# Mechanics

## Level-III

## Learning Guide: 31

**Unit of Competence: Perform Oxyacetylene Gas Welding**

**Module Title: Performing Oxyacetylene Gas Welding**

**Module Code: XXXXX**

**LG Code: XXXXX**

**TTLM Code: XXXXX**

**LO 1: Select welding Equipment and Consumables**

| Instruction Sheet | Learning Guide -31 |
|---|---|

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

- Selecting correct welding equipment.
- Selecting correct welding consumables.
- Welding Procedure and Specifications (WPS)

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

- Select correct welding equipment.
- Select correct welding consumables.
- Identify Welding Procedure and Specifications (WPS)

**Learning Instructions:**

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below.
- Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
- Accomplish the "Self-check "given
- Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check).
- If you earned a satisfactory evaluation proceed to "Information Sheet 2". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
- Submit your accomplished Self-check. This will form part of your training portfolio.

| Information Sheet-1 | Selecting correct welding equipment. |
|---|---|

## 1. Fundamentals of the process

Oxyacetylene Gas Welding includes any welding operation that uses combustion with oxygen as a heating medium. The process involves melting the base metal and usually a filler metal, using a flame produced at the tip of a welding torch. Fuel gas and oxygen are combined in the proper proportions inside a mixing chamber which may be part of the welding tip assembly. Molten metal from the plate edges, and filler meta1,jf used, intermix in a common molten pool and coalesce upon cooling.

One advantage of this welding process is the control a welder can exercise over heat input and temperature, independent of the addition of filler metal. Weld bead size, shape, and weld puddle viscosity are also controlled in the welding process.

**a. Advantages of Gas Welding –**

- 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;
- 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;
- 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;
- 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;
- 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

**b. Limitations of gas welding:**

- Gas flame takes a long time to heat up the metal than an arc;
- Flame temperature is less than the temperature of the arc;
- Slower speed of welding compared electric arc welding;
- Heavy sections cannot be joined efficiently;
- For heavy sections proper penetration may not be achieved;
- Refractory metals (e.g., tungsten, molybdenum, tantalum, etc.) and reactive metals (e.g., titanium and zirconium) cannot be gas welded;
- Flux used in the filler metal provides fumes which are irritating to the eyes, nose, throat and lungs;
- More safety is recommended in gas welding;
- Acetylene and oxygen are expensive gases;
- 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.

## 1.1. **Welding Equipment**

Before discussing how the system works, it is important to know the name of the components that makes the oxy-fuel apparatus.

Oxy-fuel apparatus consists of two cylinders (one oxygen and one acetylene) equipped with two regulators, pressure gauges, two lengths of hose, and a blow torch. The regulators are attached to cylinders and are used to reduce and maintain a uniform pressure of gases at the torch. The gases at reduced pressure are conveyed to the torch by the hoses. The regulators include high pressure and low pressure gauges to indicate the contents of the cylinder and the working-pressure on each hose. When the gases reach the torch they are there mixed and combustion takes place at the welding tip fitted to the torch.

The basic equipments 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)
- Acetylene gas hose (Red)

- Welding torch or blow pipe with a set of nozzles and gas lighter
- Trolleys for the transportation of oxygen and acetylene cylinders
- Set of keys and spanners
- Protective clothing for the welder (e.g., asbestos apron, gloves, goggles, etc.)

**1.1. 1. Oxygen gas cylinder**

Oxygen cylinder is drawn from a piece of high strength steel plate and is available in different sizes. 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.

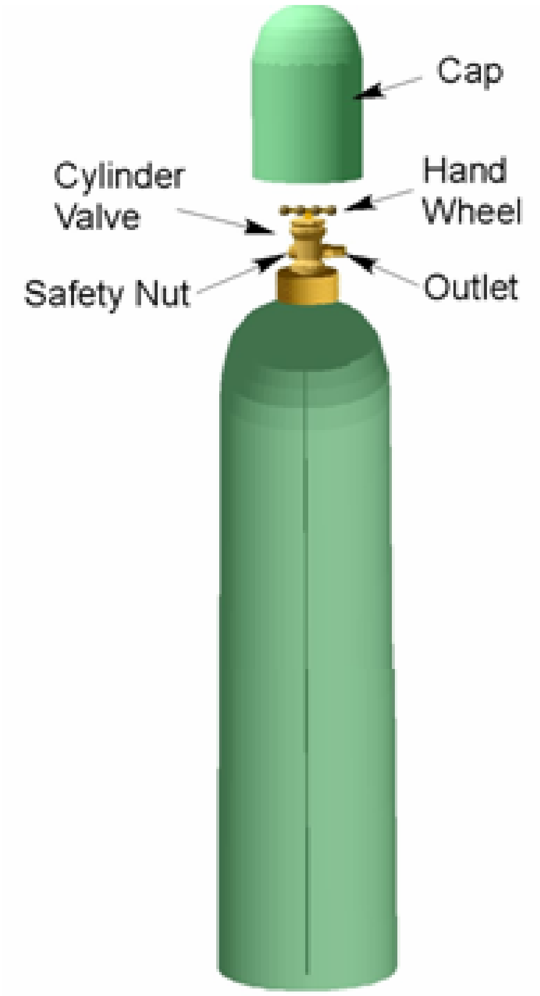



Figure 1: oxygen cylinder

The oxygen volume in a cylinder is directly proportional to its pressure. In other words, if the original pressure of a full oxygen cylinder drops by 10% during welding, it means 1/10th of the cylinder contents have been consumed. Oxygen cylinders are usually painted green and are screwed right handed.

### 1.1.2. Oxygen Cylinder Valves

The oxygen cylinder valve is made largely of brass with **right hand** threads. Its outlet is threaded and machined to comply with standards set by the Compressed Gas Association (CGA). Every oxygen cylinder valve is also equipped with *a bursting disk* which will rupture and release the contents of the cylinder if cylinder pressure should approach cylinder test pressure (as it might in case of a fire). In order to protect cylinder valve from getting damaged, a removable steel cap is screwed on the cylinder at all times when the cylinder is not in use. The cylinder valve is kept closed when the cylinder is not in use and even when cylinder is empty.

**Caution**

- The valve shall never be left exposed. It must always have the regulator attached or the cap on.
- The valve must be opened all the way when in use.

### 1.1.3. Acetylene gas cylinder

An acetylene cylinder is also a solid drawn steel cylinder and the common sizes are 300, 120 and 75 cubic feet. Cylinder pressure is 250 PSI when filled. An acetylene cylinder is painted maroon and the valves are screwed **left handed** (with grooved hex on nut or shank).

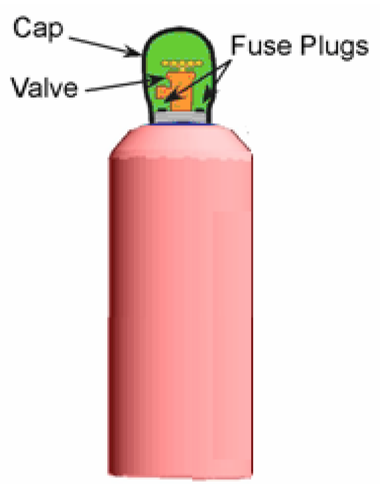



Figure 2: acetylene cylinder

Acetylene is extremely unstable in its pure form at pressure above 15 PSI. This instability places special requirements on the storage of acetylene. Acetylene cylinders are packed with porous material (balsa wood, charcoal, corn pith, or port land cement) that is saturated with acetone to allow the safe storage of acetylene. These porous filler materials aid in the prevention of high-pressure gas pockets forming in the cylinder.

Acetone, a colorless, flammable liquid, is than added to the cylinder until about 40 percent of the porous material is saturated. Acetone is a liquid chemical that dissolves large portions of acetylene under pressure without changing the nature of the gas and is a liquid capable of absorbing **25** times its own volume of acetylene gas at normal pressure. Being a liquid, acetone can be drawn from an acetylene cylinder when it is not upright.

**Here are two very important things to remember about dissolved acetylene cylinders:**

First, acetylene cylinders should always be stored in the upright position to prevent the acetone form escaping thus causing the acetylene to become unstable.

Second, for full withdrawal of the contents of the cylinder on a continuous basis, the flow rate should be no more than 1/15 (one-fifteenth) of the capacity of the cylinder per hour." If acetylene is withdrawn too rapidly, quite a lot of acetone may come with it, in vapor or droplet form, and the cylinder may cool down so much that it cannot sustain the high rate. This will affect your torch flame, and will mean that your supplier must replenish the acetone in the cylinder more frequently.

Many acetylene cylinder valves are not equipped with hand wheels, and must be operated by a wrench. The wrench should always be left in place while the cylinder valve is open. Acetylene cylinders should be opened only 1/3 to ¼ of a turn when in use.

**A. Pressure Relationship**

In an oxygen cylinder there is a precise relationship between cylinder pressure and cylinder contents. A standard oxygen cylinder that contains 244 cu-ft(Cubic feet) at 2200 psi @ 700°F will contain 122 cu-ft when the pressure has dropped to 1100 psi at 700°F. In contrast, an acetylene cylinder will not be precisely half-full when its pressure drops to half. Note that the changes in temperature affect the pressure in an acetylene cylinder at a much faster rate than it affects the pressure in an oxygen cylinder. Pressure in an oxygen cylinder will go up or down only about 4 percent for each 20-degree change in temperature (F) from 70 deg. A full acetylene cylinder which has a pressure of 250 psi at 700°F will have a pressure of 315 psi at 900°F and a pressure of 190 psi at 500°F. You must always take temperature into account when estimating how much acetylene the cylinder contains.

**B. Safety Devices on Acetylene Cylinder**

An acetylene cylinder is protected by number of fusible plugs, which melt at 220°F (104°C). These plugs melt and release the pressure in case the cylinder is exposed to excessive heat. Small cylinders (the 10 cu-ft. and 40 cu-ft. sizes) have one fusible metal channel located in the cylinder valve. The large cylinders normally used in welding and cutting, with capacities ranging up to nearly 300 cubic feet of acetylene, have two to four plugs, located in both top and bottom of the cylinders. If a cylinder is exposed to a fire, one or more safety devices will melt and allow the acetylene and acetone to escape and burn gradually. If it did not have such a safety device, a full acetylene cylinder exposed to a fire would rupture and release its contents all at once, perhaps explosively.

