cylinder and causing backfire, flashback and explosion.

Backfire: A backfire is caused by the flame going out suddenly on the torch. A backfire may occur when:

- The tip is touched against the work piece;
- If the flame setting is too low;
- If the tip is dirty, damage or loose, or;
- If the tip is overheated.

When a torch backfires, it could cause a flashback.

A flashback is a condition in which the flame burns inside the tip, the torch, or the hose. Flashbacks are caused by the improper mixture of the gases, which increases the rate of flame propagation to such an extent that the flame will flash back to the mixing chamber. If it is not stopped, the flame will ignite the mixture and will travel backwards from the torch, along the hoses, through the regulator and into the cylinder. To prevent such occurrence, a flash arrestor shall be installed. Flashback arrestor (not to be confused with a check valve) prevents the shock waves from downstream coming back up the hoses and entering the cylinder (possibly rupturing it), as there are quantities of fuel/oxygen mixtures inside parts of the equipment (specifically

within the mixer and blowpipe/nozzle) that may explode, if the equipment is incorrectly shut down; and acetylene decomposes at excessive pressures or temperatures. The flashback arrestor will remain switched off until someone resets it.

Note - Combination Check/ Flashback Valves can be placed at the torch or regulator.

## 6. WELDING TORCH & BLOW PIPE

A welding torch mixes oxygen and acetylene in the desired proportions, burns the mixture at the end of the tip, and provides a means for moving and directing the flame.

There are two types of welding torches, namely:

I.High pressure (or equal pressure) type

II.Low pressure (or injector) type

High pressure blowpipes or torches are used with (dissolved) acetylene stored in cylinders at a pressure of 117 psi. Low pressure blowpipes are used with acetylene obtained from an acetylene generator at a pressure of 8 inch - head of water (approximately 0.3 psi).

In high pressure blow torch, both the oxygen and acetylene are fed at equal pressures and the gases are mixed in a mixing chamber prior to being fed to the nozzle tip. The high pressure torch also called the equal pressure torch is most commonly used because:

- a. It is lighter and simpler;
- b. It does not need an injector;
- c. In operation, it is less troublesome since it does not suffer from backfires to the same extent.

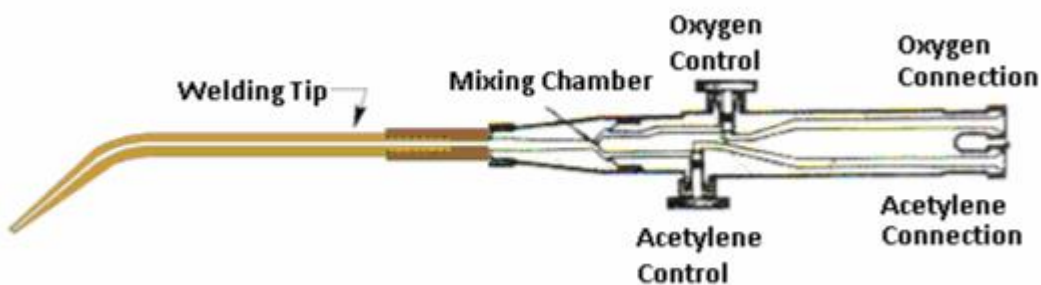


Figure 1. 9welding torch & blow pipe

To change the power of the welding torch, it is only necessary to change the nozzle tip (size) and increase or decrease the gas pressures appropriately.

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.

### **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.

## **7. Filler Metals:**

Filler metals are used to supply additional material to the pool to assist in filling the gap (or groove) and it forms an integral part of the weld. Filler rods have the same or nearly the same chemical composition as the base metal and are available in a variety of compositions (for welding different materials) and sizes. These consumable filler rods may be bare, or they may be coated with flux.

## **8. Flux**

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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.

### **9. Gas Lighter /spark lighter**

A gas (spark) lighter provides a convenient, safe and inexpensive means of lighting the torch. Match sticks should never be used for this purpose because the puff of the flame produced by the ignition of the acetylene flowing from the tip is likely to burn the welder's hand. Spark lighters are constructed from flint and steel.

### **10. Gas Cylinder Trolleys**

Trolleys should be capable of accommodating one oxygen cylinder and one acetylene cylinder required for gas welding. Normally cylinders can be mounted on a trolley side by side, but where work has to be done. Trolleys may have rubber tires or steel rim wheels. The gas cylinders are held in place with chains and supported on the bottom with a steel platform.

### **11. Goggles**

They are used to protect the eyes of the operator from harmful heat and radiation of infrared and ultraviolet rays produced during the welding.

### **12. Apron, &Gloves**

The molten metal has a tendency to pop and splatter as heat is applied and oxygen reacts with the superheated metal. It is critical that operators using the oxy-acetylene welding or cutting process wear proper gloves and apron.

### 1.3. Material preparation

The spacing between the parts to be joined should be considered carefully. The root opening for a given thickness of metal should permit the gap to be bridged without difficulty, yet it should be large enough to permit full penetration. Specifications for root openings should be followed exactly.

The thickness of the base metal at the joint determines the type of edge preparation for welding. Thin sheet metal is easily melted completely by the flame. Thus, edges with square face can be butted together and welded; this type of joint is limited to material under 3/16 in. (4.8 mm) in thickness. For thicknesses of 3/16 to 1/4 in. (4.8 to 6.4 mm), a slight root opening or groove is necessary for complete penetration, but filler metal must be added to compensate for the opening.

Joint edges 1/4 in. (6.4 mm) and greater in thickness should be beveled. Beveled edges at the joint provide a groove for better penetration and fusion at the sides. The angle of bevel for oxyacetylene welding varies from 35 to 45 degrees, which is equivalent to a variation of the included angle of the joint from 70 to 90 degrees, depending upon the application. A root face 1/16 in. (1.6 mm) wide is normal, but feather edges are sometimes used. Plate thicknesses 3/4 in. (19 mm) and above are double beveled when welding can be done from both sides. The root face can vary from 0 to 1/8 in. (0 to 3.2 mm). Beveling both sides reduces by approximately one-half the amount of filler metal required. Gas consumption per unit length of weld is also reduced.