**Note:** Acetylene cylinders are equipped with fusible metal safety plugs and NOT rupture-disk safety devices, as in oxygen and nitrogen gas cylinders.

**Caution**

- DO NOT adjust, alter, change, build, or do any experimental work on cylinders, regulators, torches, or any other gas equipment;
- DO NOT lift cylinders by the caps or valves;
- DO NOT transport the cylinders without the caps in place;
- Cylinders must be stored in **upright** position;
- KEEP valves closed on empty cylinders;
- MAKE sure, cylinders are regularly re-tested using hydrostatic (NDE) while in service.

**C. Cylinder Transportation**

- NEVER transport cylinders without the safety caps in place. When using fuel and oxygen tanks they should be fastened securely upright to a post or a portable cart. An oxygen tank
  is especially dangerous for the reason that the oxygen is at a pressure of 3000 PSI when full and if the tank falls over and its valve strikes something and is knocked off, the tank will effectively become an extremely deadly flying missile propelled by the compressed oxygen;
- NEVER transport with the regulators in place;
- NEVER allow bottles to stand freely. Always chain them to a secure cart or some other object that cannot be toppled easily.

### 1.1.4. Oxygen & acetylene 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, and
- 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

Figure 3: gas regulator

Gas pressure regulators may be classified as:

- Single stage Regulator
- 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. In many instances oxygen regulators are put out with the copper diaphragms, whereas another metal must be used on the acetylene regulators, because acetylene gas attacks copper and usually a German silver or rubber diaphragm is used. On account of the lower pressures used in charging the acetylene cylinders, lower pressure gauges are used with acetylene regulators.

**a. 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.

**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. Generally speaking, the inlet connections installed by the regulator

manufacturer make mismatching impossible. However, that cannot always be the case, since there just are not enough mechanically distinct connections to permit each gas to have individual treatment. Therefore, some gases – for example, the inert gases and certain fuel gases – are treated in groups. A propane regulator will fit many acetylene cylinders, but should not be so used.

- Oil or other petroleum products must never be used around oxygen regulators because these products will either cause a regulator explosion or fire

**1.1.5. 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.

Size is determined by the inside diameter, and the proper size to use depends on the type of work for which it is intended. Hose used for light work has a 3/1 6 or 1/4 inch inside diameter and one or two plies of fabric. For heavy-duty welding and cutting operations, use a hose with an inside diameter of 5/1 6 inch and three to five plies of fabric. Single hose is available in the standard sizes as well as 1/2-, 3/4-, and 1-inch sizes. These larger sizes are for heavy-duty heating and for use on large cutting machine

**Figure 4: Rubber flexible hose**

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.

The length of hose you use is important. The delivery pressure at the torch varies with the length of the hose. A 20-foot, 3/16-inch hose maybe adequate for a job, but if the same hose was 50 feet long, the pressure drop would result in insufficient gas flow to the torch. Longer hoses require larger inside diameters to ensure the correct flow of gas to the torch. When you are having problems welding or cutting, this is one area to check

#### 1.2.6. 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 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.

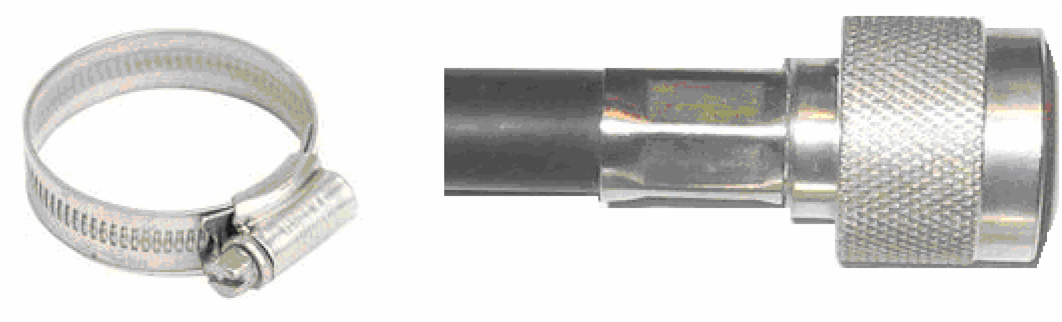


Figure 5: hose clamp

#### 1.1.7. 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.

**1.1.8. 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:

- High pressure (or equal pressure) type
- 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:

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

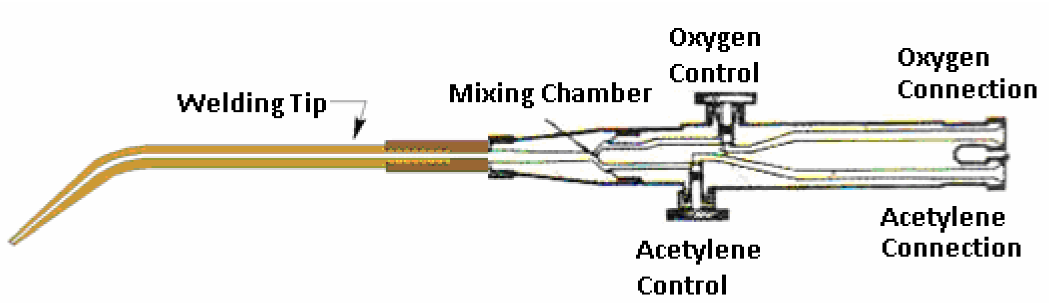



Figure 6. Welding torch

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.

**NOTE:** The real tool of the oxy-acetylene welding process is the flame, NOT the torch. When we come to oxygen cutting, we must consider the pure oxygen jet as a second tool, working hand-in-hand with the flame. To produce only the flame, we use a welding torch, fitted with the appropriate size welding head or tip. To produce both flames and the oxygen jet, we use a cutting torch or cutting attachment, equipped with the appropriate cutting nozzle or tip.

#### 1.1.9. Welding Nozzles or Tips

The welding nozzle or tip 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:

- Either, a set of tips which screw onto the head of the blowpipe, or
- 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:

- The position of the weld
- The type of joint
- Job thickness and the size of welding flame required for the job
- 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.

| Self check-1 | Multiple choice and true/false |
| --- | --- |

**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

*Note:* Satisfactory rating - 3 points Unsatisfactory - below 3 points

Answer Sheet

Score = ___________

Rating: ____________

Name: ___________________________ Date: ________________

| Information Sheet-2 | Welding consumables |
|---|---|

## 2.1. Acetylene

Acetylene is the fuel gas of choice for welding because of its high-combustion intensity. While the other fuel gases are rarely, if ever, used for welding. Acetylene is a hydrocarbon, just as are propane, methane, and virtually all the components which make up gasoline and fuel oils. However, it differs from those hydrocarbons in a way that its molecule is made up of two carbon atoms and two hydrogen atoms, the carbon atoms are joined by what chemists call a ”triple bond”. When acetylene reaches its kindling temperature; the bond breaks and releases energy. In other hydrocarbons, the breaking of the bonds between the carbon atoms absorbs energy. The triple bond is the reason that when acetylene and oxygen are mixed and ignited, the flame can reach the temperature of 5700°F to 6300 °F, highest among commonly used gaseous fuels.

### 2.1.1. Production for acetylene

Acetylene **is** the product of a chemical reaction between calcium carbide (CaC2) and water. In that reaction, the carbon in the calcium carbide combines with the hydrogen in the water, forming gaseous acetylene. At the same time the calcium combines with oxygen and hydrogen to form a calcium hydroxide residue. The chemical equation is CaC2 + 2H20 + C2H2 + *Ca* (OH) 2.

The carbide used in this process is produced by smelting lime and coke in an electric furnace. When removed from the furnace and cooled, the carbide is crushed, screened, and packed in airtight containers, the most common of these holds 100 lb **(45** kg) of the hard, grayish solid. Ten cubic ft (0.28 m3) of acetylene can be generated from approximately 2.2 lb (1 kg) of calcium carbide.

Acetylene is also frequently produced in petrochemical plants, and may be used for a variety of processes other than oxy-fuel gas welding and cutting

### 2.1.2. Acetylene generators

The two principal methods currently employed to generate acetylene are carbide-to-water and water-to-carbide. In the United States, the carbide-to-water method is used almost exclusively. The construction of the generator used for this method allows small lumps of carbide to be discharged from a hopper into a relatively large body of water. The details of its construction vary with different manufacturers. **All** carbide-to-water generators can be classified as low-pressure or medium-pressure types. The former operate at about 1 psig or less, while the latter produce acetylene at 1 to **15** psig.

The water-to-carbide type of acetylene generator is rarely used in this country, but is popular in Europe. Fundamentally, the operating principal is the same as that of the carbide-to-water type, but the method differs, Water from a tank is allowed to drip onto a bed of carbide, and the gas evolved is piped from the generator. The carbide is usually in the form of bricks or cakes, to limit the surface area exposed to the water.

The generation of acetylene evolves a considerable amount of heat, which must be dissipated because of the instability of acetylene at elevated temperatures. The relatively large volume of water employed in the carbide-to water generator makes this type highly efficient in dissipating the heat. The water-to-carbide type, on the other hand, uses the minimum amount of water, and its heat dissipation is slow.

Acetylene generators are available in both stationary and portable units, in a large range of sizes and gas production rates.

### 2.2. Oxygen

In the gaseous state is colorless, odorless, and tasteless. It occurs abundantly in nature. **A** chief source of oxygen is our atmosphere, which contains approximately 21 percent oxygen by volume. Although there is sufficient oxygen in air to support fuel gas combustion, the use of pure oxygen speeds up burning reactions and increases flame temperatures. Most oxygen used in the welding industry is extracted from the atmosphere by liquefaction techniques. In the extraction process, air may be compressed to approximately 3000 psig (20 MPa), although some types of equipment operate at much lower pressure. The carbon dioxide and any impurities in the air are removed; the air passes through coils, and is allowed to expand to a rather low pressure. The air becomes substantially cooled during the expansion, and then it is passed back over the coils, further cooling the incoming air, until liquefaction occurs.

The liquid air is sprayed on a series of evaporating trays or plates in a rectifying tower. Nitrogen and other gases boil at lower temperatures than the oxygen and, as these gases escape from the top of the tower, high-purity liquid *oxy*gen collects in a receiving chamber at the base. Some plants are designed to produce bulk liquid oxygen; in other plants, gaseous oxygen is withdraw for compression into cylinders.

### 2.3. 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.

## 2.4. Flux

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.

### 2.4.1. 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.

### 2.4.2. 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.

## 2.5. Accessories

In addition to the equipment and materials described above, a wide variety of auxiliary equipment may be used in the process of gas welding. Only a brief description of such items is included here.

Two of the most universally required articles are the friction lighter, which should always be used to ignite the gas, and check valves at both ends of the hoses for safety. Other accessories, such as tip cleaners, cylinder trucks, clamps, and holding jigs and fixtures are also important auxiliary aids for gas welding.

### 2.6. Apron, Gloves & Safety Goggles

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 use approved safety goggles or face shield. The goggles and/or face shield protect the eyes from sparks and flying hot metal particles. The goggles or face shield use special lenses to protect the eyes form light damage. A variety of lenses are used depending on the type of welding or cutting that needs to be done, the type of material, and the thickness of the material. If protective eye shielding is not used, painful burns can occur on the surface of the eye, and could result in permanent damage

Welders should at all times use goggles or eye shields as a protection against sparks and the intense glare and heat radiated from the flame and molten metal. Suitable gloves, leather aprons, sleeves, and leggings should also be worn. In some situations, a forced ventilation or supplemental breathing system may be required.

| Self-Check -2 | Multiple choice |
|---|---|

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

**1.** Acetylene is the product of a chemical reaction between:

A. calcium carbide and oxygen B. calcium carbide and water

C. water and oxygen D. calcium chloride and calcium carbide

2. Which one of the following is the basic consumable of oxy-gas welding?

A. cylinders B. gases C. regulators D. none

3. The purpose of the flux in oxy-gas welding is:

A. helps to dissolve and remove oxides

B. helps to magnify oxidation of surfaces

C. helps to add foreign substances to the weld

D. all are answers

*Note:* Satisfactory rating - 3 points Unsatisfactory - below 3 points

Answer Sheet

| |
|---|
| Score = ____________ |
| Rating: _____________ |

Name: ______________________________ Date: __________________

| Information Sheet-3 | Welding Procedure and Specifications (WPS) |
| --- | --- |

## 3.1. Welding procedure specification for oxy-acetylene welding

**3.1.1. Scope**

This Welding Procedure Specification covers welding and related operations ferrous and non-ferrous structures which are fabricated in accordance with the terms outlined in CSA Standards W47.1 and W59, latest revisions. The attached Data Sheets form an essential part of this specification.

**3.1.2. Welding Procedure**

The welding shall be done by the Oxy-acetylene using different types of equipment, with flame arcs as indicated on the Welding Data Sheets. Joints shall be made following the procedural stipulations indicated in CSA Standard W59, and may consist of single or multiple passes in accordance with the accepted Welding Procedure Data Sheets to which this specification refers.

**3.1.3. Base Metal**

The base metal shall conform to the specifications of steel groups 1, 2, 3 as per CSA Standard W59. Other groups may be welded providing Welding Procedure Data Sheets are accepted.

**3.1.4. Base Metal Thickness**

Sheet metal up to 3mm thickness may be welded under this specification providing the respective Welding Procedure Data Sheets have been supplied and accepted for the appropriate weld size.

**3.1.5. Storage and Conditioning of Fluxes**

Flux used for oxy-acetylene welding shall be dry and free from contamination of dirt, mill scale or other foreign material. All flux shall be purchased in packages capable of being stored under normal conditions for at least 6 months without such storage affecting its welding characteristics or weld metal properties. Flux from damaged packages that have been exposed to free moisture shall be discarded or shall be dried before use in shallow layers (2 inches maximum) at minimum temperature of 500oF for at least 1 hour or at time and temperature conditions as recommended by the manufacturer. Flux fused in welding shall not be reused.

#### 3.1.6. Position

The welding shall be done only in the position indicated on the Welding Data Sheet.

#### 3.1.7. Heat Treatment and Stress Relieving

This will not be applicable to structures welded under this specification, unless a specific Data Sheet showing all the parameters is submitted to the Canadian Welding Bureau and acceptance is obtained.

#### 3.1.8. Electrical Characteristics

The current used shall be either direct current (DC) or alternating current (AC) as indicated on the Welding Data Sheets.

**i. Welding Technique**

The correct amperage and voltage, speed of travel, thickness of layers, and number of passes, position, material electrodes and any special instructions will be as per Data Sheet

#### 3.1.9. Preparation of Base Material

The edges or surfaces of parts to be joined by welding shall be prepared by oxy-acetylene machine cutting. Where hand cutting is involved the edge will be ground to a smooth surface. All surfaces and edges shall be free from fins, tears, cracks or any other defects that will adversely affect the quality of the weld. All loose or thick scale, rust, moisture, grease or other foreign material that would prevent proper welding or produce objectionable fumes, shall be removed.

#### 3.1.10. Quality

Cracks or blow holes that appear on the surface of any pass shall be removed before depositing the next covering pass. The procedure and technique shall be such that undercutting of base metal or adjacent passes is minimized. Fillet and butt welds shall meet the desirable or acceptable fillet weld profiles shown in Figure  of CSA Standard W59. The reinforcement in groove welds shall not exceed 3 mm (1/8") and shall have a gradual transition to the plane of the base metal surface In general, the weld quality will be such as to meet the requirements of Clause 11.5.4/12.5.4 of CSA Standard W59.

#### 3.1.11. 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.

#### 3.1.12. Treatment of Underside of Welding Groove

Prior to depositing weld metal on the underside of a welding groove, the root shall be gouged, or chipped to sound metal, unless otherwise specified on the applicable Data Sheet

## 3.2. Procedures

### 3.2.1. Lighting-Up Procedure

To begin oxygen/acetylene welding or cutting,

- Open the cylinder valves slowly by means of the cylinder key(s).
- Do not open suddenly or there may be serious damage to the regulator and the possibility of an accident.
- Open the cylinder valve spindles one turn only.
- Open the fuel gas control valve on the blowpipe and adjust the regulator to give the correct working pressure, this ensures that any air or oxygen is purged from the hose. Repeat the procedure for the oxygen side.
- Light the gas by means of a suitable spark lighter making sure that the spark lighter is held at right angles to the nozzle. Do not use liquid igniters (such as cigarette lighters) as the vapor/gas combination can be dangerous.
- Reduce or increase the acetylene supply to the blowpipe valve until the flame just ceases to smoke.
- Slowly increase the oxygen via the blowpipe control valve until the white inner cone in the flame is sharply defined with the merest trace of an acetylene haze. The blowpipe is now correctly adjusted.

#### 3.2.2. To Extinguish the Flame and Stop Welding

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

| Self-Check -3 | True/false |
|---|---|

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

**1.** Lighting and extinguishing are the parts of oxy-gas welding procedures.

2. Closing and opening cylinder valve can not affect the weld process

*Note:* Satisfactory rating - 3 points Unsatisfactory - below 3 points

Answer Sheet

Score = ____________

Rating: ______________

Name: ___________________________ Date: ________________

| Operation Sheet 1 | Techniques of Identifying welding equipment |
|---|---|

**1. Identify cylinders in color and size**

Methods: 1. the size of oxygen cylinder is larger than the size of acetylene cylinder or

2. The size of acetylene cylinder is shorter than the size of oxygen cylinder
3. The color of oxygen cylinder is green
4. The color of acetylene cylinder is red

2. Identify hoses in color

Methods: 1.The color of oxygen hose is green

2. The color of acetylene hose is red

| Operation Sheet 2 | Methods of Producing the consumable acetylene gas |
|---|---|

1. procedures/steps for producing acetylene gas

Steps: 1. collect the right type of generator

2. Collect the smelted calcium carbide
3. Add water in to the generator
4. Add calcium carbide to water

| Operation Sheet 3 | Procures to Carryout Lighting-up and extinguishing welding torch |
|---|---|

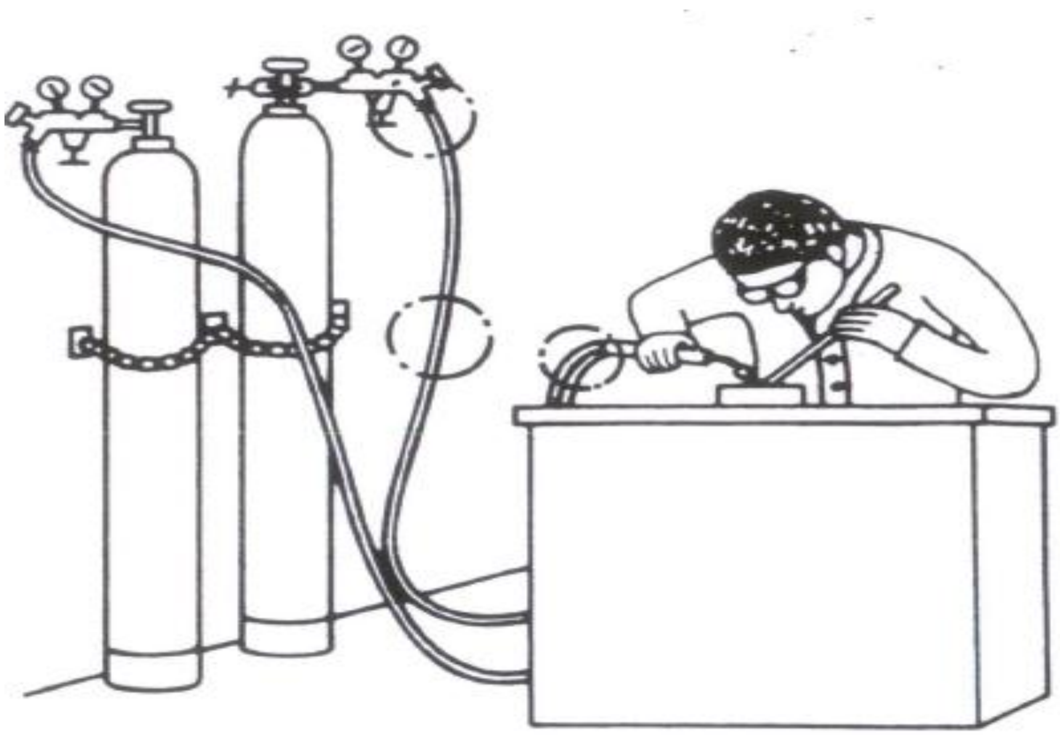
**1. procedures/steps for lighting-up the welding torch**