A square groove edge preparation is the easiest to obtain. This edge can be machined, chipped, ground, or oxygen cut. The thin oxide coating on an oxygen-cut steel surface does not need to be removed because it is not detrimental to the welding operation or to the quality of the joint. A bevel angle can be oxygen

## Self check 1

**Directions:** A. Select one of the appropriate alternatives for the given questions.

1. Which one of the following is the basic equipment of oxy-gas welding?

- A. oxygen gas cylinder      B. acetylene gas cylinder  
C. oxygen gas hose      D. acetylene gas hose      E. all

2. One of the following indicates the factors in the selection of appropriate welding nozzle?

- A. the position of the weld      B. the type of joint  
C. job thickness      D. all

B. Write true/false for the given questions

1. The size of acetylene gas cylinder is larger than that of oxygen cylinder

2. A welding torch mixes oxygen and acetylene gases

C. Write short answer for the ff questions

1. Describe the proper sequence of steps in preparing the oxyacetylene system for lighting the cutting torch.

2. Describe the three types of flames and their effects on the metal to be welded.

3. What do the numbers on the welding tip mean?

4. What are the visual safety checks for the cutting tip.

5. What is the name of the tool used to produce a spark for lighting the torch.

6. Name the safety details below regarding personal protective equipment

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## Unit Two: Set up oxyacetylene cutting outfit and welding

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

- Welding symbols
- Assembling and setting up equipment
- working pressure

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 welding symbols and bead sizes
- Assemble and set up oxy-acetylene welding equipment
- Set up working pressure

### 2.1. Welding symbol










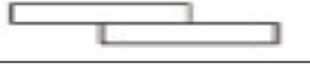



The terms weld symbol and welding symbol have different meanings. A weld symbol indicates the required type of weld. The welding symbol includes the weld symbol and supplementary information. A complete welding symbol consists of the following elements:

- Reference line (always shown horizontally)
- Arrow
- Basic weld symbol
- Dimensions and other data
- Supplementary symbols
- Finish symbols
- Specification, process, or other references

All elements need not be used unless required

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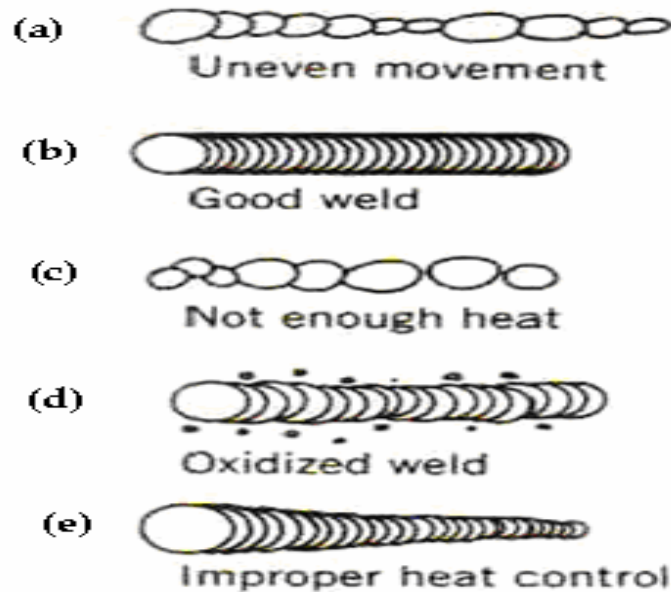
gap preparations	denotation	symbol
	flange weld	
	plain butt weld	
		
	V - weld	
	corner weld	
	lap seam	
	fillet weld	

### 2.1.1. Bead size, reinforcement and placement

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.



## Welding joints

### *Outside Corner Joint*

- Flat outside corner joint made with or without filler metal
- One of the easiest welded joints to make
- Filler metal not needed if sheets are tacked properly
- Filler metal is added uniformly

### *Lap Joint*

- Flat lap joint easily welded with basic manipulations
- Use caution when heating the two sheets. Both sheets start melting at the same time
- Direct the flame on the bottom sheet away from top sheet
- Filler rod added to the top sheet
- Gravity pulls the molten weld pool down

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## Tee Joint

- Flat tee joint is difficult because the Uneven heating
- Large percentage of welding heat is reflected back on the torch
- Angle the torch in the direction of weld travel (push technique)
- Adjust the flame to be somewhat oxidizing
- Keep a tight coupling distance to focus heat at the root.

## 2.2. Assembling and setting up cutting Equipment

### Equipment Assembly

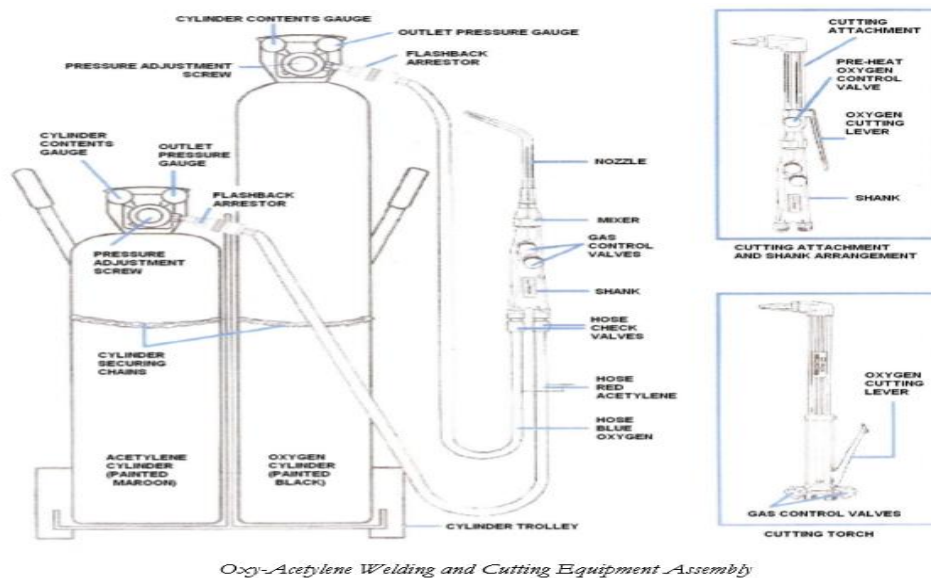


Figure 2. 1 Oxy-Acetylene Welding equipment assembly

### 2.2.1. Setup procedure

1. Equipment assembly: Ensure that the equipment is assembled correctly as in section above.
2. 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

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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.

3. Purge the system: 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. Repeat this procedure with the acetylene cylinder.
4. Install the torch handle: The torch handle is the connection between the hoses and the working tips.
5. 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.
6. Install the correct tip: Welding tips come in sizes that are stamped with a number. Number one is the smallest tip. The larger the number, the larger the tip and the greater the heat that it will provide. Select the tip size suitable for the task and screw it onto the end of the torch handle. Hold the torch handle in your hand, so that you can comfortably adjust the oxygen and acetylene taps.
7. 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.
8. 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. Turn the oxygen regulator handle clockwise until the needle in the gauge registers 2-5 PSI. Turn the acetylene regulator handle clockwise until the needle in the gauge registers 2-5 PSI. This is your working pressure for welding light plate.
9. 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.
10. 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.

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11. 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”, you can now adjust to the desired flame, for the task you are doing. ( Welding, brazing )

### 2.2.2. Nozzle Size

For a given welding torch, the NOZZLE OUTLET SIZE has a much greater influence on governing the flame size than changing the gas pressures on adjusting the control valves. The manufacturers of gas welding equipment have adopted various methods of indicating nozzle sizes, such as:

- By the approximate consumption of each gas per hour.
- By the nozzle outlet bore size (orifice diameter).
- By a reference number corresponding to a metal thickness range which may be welded with a specific nozzle.