Steps:

- Wear correct PPE
- Open the cylinder valves slowly by means of the cylinder key(s).
- Open the cylinder valve spindles one turn only
- Open the fuel gas control valve on the blowpipe and adjust the regulator to give
- The correct working pressure, this ensures that any air or oxygen is purged from hose. Repeat the procedure for the oxygen side.
- Light the gas by means of a suitable spark lighter making sure that the spark lighter
- Is held at right angles to the nozzle

- Reduce or increase the acetylene supply to the blowpipe valve until the flame just Ceases to smoke
- Repeat the same procedure for purging acetylene
- **2. procedure/steps to extinguish:**

- Wear correct PPE
- when the welding or cutting operation is finished, close the torch acetylene valve first and then turn off the torch oxygen valve
- Close the oxygen cylinder valve
- Release the pressure in the hose and regulator by opening the oxygen control valve on the Torch
- Release the pressure on the oxygen regulator diaphragm by turning the regulator to the Minimum pressure position
- Close the oxygen control valve on the torch.
- Repeat the same procedure for purging acetylene



| LAP Test | Practical Demonstration |
|---|---|

**Instructions:** Given necessary tools and materials you are required to perform the following tasks within --- hour.

Task 1 Identify each welding equipment

Task 2 Identify each welding consumables and apply the production steps for acetylene

Task3 Carryout lighting-up process

Task4 carryout extinguishing process

Time started: ________________________ Time finished: ________________

Name: _____________________________ Date: ________________

## List of Reference Materials


1. Ballis, W. L., et al. “Training of oxyacetylene welding to weld mild steel pipe.” *Welding journal 56(4): 15-19;* April*1977.*

2. Fay, R. H. “Heat transfer from fuel gas flames.” *Welding Journal 46(8):3 80~383s*August *1967.*

3. International Acetylene Association: *Oxyacetylene welding and its applications.* New York: International Acetylene Association, *19.58.*Obtained from the Compressed Gas Association.

4. Koziarski, J. “Hydrogen vs. acetylene vs. inert gas in welding aluminum alloys.”*Welding Journal36 (2):1 41-148;* February *1957.*

# Mechanics

## Level-III

## Learning Guide: 32

**Unit of Competence:** Perform Oxyacetylene Gas Welding

**Module Title:** Performing Oxyacetylene Gas Welding

**Module Code: XXXXX**

**LG Code: XXXXX**

**TTLM Code: XXXXX**

**LO 2:** Prepare and assemble welding materials and Equipment

| Instruction Sheet | Learning Guide -32 |
| --- | --- |

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

- preparing  welding equipment and consumables
- preparing materials to weld Specification

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

- prepare  welding equipment and consumables
- prepare materials to weld Specification

**Learning Instructions:**

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below.
- Read the information written in the “Information Sheets”. Try to understand what are being   discussed. Ask you teacher for assistance if you have hard time understanding them.
- 4. Accomplish the “Self-check “given
- 5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check).
- 6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”.  However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
- Submit your accomplished Self-check.  This will form part of your training portfolio.

| Information sheet-1 | preparing welding equipment and consumables |
|---|---|

**2.1. Setting up an oxyacetylene torch**

Before you begin a welding operation, make a thorough inspection of the area. Ensure that there are no combustible materials in the area that could be ignited by the sparks or slag produced by the welding operation.

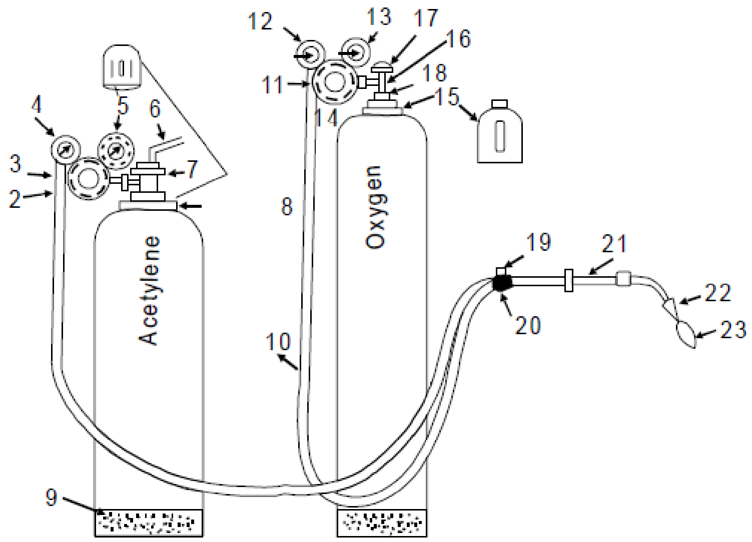
**Safety check**

- Read carefully the safety considerations;
- Oxygen and acetylene cylinders must be securely stored in an upright position;
- An oxyacetylene torch can produce a large amount of heat. Be aware that any objects you direct the flame towards will become hot;
- Always have a suitable fire extinguisher near your work area;
- Make sure that you understand and observe all legislative and personal safety procedures when carrying out the following tasks. If you are unsure of what these are, ask your supervisor.

**2.1.2. Component identification**

It is important to learn the names of all associated equipment and auxiliaries related to oxy-acetylene process. Some parts of this illustration are labeled.

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.




1. Acetylene hose
2. Adjusting screw
3. Acetylene regulator
4. Regulator outlet pressure gauge
5. Cylinder pressure gauge
6. Valve wrench
7. Acetylene cylinder valve
8. Cylinder cap
9. Fusible plugs
10. Oxygen hose
11. Oxygen regulator
12. Regulator outlet pressure gauge
13. Cylinder pressure gauge
14. Cylinder cap
15. Oxygen cylinder valve
16. Oxygen cylinder valve
17. Hand wheel
18. Bursting disc
19. Acetylene valve
20. Oxygen valve
21. Welding torch
22. Torch tip
23. Flame

#### 2.1.3. 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.

#### 2.1.4. 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.

#### 2.1.5. 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.

#### 2.1.6. 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.

| Self check-1 | Multiple choice |
|---|---|

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

**1.** The torch handle is the connection between:

A. hoses and regulator B. regulator and valve

B. hoses and working tips D. all

2. Identify the wrong statement

A. oxygen connector is a right hand thread

B. oxygen connector is a left hand thread

C. acetylene connector is a right hand thread

*Note:* Satisfactory rating - 3 points Unsatisfactory - below 3 points

Answer Sheet

Score = ____________

Rating: _____________

Name: ___________________________ Date: ________________

## 2.1. Metal 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 *oxy*gen 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-2 | True/false |
| --- | --- |

**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

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

***Note:*** **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

**Answer Sheet**

Score = ____________

Rating: _____________

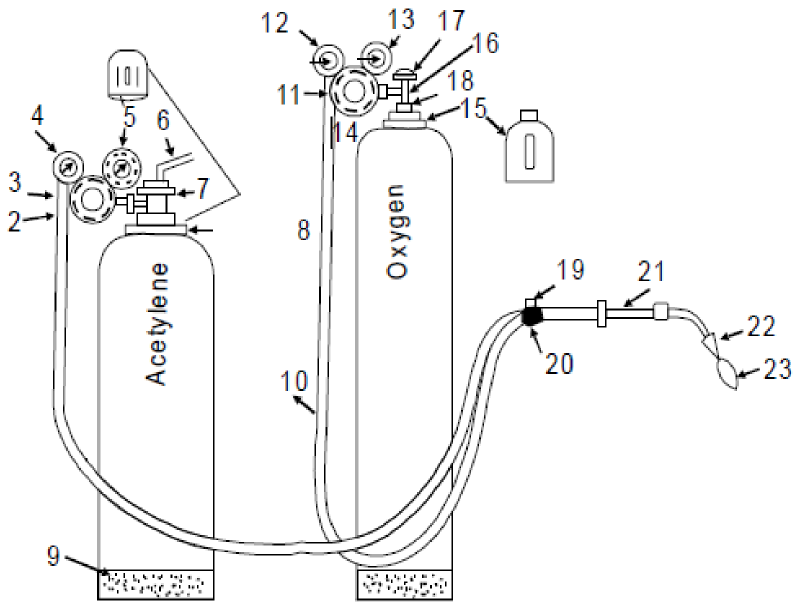
Name: ___________________________ Date: ________________

**Short Answer Questions**

| Operation Sheet 1 | Methods of Identifying oxy-acetylene welding component |
|---|---|

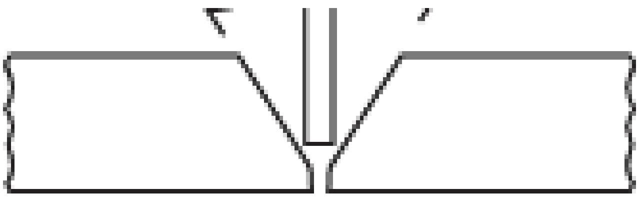
**1. Methods for identifying oxy-acetylene welding component**

**Methods**: 1. Colors for cylinders (green for oxygen and red for acetylene)
2. Colors for hoses (green for oxygen and red for acetylene)
3. Oxygen connector is right hand thread and the acetylene connector is a left hand thread.




| Operation sheet-2 | Prepare metal to the required shape and size |
|---|---|

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



| LAP Test | Practical |
|---|---|

**Instructions:** Given necessary tools and materials you are required to perform the following tasks within --- hour.

Task 1 Identify the components carefully

Task 2 prepare metal to the required shape and size

Name: ______________________________ Date: ________________

Time started: _________________________ Time finished: ________________

## List of Reference Materials


1. Moen, W.B, and Campbell, J, Evaluation of fuels and oxidants for welding and associated processes. *Welding journal 34(9): 870-876;* September*1955.*

***2.*** National Fire Protection Association, *Gas systems for welding and cutting,* NFPA No. *51.* Quincy, Massachusetts: National Fire Protection Association.