Whatever the method employed for indicating nozzle sizes there is a definite relationship between the sizes of welding nozzles and the metal thicknesses. Manufacturer’s recommendations should always be followed with regard to nozzle sizes and gas pressures for a particular application.

Tip sizes are designated in tenths of a mm, ie 8 = 8/10 = 0.8 mm. Size 20 = 2 mm.

**Table2. 1 size of welding nozzle**

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Tip sizes	Filler rod diameter (mm)	Thickness of mild steel	Pressure* kPa	
			oxygen	acetylene
8	1.6	0.8 mm	50	50
8–10	1.6	1.6 mm	50	50
10–12	1.6	2.4 mm	50	50
12–15	2.4	3 mm	50	50

As the thickness of the work increases, the flame will be required to supply more heat. This is made possible by increasing the nozzle size and the regulator gas pressures (in accordance with manufacturers' instructions).

If you try to weld thick metal with a small nozzle by increasing the gas pressure, there comes a point where the flame leaves the end of the nozzle. This indicates that the pressure is too high, resulting in a very noisy flame. It is much better to work with a 'soft' flame, which is obtained by using the correct nozzle size and pressure settings. At the other extreme, if you try to weld with a nozzle that is too large for the work, by reducing the supply of gas at the blowpipe valves instead of changing to a smaller nozzle, then small explosions will occur at the nozzle. This is because the gas tends to build up round the nozzle in small bubbles. These small explosions indicate that the gas pressure is too low. The table above lists typical nozzle sizes and gas pressures for oxyacetylene welding. Always consult the manufacturer's information, as this information can vary slightly with different makes of blowpipe.

<b>Self-Check -2</b>	<b>Written Test</b>
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**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

- Is created by allowing calcium carbide (a manmade product) to react with water.
  - oxygen gas
  - acetylene gas
  - argon gas
  - none
- Write the steps of welding equipment set up to start the operation.

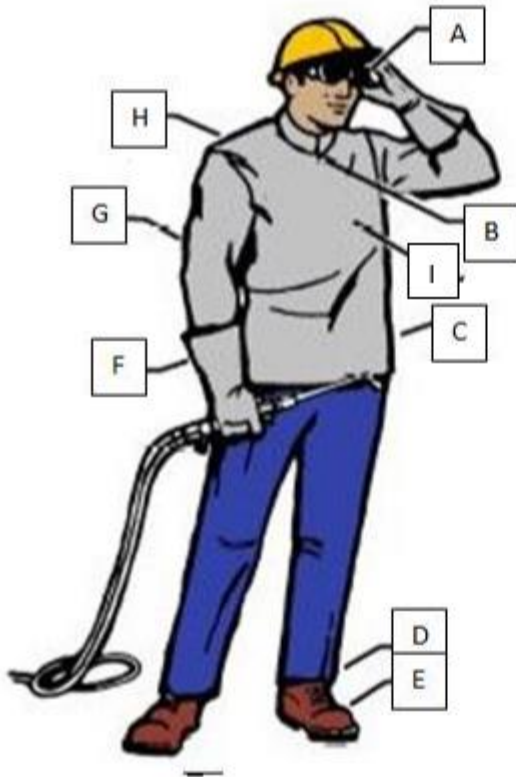
**Directions:** write true /false for the given questions below.

- Lighting and extinguishing are the parts of oxy-gas welding procedures.
- Closing and opening cylinder valve can not affect the weld process

**Directions:** Select one of the appropriate alternatives for the given questions.

- The torch handle is the connection between:
  - hoses and regulator
  - regulator and valve
  - hoses and working tips
  - all
- Identify the wrong statement
  - oxygen connector is a right hand thread
  - oxygen connector is a left hand thread
  - acetylene connector is a right hand thread

Identify the personal protective equipment with the given letter



A.	_____
B.	_____
C.	_____
D.	_____
E.	_____
F.	_____
G.	_____
H.	_____
I.	_____



### Unit Three: Perform Cutting and welding using oxyacetylene

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

- Cutting positions.
- Component inspection
- Before weld cleaning
- Welding
- Post welding cleaning
- OHS procedures

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:

- cut and welding in vertical, horizontal and overhead position.
- Inspect cut components
- Clean components before weld
- Weld metallic materials
- Clean weld seams after the completion of welding
- Apply safe working practice for cutting and welding .

### 3.1. Cutting and welding position

#### 3.1.1. Horizontal welding position

Welding cannot always be done in the most desirable position. It must be done in the position in which the part will be used. Often that may be on the ceiling, in the corner, or on the floor. Proper description and definition is necessary since welding procedures must indicate the welding position to be performed, and welding process selection is necessary since some have all-position capabilities whereas others may be used in only one or two positions.

This type of welding is performed from the upper side of the joint. The face of the weld is approximately horizontal position of the welding flame above the molten puddle should be carefully maintained. The welding torch should be adjusted to give the proper type of flame for the particular metal being welded. Narrow bead welds are made by raising and lowering the welding flare with a slight circular motion while progressing forward. The tip should form an angle of approximately 45 degrees with the plate surface.

#### 3.1.2. Vertical position

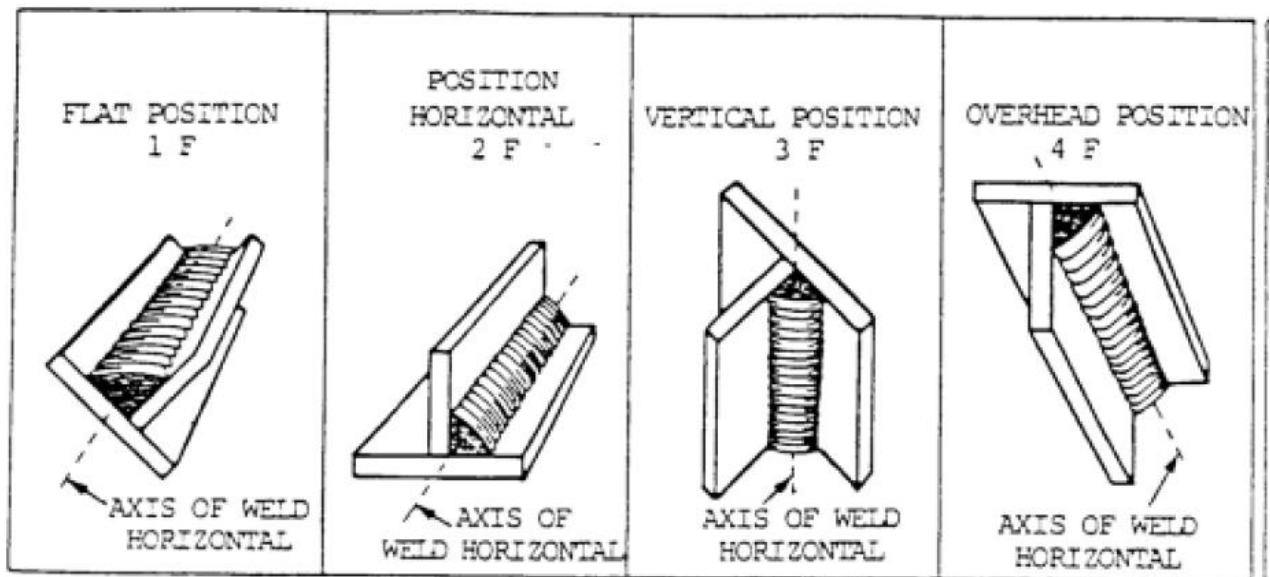
In vertical position welding, the axis of the weld is approximately vertical. When welding is done on a vertical surface, the molten metal has a tendency to run downward and pile up. A weld that is not carefully made will result in a joint with excessive reinforcement at the lower end and some undercutting on the surface of the plates.