3. Postman, B. F, Safety in installation and use of welding equipment: *Welding journal 34(4): 337-344;* April *1955.*

4. Sosnin, H. A, efficiency and economy of oxyacetylene process: *Welding Journal 6(10): 46-48;* October *1982.*

**5.** National Training Fund for Sheet Metal and Air Conditioning Industry: *Welding book* I, 1st Ed. Alexandria, Virginia, The National Training Fund for the Sheet Metal and Air Conditioning Industry, *1979.*

# Mechanics

## Level-III

## **Learning Guide:** 33

**Unit of Competence:** Perform Oxyacetylene Gas Welding

**Module Title:** Performing Oxyacetylene Gas Welding

**Module Code: XXXXX**

**LG Code: XXXXX**

**TTLM Code: XXXXX**

**LO 3:** Perform weld joints

| Instruction Sheet | Learning Guide -33 |
|---|---|

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

- Welding materials in all positions.
- Interpreting instructions, symbols and specifications.

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

- Weld materials in all positions.
- Interpret instructions, symbols, and specifications.

**Learning Instructions:**

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below.
- Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
- Accomplish the "Self-check **"**given
- Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
- If you earned a satisfactory evaluation proceed to "Information Sheet 2". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
- Submit your accomplished Self-check. This will form part of your training portfolio.

### 1. Welding position

## 1.1. Horizontal position welding

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.

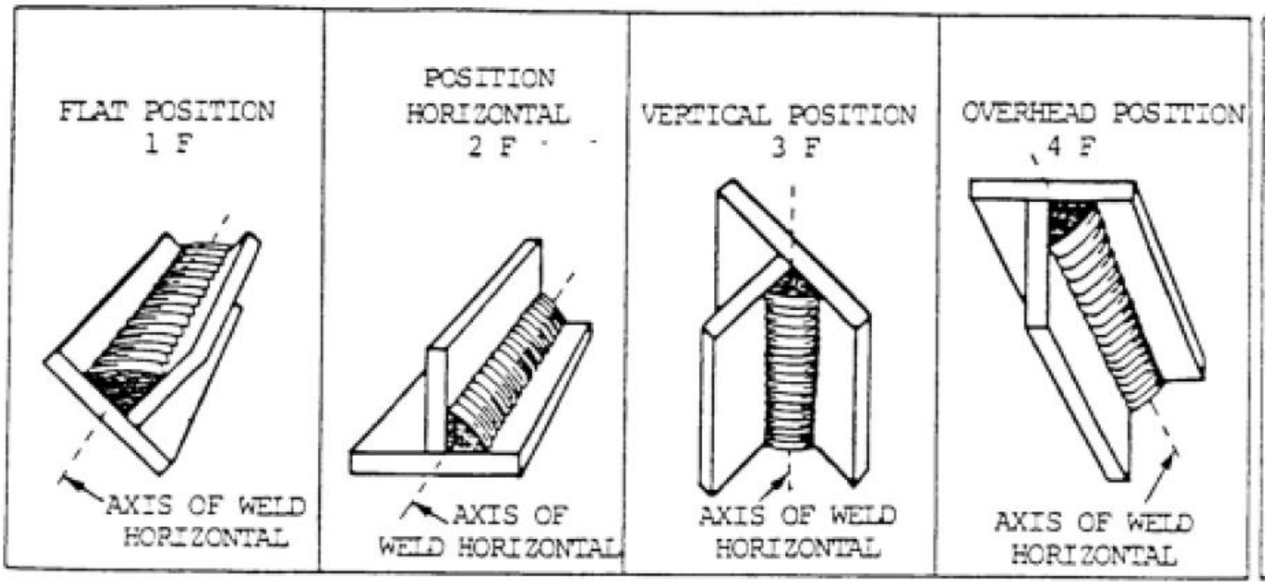
## 1.2. Vertical position welding

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.

## 1.3. Overhead welding 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. Welding joint

***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

***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.

| Self check-1 | Multiple choice |
|---|---|

**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

*Note:* Satisfactory rating - 3 points  Unsatisfactory - below 3 points

Answer Sheet

Score = ____________

Rating: _____________

Name: ___________________________  Date: ________________

| Operation Sheet 1 | Perform lap weld |
|---|---|

**Steps:**

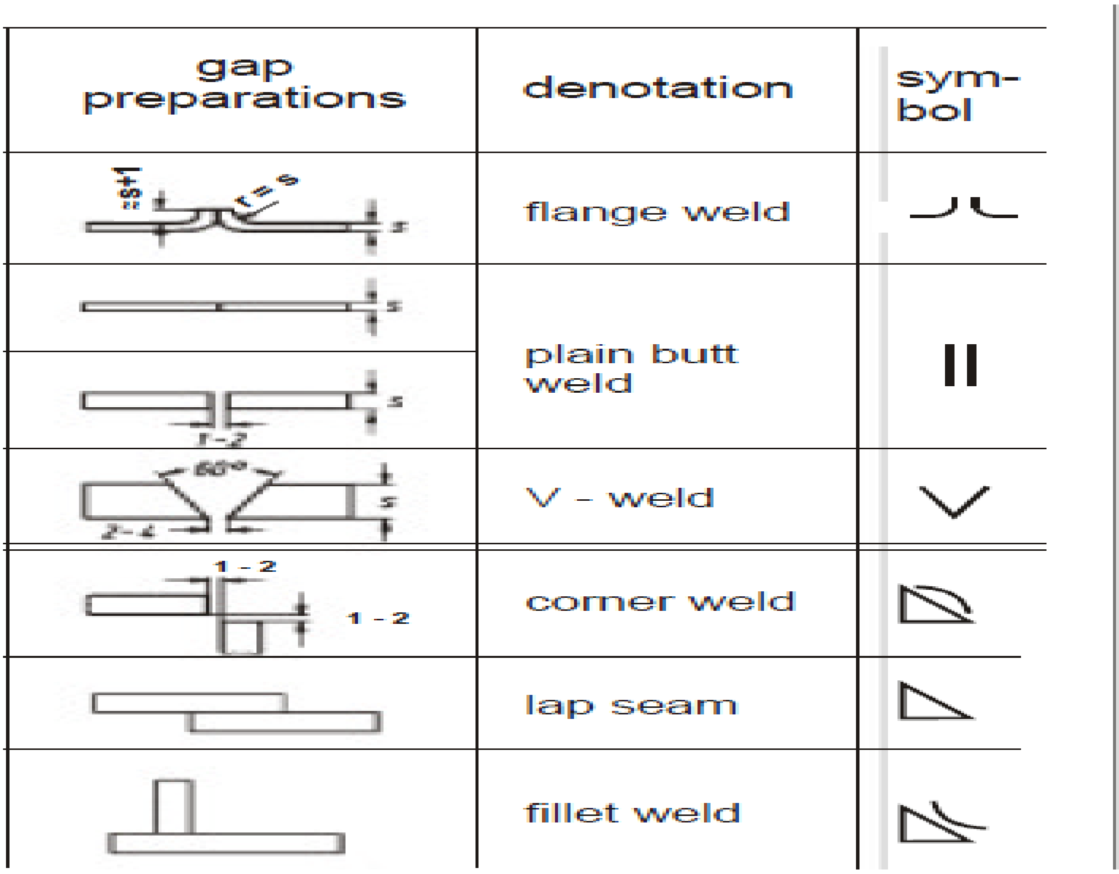
1. Wear all protection clothes
2. Prepare metal to the required groove
3. Set the flame to neutral flame
4. Make tack weld from both ends
5. Produce continuous lap weld

## 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

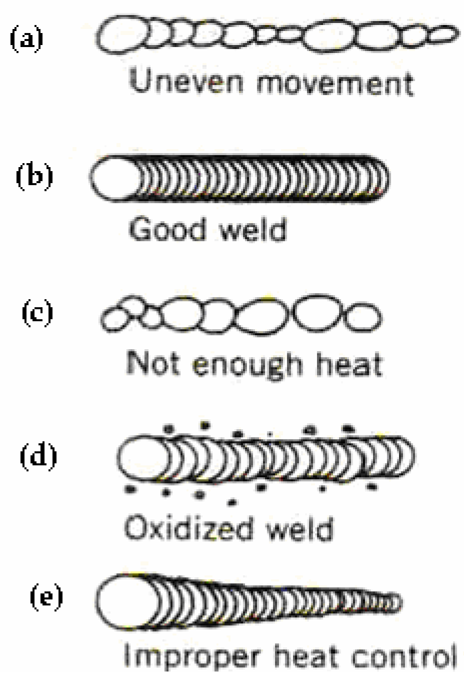
All elements need not be used unless required



## 2.2. 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.




## 1.3. 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.

**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.

| Self check-2 | Multiple choice |
|---|---|

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

1. A complete welding symbol consists of:
   A. Reference line B. arrow C. Dimensions D. all

2. One of the following is factors that impact on the quality of weld

   A. Tip size B. Rod size C. flame size D. all

3. Identify one of the correct statements

   A. the larger the filler rod, the thicker the metal
   B. the higher the number of tip, the smaller the filler rod
   C. the thicker the metal, the smaller the tip

***Note:*** **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

**Answer Sheet**

Score = ____________

Rating: _____________

Name: ______________________________ Date: __________________

**Short Answer Questions**

# List of reference materials


1. Lewis. and Von Elbe. G. *Combustion Flames and Explosions of Gases.* New York: Academic Press, Inc.*1961.*
2. Moen, W.B, and Campbell, J, Evaluation of fuels and oxidants for welding and associated processes. *Welding journal 34(9): 870-876;* September*1955.*
3. National Fire Protection Association, *Gas systems for welding and cutting,* NFPA No. *51.* Quincy, Massachusetts: National Fire Protection Association.
4. Postman, B. F, Safety in installation and use of welding equipment: Welding journal 34(4): *337-344;* April *1955.*
5. Sosnin, H. A, efficiency and economy of oxyacetylene process: *Welding Journal 6(10): 46-48;* October *1982.*
6. National Training Fund for Sheet Metal and Air Conditioning Industry: *Welding book* I, 1st Ed. Alexandria, Virginia, The National Training Fund for the Sheet Metal and Air Conditioning Industry, *1979.*
7. Union Carbide Corporation. *The oxyacetylene handbook* 2nd Ed., New York: Union Carbide Corporation, Linde Div., *1960.*

# Mechanics

## Level-III

## **Learning Guide:** 34

**Unit of Competence:** Perform Oxyacetylene Gas Welding

**Module Title:** Performing Oxyacetylene Gas Welding

**Module Code: XXXXX**

**LG Code: XXXXX**

**TTLM Code: XXXXX**

**LO 4:** Correct faults

| Instruction Sheet | Learning Guide -34 |
|---|---|

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

- Identifying weld defects.
- Removing defects with minimum loss of sound metal and apply appropriate welding Techniques

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

- Identify weld defects.
- Remove defects with minimum loss of sound metal and apply appropriate welding Technique

**Learning Instructions:**

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below.
- Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
- Accomplish the "Self-check **"**given
- Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
- If you earned a satisfactory evaluation proceed to "Information Sheet 2". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
- Submit your accomplished Self-check. This will form part of your training portfolio.

| Information sheet-1 | Identifying weld defects |
|---|---|

# 1. Weld defect
## 1.1. Distortion
### Cause

1. Shrinkage of deposited metal pulls welded parts together and changes their relative positions.
2. Non-uniform heating of parts during welding causes them to distort or buckle before welding is finished. Final welding of parts in distorted position prevents control of desired dimensions.
3. Improper welding sequences.