The flow of metal can be controlled by pointing the flame upward at a 45 degree angle to the plate, and holding the rod between the flame and the molten puddle. The manipulation of the torch and the filler rod keeps the metal from sagging or falling and ensures good penetration and fusion at the joint. Both the torch and the welding rod should be oscillated to deposit a uniform bead. The welding rod should be held slightly above the center line of the joint, and the welding flame should sweep the molten metal across the joint to distribute it evenly.

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### 3.1.3. Overhead position

Overhead welding is performed from the underside of a joint. In overhead welding, the metal deposited tends to drop or sag on the plate, causing the bead to have a high crown. To overcome this difficulty, the molten puddle should be kept small, and enough filler metal should be added to obtain good fusion with some reinforcement at the bead. If the puddle becomes too large, the flame should be removed for an instant to permit the weld metal to freeze. When welding light sheets, the puddle size can be controlled by applying the heat equally to the base metal and filler rod.



### 3.2. Components inspection

Most of the time visual inspection is done but there is different types of inspecting equipment in the field.

### 3.3. Before weld cleaning

Welding Seam and Seam surface cleaning is definitely one of those classic applications of industrial laser cleaning. It can be applied on steel, stainless steel and aluminium welds

without damaging the substrate.

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For a strong weld, you need to clean the metal beforehand so there are no contaminants. This is because it can interfere with the welding, create resistance and even create a weld splash. So if the metal you want to weld has rust, paint, and dirt or mill scale then you need to clean it. There are many ways to safely clean your metal. Don't worry if you don't know what is best for you yet. In this blog, we are helping you decide by showing you how to clean your metal before a weld.

## **Contaminants**

Before you weld, you should clean the surface with acetone to clear away contaminants. Even if you've removed all the rust and paint you'll still need to wipe down the metal. There might be lingering particles that may react during the welding, and you risk doing all that removing for nothing.

## **Used material.**

### **Sandpaper**

Sandpaper is great for removing rust and paint. While courser grit will be faster it will also create scratches on the metal. An aluminium oxide paper will last longer on metal. If you are cleaning rust from machinery, 80 – 100 grit will do the job. If you want a nice finish for something like furniture, then don't go any coarser than 150 grit.

### **Abrasive blasting**

Also known as sandblasting, abrasive blasting is mainly used for more advanced cleans. If the metal has a coating or is extremely rusty, then sandpapering it will probably be a waste of time. You'll also need to blast the metal if the paint is bonded to the metal. This equipment is a pretty industrial, however, there are portable versions available.

### **Wire Brush**

If you need to get into odd angles and grooves then nothing will do the job like a wire brush. They are perfect for removing light contaminants like flaky paint, rust and weld splatter. You can

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use a crimped wire brush for fast and light cleaning or a knotted brush for things a little more heavy duty. However, a wire brush won't be any good for removing anything bonded to the metal. You will need to take additional steps.

### **Angle grinder**

An angle grinder is fast and is best for removing big contaminants. You can use a flap disc or a sanding disc to remove rust, paint, mill scale and more. It will take a lot off, so if you are better off using an angle grinder on thicker materials. If you're not careful you can gauge and ruin the metal you want to weld. Keep that in mind when you decide what the best method to clean your metal is.

### **Chemicals**

Acid-like chemicals can be used to strip rust, paint and other contaminants away. There is always a risk using chemicals, if you are careful and know how to handle them then it shouldn't be a problem. If not handled with care the fumes and the corrosive acid can cause some serious damage. Non-toxic chemicals can also be used but there will take a little more time to work.

Cleaning removes lubricants, ferrous and non-ferrous from metals to produces high quality welds and brazed seams that are smooth and pore-free offering highest stability and quality for visible seams.

### **Typical applications**

- De-oiling
- De-greasing
- Removal of oxide layers
- Removal of hydrates
- Shop-primer removal

### 3.4. Welding

#### **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 closer 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 tool 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 sure 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.

Edge Preparations for Different Thicknesses of Plate. Above 13mm thickness, plate can be beveled and welded from both sides.

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 with the adjacent figure on the table above.

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.

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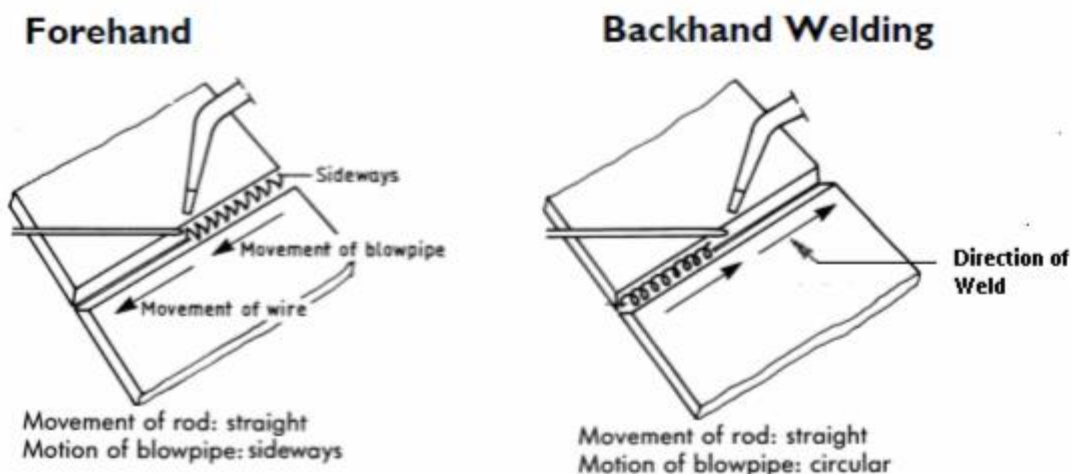
The welder must add the filler rod to the molten puddle. The welder must also keep the filler metal in the hot outer flame zone when not adding it to the puddle to protect filler metal from oxidation. Do not let the welding flame burn off the filler metal. The metal will not wet into the base metal and 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.

### 3.4.1. The Leftward Technique of Gas Welding.

The first stage is to deposit a straight bead of weld on a single piece of material and then, when you have perfected this, to practice joining two pieces. The ultimate aim is to achieve a standard of weld quality that will enable you to produce the required test pieces, if you want to become a qualified welder.

The leftward method of gas welding is used for welding steel plate up to 5 mm in thickness. It can also be used for welding non-ferrous metals.

When the blowpipe is held in the right hand, the weld travels from right to left, with the filler rod in front of the nozzle (Error! Reference source not found.). The inner cone of the flame, which should be in the neutral condition for welding mild steel, is held close to the metal but not touching it.



**Figure3. 1 Forward and back ward movement**

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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.

### 3.4.2. The Rightward Technique of Gas welding.

As the plates get thicker, different edge preparations are employed. These different edge preparations are shown. Notice that as the plate gets more than 4 mm thick, it is recommended that another technique, the rightward technique, is used.

## 3.5. post-weld cleaning?

Electrochemical weld cleaning is a process by which post-weld impurities such as rust, heat tints, and discoloration are removed from metal surfaces under the effect of mild electrolytic fluids and a weak electrical current.

### 3.5.1. How do you clean welding flux?

The most common methods for post-braze flux removal are: **Soaking/wetting** – Use hot water with agitation in a soak tank to remove excess flux immediately following the braze operation, and then dry the assembly. When soaking is not possible, use a wire brush along with a spray bottle or wet towel.

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### Self-check.

**Directions:** Select one of the appropriate answers

1. One of the following is the types of welding position?
  - A. lap
  - B. Overhead
  - C. butt
  - D. A and C
  
2. under vertical position:
  - A. minimum blow pipe movement throughout steady upward travel
  - B. minimum blow pipe movement throughout steady travel towards welder
  - C. minimum blow pipe movement throughout steady right ward travel
  - D. none
  
3. One of the following is the type welding joint?
  - A. Tee
  - B. vertical
  - C. overhead
  - D. Band C

### Operation sheet - 3.1 :perform and cut materials for edge preparation

#### Operation title : v-shape edge preparation

Purpose: preparation of edges for quality weld

**Instructions:-**As the Drawing given below prepare the v-shape from both adjacent edge of the work material in approximate degree with in 15 minute for the next butt joint task.

Tools and equipment:- 1. Cutoff or hack saw

2.. tap rules

3. scribe

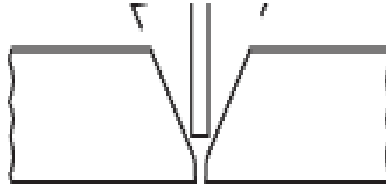
4. Bevel protractor

5. portable grinder

#### Steps:

1. Select the appropriate metal
2. Cut to the require length
3. Shape to the required shape size
4. Produce the necessary groove

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**Quality criteria:-** the given beveling v- shape is measured with protractor approximate to  $60^0$  accuracy

**Precautions:** securely hold the work material on the bench vice while grinding the half bevel.

## Operation sheet 3.2: welding techniques

**Operation title :** Running beads

**Purpose:-** to exercise beginners to determine and familiarize the flow of fire blowes and the running speed to start the welding pool.

**Instructions :-** as the figure below first mark three straight line 15mm apart on the work piece then punch a small dots continuously up to the edge of the work piece repeat for all lines in the same way. You have to complete in five minute.

### MATERIALS

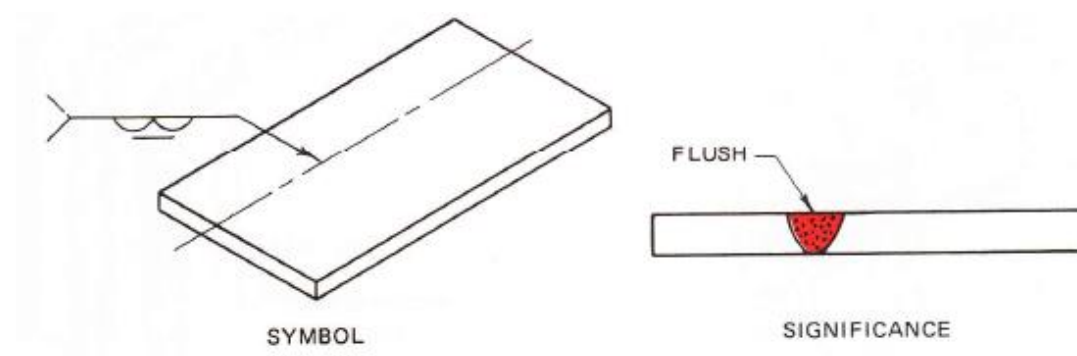
1. mild steel plate 3 to 4 mm thick. 100mm wide X 1120mm in length.
- 2.. center punch
3. Scriber, Steel rule 1kg hammer
4. Welding torch, Gauge material, Oxyacetylene unit, Gloves, Goggles.
5. personal safety protective equipments
6. prepared welding table and 2mm nozzle tip.

### Steps

1. Light the torch and adjust the flame to neutral.

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2. Hold the tip of the inner cone of the flame about 1/8 inches above the work and pointed in the exact direction in which the weld is to proceed. The centerline of the flame should make an angle of 45 to 60 degrees with the work, figure 3.4.
  3. Hold the flame in one spot until a puddle of metal 1/4 inch to 3/8 inch in diameter is formed.
  4. Proceed with the weld, advancing the flame at a uniform speed in order to keep the molten puddle the same diameter at all times. This keeps the weld or *bead* the same width throughout its length. Start this bead 1/2 inch from the near edge of the plate being welded and proceed in a straight line parallel to this edge.
- Note:* The width of the bead is directly related to the thickness of the plate being welded. The accepted standard for welds in aircraft tubing and light sheet metal requires the weld to be six times as wide as the thickness of the metal.
5. After the weld has been completed, examine it for uniformity of width and smoothness of appearance. Turn the plate over and examine the bottom for uniformity of *penetration*.



**Quality Criteria:-** The quality of the finished weld depends to a large extent on the correct adjustment and use of the flame. This unit provides an opportunity to weld with different kinds of flames and to compare the results. At the same time some actual welding skill is acquired.

**Precautions:** 1. never weld without adequate ventilation

2.. and take proper precautions to prevent fires

3. Wear eye protection in all time

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<b>LAP Test - 3</b>	<b>Practical Demonstration</b>
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**Directions:** write true /false for the given questions below.

1. The thickness of the base metal at the joint determines the type of edge preparation for welding

1. Beveled edges at the joint provide a groove for better penetration

## Unit four: Assure quality and clean up

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

- Inspection of Weld seam.
- Specification of Weld joints.
- OHS

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 and Clean weld seam
- Measures weld joints to conform their degree of accuracy.
- Clean equipment and their working area.