**Corrective**

1. Properly clamp or track parts to resist shrinkage. Separate or perform parts sufficiently to allow for Shrinkage of welds. Peen the deposited metal while still hot.
2. Support parts of structure to be welded to prevent buckling in heated sections, due to weight of parts themselves. Preheating is desirable in some heavy structures. Removal of rolling or forming strains before welding is sometimes helpful.
3. Study the structure and develop a definite sequence of welding. Distribute welding to prevent excessive local heating.

## 1.2. Welding stresses

**Cause**

1. Joints too rigid.
2. Incorrect welding procedure.
3. Inherent in all welds, especially in heavy parts.

**Corrective**

1. Slight movement of parts during welding will reduce welding stress. Develop welding procedure that permits all parts to be free to move as long as possible.
2. Make weld in as few passes as practicable. Use special intermittent or alternating welding sequence and step-back or skip procedure. Properly clamp parts adjacent to the joint. Use back-up cool parts rapidly.

3. Peen each deposit of weld metal. Stress-relief finished product.

## 1.3. Warping (thin plates)

## Cause

1. Shrinkage of deposited weld metal.
2. Excessive local heating at the joint.
3. Incorrect preparation of joint.
4. Improper welding procedure.
5. Improper clamping of parts

**Corrective**

- Distribute heat input more evenly over full length of the seam.
- Weld rapidly with a minimum input to prevent excessive local heating of the plates adjacent to the weld.
- Do not have excessive space between the parts to be welded. Prepare thin plate edges with flanged joints, making off-set approximately equal to the thickness of the plates. No filler rod is necessary for this type of joint. Make a U-shaped corrugation in the plates parallel to an approximately 13.0 mm (1/2 in) away from the seam. This will serve as an expansion joint to take up movement during and after the welding operation.
- Use special welding sequence and step-back or skip procedure.
- Properly clamp parts adjacent to the joint. Use back-up to cool parts rapidly.

## 1.4. Poor weld appearance

## Cause

- Poor welding technique: Improper flame adjustment or welding rod manipulation.
- Inherent characteristics of welding rod used.
- Improper joint preparations.

**Corrective**

- Use the proper welding techniques for the welding rod used.
- Do not use excessive heat. Use a uniform weave and welding speed at all times.
- Use a welding rod designed for the type of weld.
- Prepare all joints properly.

### 1.5. Cracked welds

- Joint too rigid.
- Welds too small for size of parts joined.
- Improper welding procedure.
- Poor welds.
- Improper preparation of joints.

**Corrective**

- Design the structure and develop a welding procedure to eliminate rigid joints.
- Do not use too small a weld between heavy plates. Increase the size of welds by adding more filler metal.
- Do not make welds in stringer beads. Make welds full-size in short sections 200 mm (8 in) to 250 mm (10 in) long. Welding sequence should be such as to leave ends free to move as long as possible. Preheating parts to be welded sometimes helps to reduce high contraction stresses caused by localized high temperatures.
- Make sure welds are sound and the fusion is good.
- Prepare joints with a uniform and proper gap. In some cases a gap is essential. In other cases, a shrink or press fit may be required.

### 1.6. Undercut

- Excessive weaving of the blowpipe, improper tip size, and insufficient welding rod added to molten puddle.
- Improper manipulation of welding rod.
- 3 Poor welding techniques: Improper welding rod deposition with non uniform heating.

**Corrective**

- Modify welding procedure to balance weave of bead and rate of welding rod deposition, using proper tip size. Do not use too small a welding rod.
- Avoid excessive and non-uniform weaving. A uniform weave with unvarying heat input will aid greatly in preventing undercut in butt welds.
- Do not hold welding rod too low near the lower edge of the plate in the vertical plane when making a horizontal filler weld as undercut on the vertical plate will result

| Self check-1 | Multiple choice |
|---|---|

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

**1.** One of the following is categorized under weld defects
A. undercut B. distortion C. warping D. all

2. Which of the following causes result undercut?
A. joints rigid B. poor welding techniques
C. improper metal preparation D.A and B

3. Poor weld appearance can be prevented by:
A. using the proper welding techniques B. preparing all joints properly
C. applying uniform welding speed D. all

***Note:*** **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

**Answer Sheet**

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

**Short Answer Questions**

# 1. Welding techniques

### 1.1. Leftward Welding

Leftward Welding is used on steel for flanged edge welds, for unleveled plates up to 5.0mm (3/16in). It is also the method usually adopted for cast iron and non-ferrous metals. Welding is started at the right-hand end of the joint and proceeds towards the left.

The blowpipe is given a forward motion with a slight sideways movement to maintain melting of the edges of both plates at the desired rate and the welding rod is moved progressively along the weld seam. The sideways motion of the blowpipe should be restricted to a minimum.

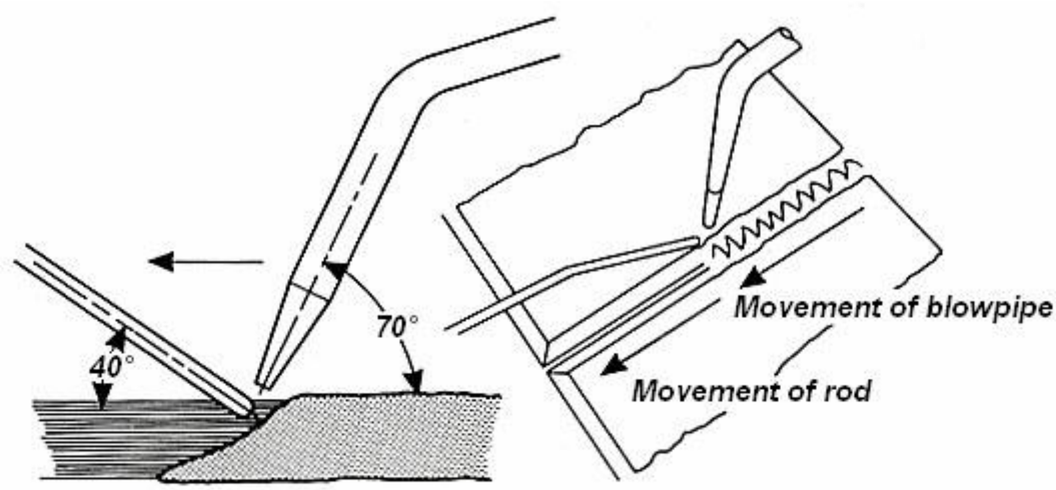



**Figure 5. Leftward welding**

## 1.2. Rightward and all position rightward welding

Rightward welding is recommended for steel plate over 5.0mm (3/16in) thick. Plates from 5.0mm to 8.0mm (3/16in to 5/16in) need not be beveled; over 8.0mm (5/16in) the edges are beveled to 30o to give an included angle of 60o for the welding V. Suitable for horizontal/vertical position.

The weld is started at the left-hand end and moves towards the right with the blowpipe flame preceding the filler rod in the direction of travel. The rod is given a circular forward motion and the blowpipe is moved steadily along the weld seam – See Fig. 3 This is faster than leftward welding and consumes less gas; the V angle is smaller, less filler rod is used and there is less distortion. The all-position rightward technique is a modification of the above and is particularly suitable for mild steel plate and pipe in the vertical and overhead position
The advantages are that it enables the welder to obtain a uniform penetration bead and an even build-up, particularly in fixed position welding; the welder can work with complete freedom of movement and has a clear view of the weld pool and the fusion zone of the joint. Considerable practice is required to become familiar with this technique even by operators skilled in normal down hand rightward welding. An apparent undercutting of the plate surface at the edges of the weld bead is a fault to which this technique is prone but this can be controlled by appropriate manipulation of the rod and flame. The rod and blowpipe angle should be adjusted to give adequate control of the molten metal as in normal rightward welding.

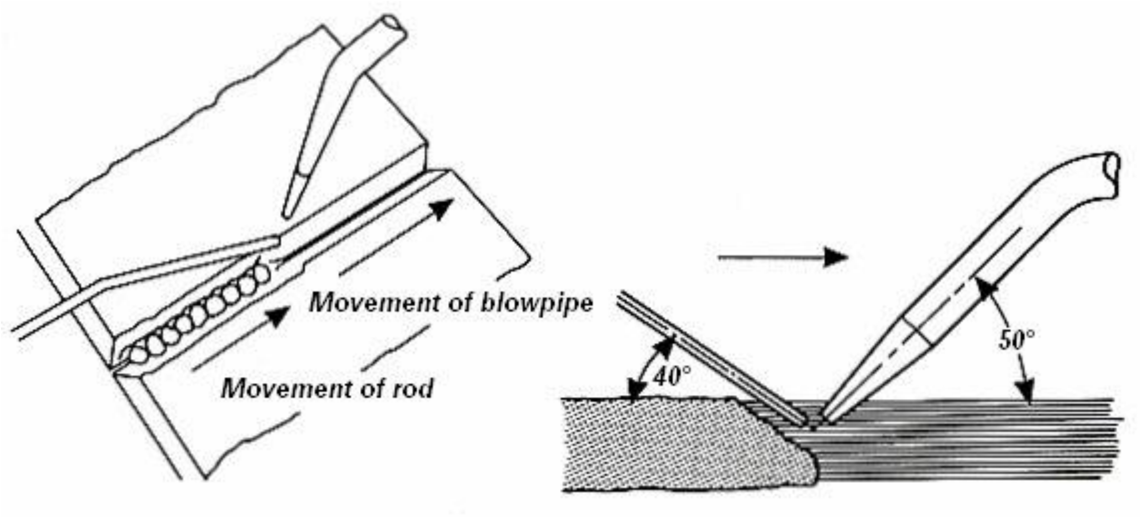



**Figure 9: Rightward Welding**

### 1.3. Types of Welding 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:

- Neutral Flame (Acetylene oxygen in equal proportions)
- Oxidizing Flame (Excess of oxygen)
- Reducing Flame (Excess of acetylene)

#### 1.3.1. 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 5900ºF.

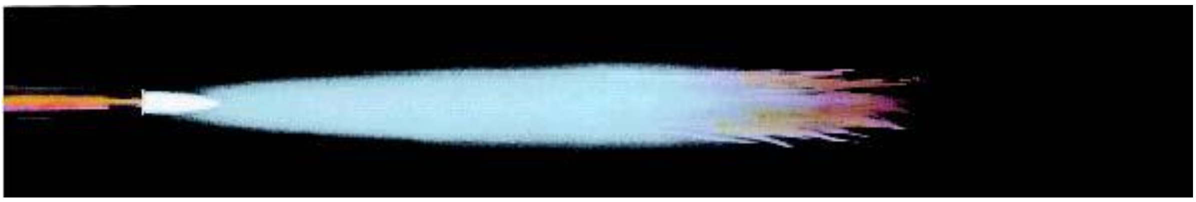


**Figure 10. Neutral Flame (5850°F). For Fusion welding of steel and cast iron**

**Characteristics of Neutral flame:**

- The neutral flame is obtained when approximately one volume of oxygen and one volume of acetylene are mixed. 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.

- Neutral flame is obtained by gradually opening the oxygen valve to shorten the acetylene flame until a clearly defined inner cone is visible. For a strictly neutral flame, no whitish streamers or feathers should be present at the end of the cone.
- 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.
- 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.
- The tip of the inner is the hottest part of the flame and is approximately 5850ºF, while at the end of the outer sheath or envelope the temperature drops to approximately 2300ºF. This variation within the flame permits some temperature control when making a weld. The position of the flame to the molten puddle can be changed, and the heat controlled in this manner.
- The neutral flame is commonly used for the welding of:
  - ✓ Mild steel
  - ✓ Stainless steel
  - ✓ Cast Iron
  - ✓ Copper
  - ✓ Aluminum

### 1.3.2. 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.

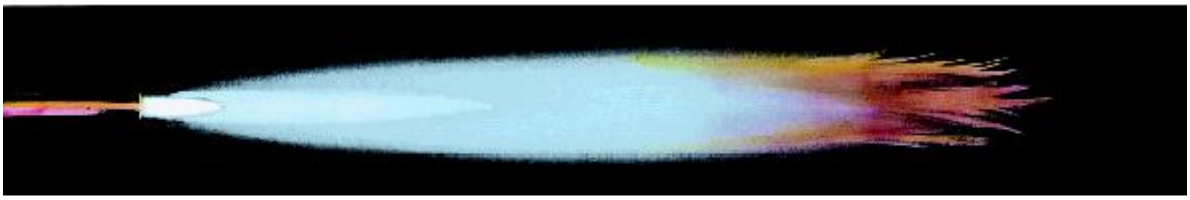


**Figure 11. Carburizing Flame (Excess acetylene with oxygen, 5700°F)**

**Characteristics of Reducing or carburizing flame:**

- 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.
- 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 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 5700ºF (3149ºC) at the inner cone tips.

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

- 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.
- 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.

- 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.

### 1.3.3. 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 12. Oxidizing Flame (Acetylene and excess oxygen, 6300°F)**

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 6300ºF (3482ºC) 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.
- 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.
- 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.

| Self check-2 | Multiple choice |
|---|---|

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

**1.** The three distinct types of flames produced on adjusting the proportions of:

A. oxygen and acetylene B. water and carbide
C. acetylene and carbon carbide D. oxygen and water

2. The type of flame produced on adjusting equal volume of gases:

A. oxidized B. neutral
C. carburized D. inner cone

3. The type of flame used for most welding operations is_______

A. neutral B. oxidized
C. carburized D. all

4. The numbers of flame zones produced in carburizing flame are:

A. Two B. four C. one D. three

***Note:* Satisfactory rating - 3 points Unsatisfactory - below 3 points**

**Answer Sheet**

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

**Short Answer Questions**

## List of reference materials


1. Moen, W.B, and Campbell, J, Evaluation of fuels and oxidants for welding and associated processes. *Welding journal 34(9): 870-876;* September*1955.*
2. National Fire Protection Association, *Gas systems for welding and cutting,* NFPA No. *51.* Quincy, Massachusetts: National Fire Protection Association.
3. Postman, B. F, Safety in installation and use of welding equipment: *Welding journal 34(4): 337-344;* April *1955.*
4. Sosnin, H. A, efficiency and economy of oxyacetylene process: *Welding Journal 6(10): 46-48;* October *1982.*
5. National Training Fund for Sheet Metal and Air Conditioning Industry: *Welding book* I, 1st Ed. Alexandria, Virginia, The National Training Fund for the Sheet Metal and Air Conditioning Industry, *1979.*

# Mechanics

## Level-III

# **Learning Guide:** 35

**Unit of Competence:** Perform Oxyacetylene Gas Welding

**Module Title:** Performing Oxyacetylene Gas Welding

**Module Code: XXXXX**

**LG Code: XXXXX**

**TTLM Code: XXXXX**

**LO 5:** Assure quality weld record handling

| Instruction Sheet | Learning Guide -35 |
|---|---|

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

- Inspecting welding joints using destructive and non- destructive testing Methods.
- Filling up weld records in accordance with specification.
- Maintaining weld records in accordance with specification.

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

- Inspect welding joints using destructive and non- destructive testing Methods.
- Fill up weld records in accordance with specification.
- Maintain weld records in accordance with specification.

**Learning Instructions:**

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below.
- Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
- Accomplish the "Self-check "given
- Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check).
- If you earned a satisfactory evaluation proceed to "Information Sheet 2". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
- Submit your accomplished Self-check. This will form part of your training portfolio.

| Information sheet-1 | Inspecting welding using destructive and non-destructive test |
|---|---|

## 1. Inspection and weld quality

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. 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.

### 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.

#### 1.1.1. 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.

### 1.1.2. 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 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.

### 1.1.3. 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 swab-bing it with a clean, lint-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.

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.

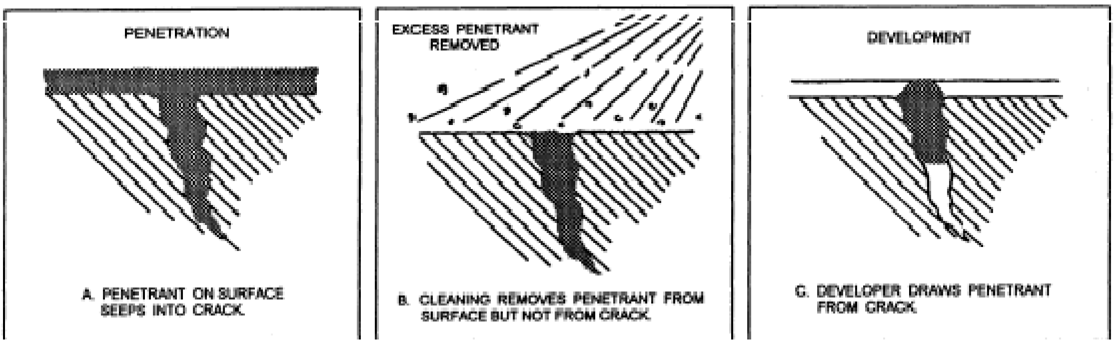



Figure 13. liquid penetrate test

### 1.1.4. Radiographic Inspection

Radiographic inspection is a method of inspecting weldments 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.

## 1.1.5. 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.

### 1.1.5. 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.

## 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.

### 2.1. 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.

The next step in the free-bend test is to scribe two lines on the face of the filler deposit. Locate these lines 1/16 inch from each edge of the weld metal, as shown in figure 7-61, view B. Measure the distance, in inches, between the lines to the nearest 0.01 inch and let the resulting measurement equal (x). Then bend the ends of the test specimen until each leg forms an angle of 30 degrees to the original centerline. With the scribed lines on the outside and the piece placed so all the bending occurs in the weld, bend the test piece by using a hydraulic press or similar machine.