### Unit Four: Assure Quality and clean Up.

#### 4.1. Cleaning and inspection of weld seams

##### Weld Metal Cleaning

Slag or flux remaining after a pass, shall be removed before applying the next covering pass. Prior to painting, etc., all slag shall be removed and the parts shall be free of loose scale, oil and dirt.

The term **inspection** usually implies a formal inspection, prescribed by a code or by the requirements of a purchaser that is given to welds and welded structures. The minimum requirements of welding codes are inflexible, and must be met.

The appearance of a weld does not necessarily indicate its quality, If discontinuities exist in a weld, they can be grouped into two broad classifications: those that are apparent to visual inspection and those that are not. Visual examination of the underside of a weld will determine whether there is complete penetration and whether there are excessive globules of metal.

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Inadequate joint penetration may be due to insufficient beveling of the edges, too thick a root face,-too high a welding speed, or poor torch and welding rod manipulation.

Oversized and undersized welds can be observed readily. Weld gages are available to determine whether a weld has excessive or insufficient reinforcement. Undercut or overlap at the sides of the welds can usually be detected by visual examination. Although other discontinuities, such as incomplete fusion, porosity, and cracking, may or may not be externally apparent, excessive grain growth and the presence of hard spots cannot be determined visually. Incomplete fusion may be caused by insufficient heating of the base metal, too rapid travel, or gas or dirt inclusions. Porosity is a result of entrapped gases, usually carbon monoxide, which may be avoided by more careful flame manipulation and adequate fluxing where needed. Hard spots and cracking are a result of metallurgical characteristics of the weldment.

#### **4.1.1. Nondestructive Testing**

Nondestructive testing is a method of testing that does not destroy or impair the usefulness of a welded item. These tests disclose all of the common internal and surface defects that can occur when improper welding procedures are used. A large choice of testing devices is available and most of them are easier to use than the destructive methods, especially when working on large and expensive items.

##### **A. Visual Inspection**

Visual inspection is usually done automatically by the welder as he completes his welds. This is strictly a subjective type of inspection and usually there are no definite or rigid limits of acceptability. The welder may use templates for weld bead contour checks. Visual inspections are basically a comparison of finished welds with an accepted standard. This test is effective only when the visual qualities of a weld are the most important.

##### **B. Magnetic Particle Inspection**

Magnetic particle inspection is most effective for the detection of surface or near surface flaws in welds. It is used in metals or alloys in which you can induce magnetism. While the test piece is magnetized, a liquid containing finely ground iron powder is applied. As long as the magnetic field is not disturbed, the iron particles will form a regular pattern

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on the surface of the test piece. When the magnetic field is interrupted by a crack or some other defect in the metal, the pattern of the suspended ground metal also is interrupted.

### C. Liquid Penetrate Inspection

Liquid penetrate methods are used to inspect metals for surface defects that are similar to those revealed by magnetic particle inspection. Unlike magnetic particle inspection, which can reveal subsurface defects, liquid penetrate inspection reveals only those defects that are open to the surface. Four groups of liquid penetrates are presently in use. Group I is a dye penetrate that is non water washable. Group II is water washable dye penetrates. Group III and Group IV are fluorescent penetrates. Carefully follow the instructions given for each type of penetrate since there are some differences in the procedures and safety precautions required for the various penetrates.

Before using a liquid penetrate to inspect a weld, remove all slag, rust, paint, and moisture from the surface. Except where a specific finish is required, it is not necessary to grind the weld surface as long as the weld surface meets applicable specifications. Ensure the weld contour blends into the base metal without under-cutting. When a specific finish is required, perform the liquid penetrate inspection before the finish is made. This enables you to detect defects that extend beyond the final dimensions, but you must make a final liquid penetrate inspection after the specified finish has been given.

Before using a liquid penetrate, clean the surface of the material very carefully, including the areas next to the inspection area. You can clean the surface by swabbing it with a clean, line-free cloth saturated in a non-volatile solvent or by dipping the entire piece into a solvent. After the surface has been cleaned, remove all traces of the cleaning material. It is extremely important to remove all dirt, grease, scale, lint, salts, or other materials and to make sure that the surface is entirely dry before using the liquid penetrate.

Maintain the temperature of the inspection piece and the liquid penetrate in the range of 50°F to 100°F. Do not attempt to use the liquid penetrate when this temperature range cannot be maintained. Do not use an open flame to increase the temperature because some of the liquid penetrate materials are flammable.

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After thoroughly cleaning and drying the surface, coat the surface with the liquid penetrate. Spray or brush on penetrate or dip the entire piece into the penetrate. To allow time for the penetrate to soak into all the cracks, crevices, or other defects that are open to the surface, keep the surface of the piece wet with the penetrate for a minimum of 15 or 30 minutes, depending upon the penetrate being used.

After keeping the surface wet with penetrate for the required length of time, remove any excess penetrate from the surface with a clean, dry cloth, or absorbent paper towel. Then dampen a clean, lint-free material with penetrate remover and wipe the remaining excess penetrate from the test surface. Next, allow the test surface to dry by normal evaporation or wipe it dry with a clean, lint-free absorbent material. In drying the surface, avoid contaminating it with oil, lint, dust, or other materials that would interfere with the inspection.

After the surface has dried, apply another substance, called a developer. Allow the developer (powder or liquid) to stay on the surface for a minimum of 7 minutes before starting the inspection. Leave it on no longer than 30 minutes, thus allowing a total of 23 minutes to evaluate the results.

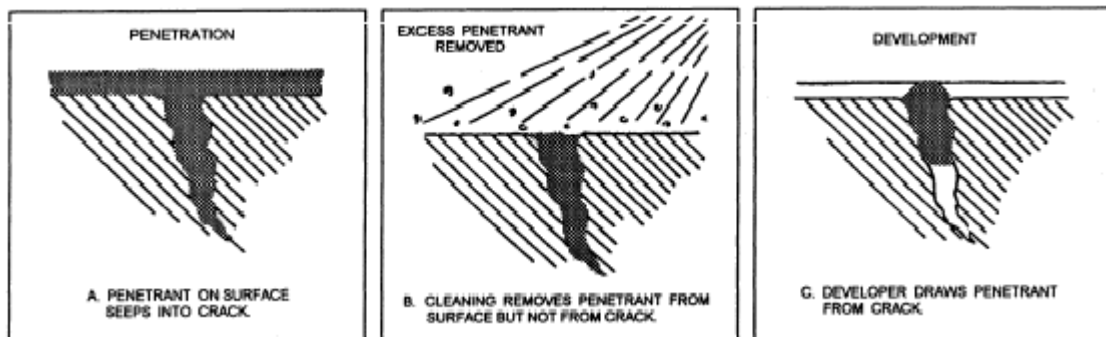


Figure 4. 1. liquid penetrate test

#### **D. Radiographic Inspection**

Radiographic inspection is a method of inspecting weldment by the use of rays that penetrate through the welds. X rays or gamma rays are the two types of waves used for this process. The rays pass through the weld and onto a sensitized film that is in direct



contact with the back of the weld. When the film is developed, gas pockets, slag inclusions, cracks, or poor penetration will be visible on the film.