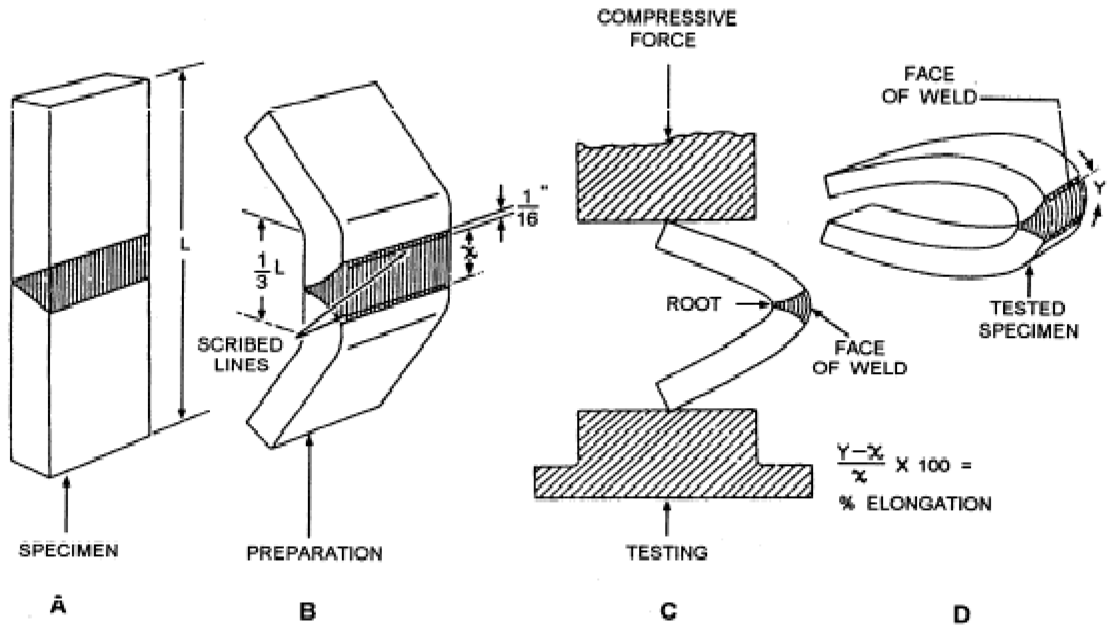



Figure 14. free bend test

## 2.2. 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

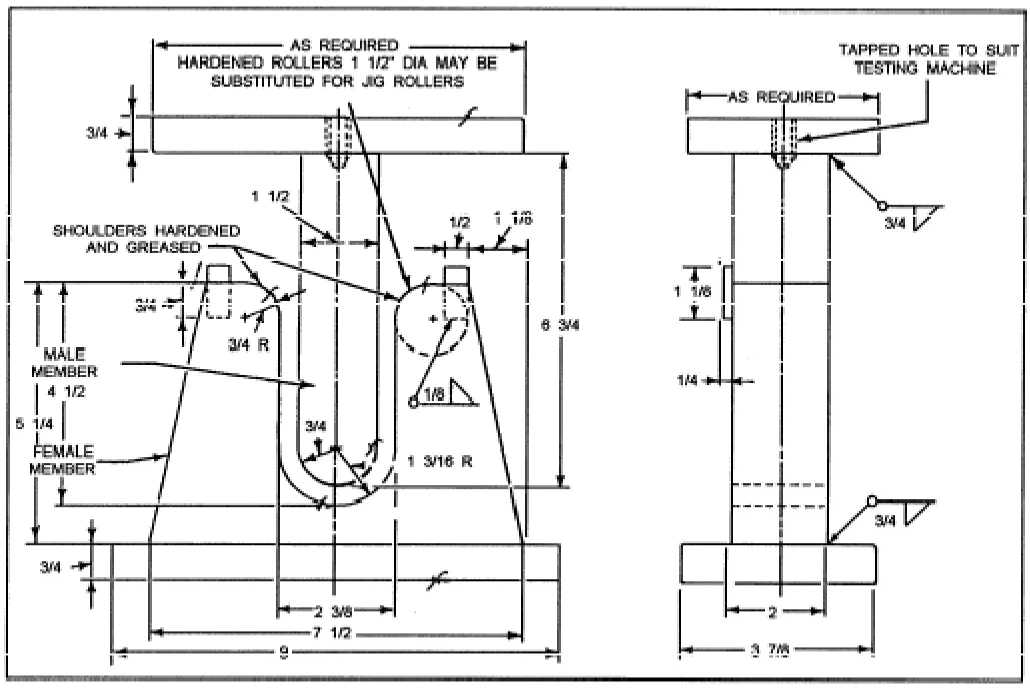



Figure 15.Guided bend test

## 2.3. 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 ¼ inch.

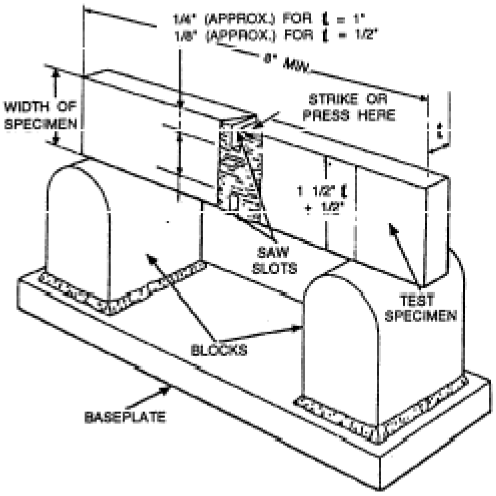



Figure 16. nick-break test

## 2.4. 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. 7-66). 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 Izod piece is supported as a vertical cantilever beam and is struck on the free end projecting over the holding vise.

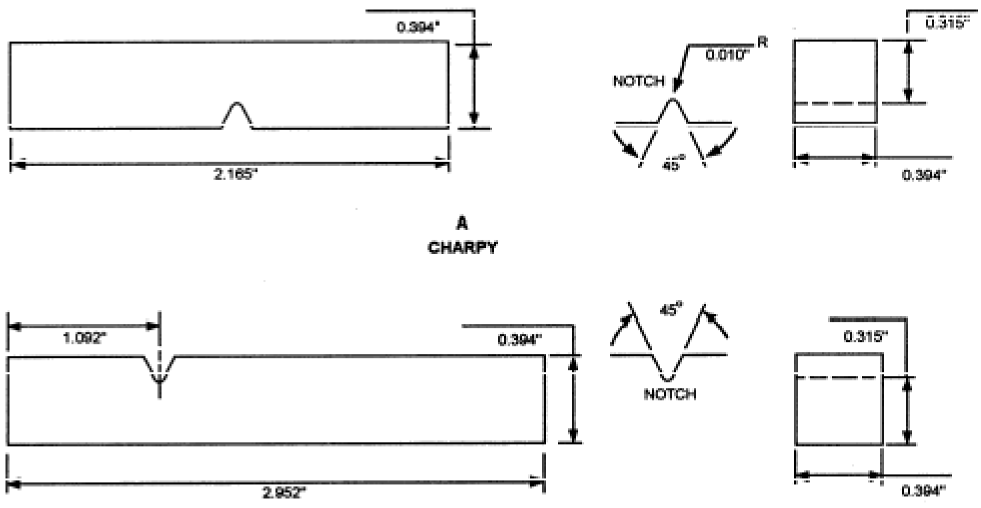



Figure 17. impact test

| Self-Check-1 | Multiple choice |
|---|---|

**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

| Information shhet-2 | Filing weld records |
|---|---|

## 2.1. Weld record file

A weld record sheet is used to track the critical information for each specific weld completed in a piping system. A typical weld record sheets which is sub- divided into 4 main sections are:

- Header section
- Weld information section
- Material information section
- Test information section

The weld record sheet is used in conjunction with the weld isometric drawing and is often printed on the back of the drawing or attached to the drawing. Where possible the design office should fill in the common information before printing to increase efficiencies and minimise the risk of error. The pipe fitter can fill out the material information section as the spool is being tacked together. The welder then generally fills out the weld information section and the weld inspector completes the final test information section

***Weld No.:*** Unique number given to each weld in sequence so that there is complete traceability for every weld in the system

***Welder No.:*** Unique number given to every welder in a company. This number is recorded on the Welder qualification record after a welder performs and passes their qualification tests. This number is then recorded for every weld completed on both the weld record sheet and marked on the pipe beside each weld completed.

***Weld Size:*** Size of the weld being completed. This is used to tie back to weld coupon log to ensure that only these size welds were completed once the correct size weld coupons were completed.

***Weld date:*** The date the weld was completed.

***Location:*** Where the weld was completed, i.e. in the workshop or out on site. Shop welds are usually much easier as they are completed on a bench with good access and minimum purging, while field welds are usually more difficult as access is usually more difficult and the complete system needs to be purged which is harder to achieve. In critical systems a reduced percentage of shop welds may be inspected while the client may insist that 100% of all field welds are inspect

***Process:*** Automatic or manual, most welds should be automatic which are more consistent and therefore more likely to pass inspection. Manual welds are only used where the fitting to fitting distance is reduced to a point where the automatic weld heads will not fit and therefore a manual weld is required. These are only usually allowed by prior approval of the client and usually require 100% inspection

| **Self check-2** | **True/false** |
|---|---|

Direction: Write true /false for the given questions below.

1. Welder No. is a No. given to each weld in a sequence

2. A weld record prepared for each specific weld

3. Material information can be included in weld record

| Information sheet-3 | Maintaining weld record |
|---|---|

## 1. Maintaining and recording

Transparency and safety coupled with productivity and time-savings are common demands in welding environments. To achieve these objectives, it is necessary for welding data to be recorded and maintained for documentation and analysis purposes – areas that are increasingly gaining in importance. Immediate feedback from the production lines helps to optimize processes, monitor system statuses, and identify faults, which in turn leads to a reliable and high-quality manufacturing operation.

The following three documents should be recorded and maintained

- Welding Engineering Standards
- Welding Procedure Specifications
- Welding Procedure Data Sheets

### 1.1. Welding Engineering Standards

Welding engineering standards cover the design of welded joints encountered by the fabricator and prepared primarily for the fabricator's engineering and drafting personnel.

The welding engineering standards typically include:

- The type of joint (e.g., butt, lap, tee, corner, edge);
- The type of weld;
- The geometry of the preparation and fit-up;
- The standard welding symbol;
- The range of thickness; and

### 1.2. Welding Procedure Specification (WPS)

All companies applying or certified to CSA Standards W47.1, W47.2 or W186 are required to prepare and submit welding procedure specifications to the CWB for acceptance.

A welding procedure specification (WPS) sets broad guidelines for the shop and field welding practice of the fabricator for each anticipated combination of essential variables. Welding parameters and ranges are specified and used to prepare the associated welding procedure data sheets.

### 1.3. Welding Procedure Data Sheet (WPDS)

A welding procedure data sheet (WPDS) is a document, used in conjunction with a WPS, detailing the welding parameters and ranges for welding a specific joint, over a range of thicknesses and weld sizes, as illustrated on the data sheet. The following is the standard welding procedure data sheet form suggested by the CWB, however, other welding procedure data sheet formats may be used. Each item on the data sheet will be described and guidance on the completion of the form will be given. Common errors in completing the form will be identified.

| Self check-3 | Multiple choice |
|---|---|

**Direction:** Select one of the appropriate answers from the given alternatives

1. One of the following documents should be recorded and maintained for weld productivity

   A. welding engineering standards B. welding procedures specifications

   C. welding procedure data sheets D. all

2. Welding standards document covers:

   A. the type of joint

   B. the type of weld

   C. the range of thickness

   D. all

3. Maintaining and recording weld documents will result in:

   A. optimizing process B. increasing productivity

   C. reducing quality of weld D. A & B E. B & C

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