Because of the danger of these rays, only qualified personnel are authorized to perform the tests. As Seabees, you will rarely come in contact with these procedures.

### **E. Ultrasonic Inspection**

Ultrasonic inspection of testing uses high-frequency vibrations or waves to locate and measure defects in welds. It can be used in both ferrous and nonferrous materials. This is an extremely sensitive system and can locate very fine surface and subsurface cracks as well as other types of defects. All types of joints can be tested.

This process uses high-frequency impulses to check the soundness of the weld. In a good weld, the signal travels through the weld to the other side and is then reflected back and shown on a calibrated screen. Irregularities, such as gas pockets or slag inclusions, cause the signal to reflect back sooner and will be displayed on the screen as a change in depth. When you use this system, most all types of materials can be checked for defects. Another advantage of this system is that only one side of the weld needs to be exposed for testing.

### **F. Eddy Current Testing**

Eddy current is another type of testing that uses electromagnetic energy to detect faults in weld deposits and is effective for both ferrous and nonferrous materials. Eddy current testing operates on the principle that whenever a coil carrying a high-frequency alternating current is placed next to a metal, an electrical current is produced in the metal by induction. This induced current is called an *eddy current*.

The test piece is exposed to electromagnetic energy by being placed in or near high-frequency ac current coils. The differences in the weld cause changes in the impedance of the coil, and this is indicated on electronic instruments. When there are defects, they show up as a change in impedance, and the size of the defect is shown by the amount of this change.

### 4.1.2. Destructive Testing

In destructive testing, sample portions of the welded structures are required. These samples are subjected to loads until they actually fail. The failed pieces are then studied and compared to known standards to determine the quality of the weld. The most common types of destructive testing are known as free bend, guided bend, nick-break, impact, fillet welded joint, etching, and tensile testing. The primary disadvantage of destructive testing is that an actual section of a weldment must be destroyed to evaluate the weld. This type of testing is usually used in the certification process of the welder.

Some of the testing requires elaborate equipment that is not available for use in the field. Three tests that may be performed in the field without elaborate equipment are the free-bend test, the guided-bend test, and the nick-break test.

#### A. Free-Bend Test

The FREE-BEND TEST is designed to measure the ductility of the weld deposit and the heat-affected area adjacent to the weld. Also it is used to determine the percentage of elongation of the weld metal. Ductility, you should recall, is that property of a metal that allows it to be drawn out or hammered thin.

The first step in preparing a welded specimen for the free-bend test is to machine the welded reinforcement crown flush with the surface of the test plate. When the weld area of a test plate is machined, as is the case of the guided-bend as well as in the free-bend test, perform the machining operation in the opposite direction that the weld was deposited.

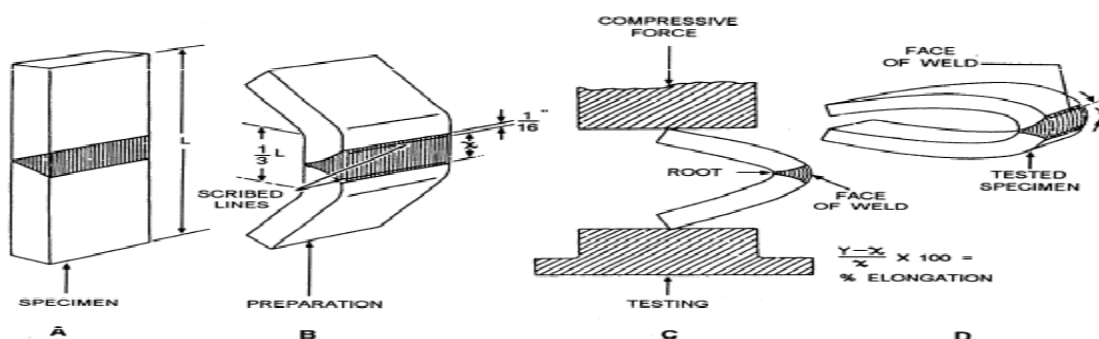


Figure 4. 2. free bend test

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## B. Guided-Bend Test

You use the GUIDED-BEND TEST to determine the quality of weld metal at the face and root of a welded joint. This test is made in a specially designed jig. An example of one type of jig

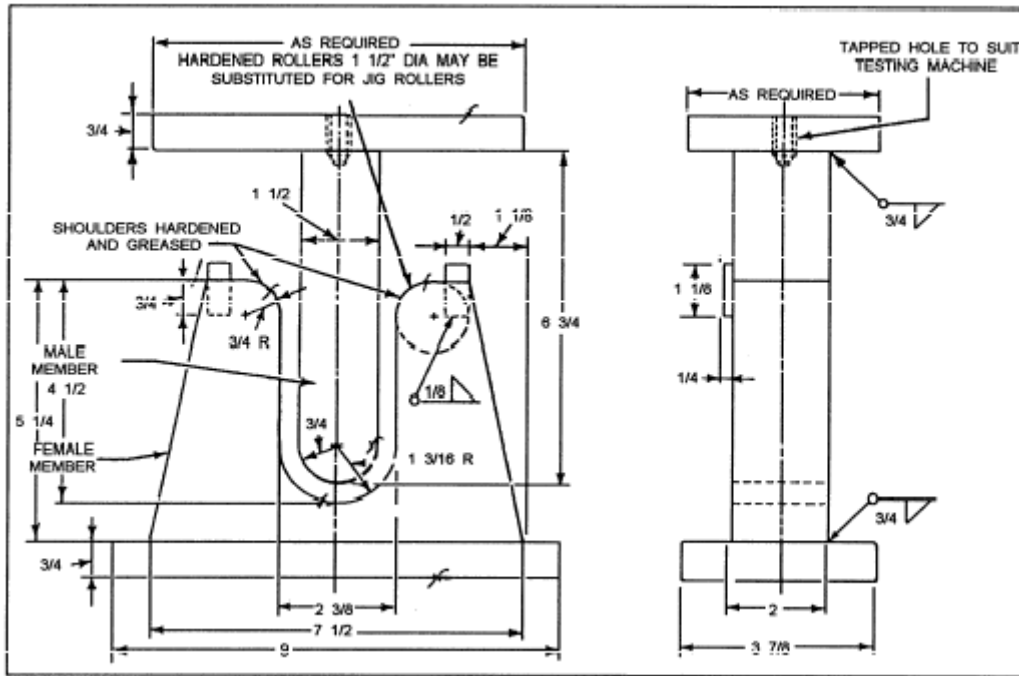


Figure 4. 3.Guided bend test

## C. Nick-Break Test

The NICK-BREAK TEST is useful for determining the internal quality of the weld metal. This test reveals various internal defects (if present), such as slag inclusions, gas pockets, lack of fusion, and oxidized or burned metal. To accomplish the nick-break test for checking a butt weld, you must first flame-cut the test specimens from a sample weld (fig. 7-65). Make a saw cut at each edge through the center of the weld. The depth of cut should be about 1/4 inch.

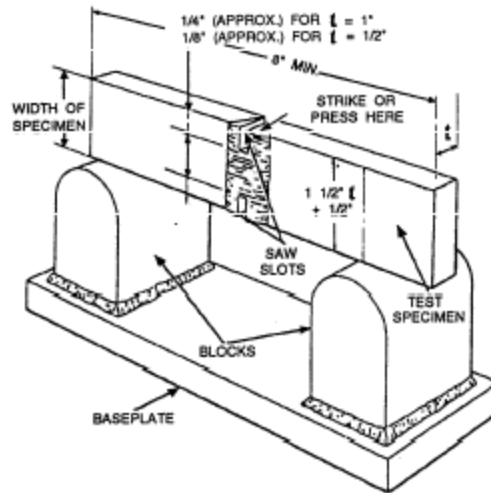
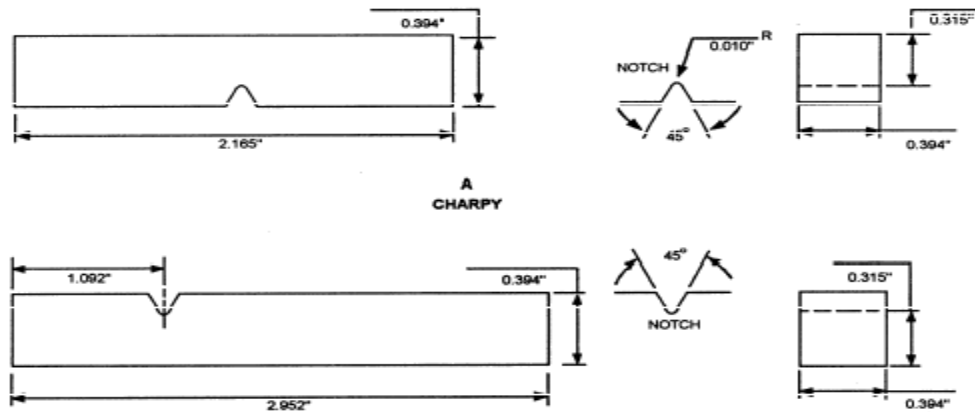


Figure 4. 4. nick-break test

#### D. Impact Test

You use the IMPACT TEST to check the ability of a weld to absorb energy under impact without fracturing. This is a dynamic test in which a test specimen is broken by a single blow, and the energy used in breaking the piece is measured in foot-pounds. This test compares the toughness of the weld metal with the base metal. It is useful in finding if any of the mechanical properties of the base metal were destroyed by the welding process.

The two kinds of specimens used for impact testing are known as *Charpy* and *Izod* (fig. 4.5.). Both test pieces are broken in an impact testing machine. The only difference is in the manner that they are anchored. The Charpy piece is supported horizontally between two anvils and the pendulum strikes opposite the notch. The Izod piece is supported as a vertical cantilever beam and is struck on the free end projecting over the holding vise (fig. 4.5, view B).



**Figure 4. 5** impact test

## 4.2. Joint Measuring

Inadequate joint penetration may be due to insufficient beveling of the edges, too thick a root face,-too high a welding speed, or poor torch and welding rod manipulation.

Oversized and undersized welds can be observed readily. Weld gages are available to determine whether a weld has excessive or insufficient reinforcement.

## 4.3. OHS

Methods of locking scrap to prevent movement during cutting.

### 4.3.1. PRE-OPERATIONAL SAFETY CHECKS

- i. Wear proper clothing and Personal Protective Equipment (PPE).
- ii. Ensure this OXY welder has a suitable safe work area.
- iii. Ensure the equipment is fitted with appropriate flash arrest (blow back) arrest system.
- iv. Keep the area clean & free of grease, oils & flammables.
- v. Hoses and regulators to be inspected and in good condition.
- vi. Ensure the area is well ventilated (with fume extraction if required).

### 4.3.2. OPERATIONAL SAFETY CHECKS

- i. When setting up, check that the oxygen and acetylene regulator adjusting knobs are closed (OFF), and are loose.
- ii. Check that both hand piece blowpipe valves are closed.
- iii. Slowly open the cylinder valves on each gas cylinder by half a turn (180°) only – for a faster emergency shutdown.
- iv. Screw in the regulator adjusting knobs slowly until the delivery pressure gauges are both correct.
- v. Purge the oxygen gas line and check for constant gas flow. Re-adjust delivery pressure if necessary.
- vi. Then purge the acetylene gas line and check for constant gas flow. Re-adjust pressure if necessary.
- vii. Open the acetylene blowpipe (hand piece) valve very slightly and light with a flint lighter ONLY.
- viii. Continue to slowly open the acetylene valve until the correct flame length is achieved.
- ix. Slowly open the oxygen blowpipe (headpiece) valve until a neutral flame is produced.
- x. Always be very aware of the dangers of a naked flame. 11. Note: When shutting down, always close the acetylene blowpipe valve first.

### 4.3.3. HOUSEKEEPING

Ensure both gas bottles are off and the welder secured with bottles stored upright at completion of work.

2. Leave the work area in a safe, clean, & tidy condition.
3. Ensure torch tips are cleaned as per manufacturer's recommendations.

#### 4.3.4. POTENTIAL HAZARDS

1. Explosion
2. Burns
3. Eye Injury
4. Fire and Explosion

<b>Self-Check-1</b>	<b>Multiple choice</b>
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**Directions:** Select one of the appropriate alternatives for the given questions.

1. Non-destructive method of testing that does not destroy the usefulness of a welded item:

- A. magnetic particle inspection      B. visual inspection  
C. radiographic inspection      D. all

2. A method of testing in which the samples are subjected to loads until they actually fail:

- A. non-destructive test      B. visual inspection  
C. destructive test      D. quality assurance

3. One of the following testing methods is classified under destructive test

- A. impact test      B. free-bend test  
C. magnetic particle inspection  
D. A and C  
E. A and B



### List of Reference Materials

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3. J F Lancaster, Metallurgy of Welding, Abington Publishing, 1999, 6<sup>th</sup> edition, England
4. Metals Handbook-Welding, Brazing and Soldering, American Society for Metals, 1993, 10th edition, Volume 6, USA.
5. R S Parmar, Welding engineering & technology, Khanna Publisher, 2002, 2nd edition, New Delhi.

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<b>6</b>						
<b>7</b>						

