Mechanics

Level – I

Based on March 2021, Curriculum Version 1

Module Title: Oxyacetylene Welding and Cutting

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Prepared by: Ministry of Labor and Skill

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Addis Ababa, Ethiopia

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ACKNOWLEDGMENT

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ACRONYM

OAW-Oxy-Acetylene welding

TTLM-Trainees Training Learning Materials

PPE-Personal Protective Equipment

UV-Uletra Violet

Introduction to the Module

In this module, we are primarily concerned with in the general working principles of oxyacetylene gas welding and cutting process and typical items of gas-welding equipment and tools, rather than the setup of oxyacetylene welding and cutting outfits and the applications of materials used for weld and cut with oxyacetylene. For specific information about the available equipment in the working station, you should consult the manufacturer's instruction manual.

This module is designed to meet the industry requirement under the mechanics occupational standard, particularly for the unit of competency: **Oxyacetylene Welding and Cutting Operation**

This module covers the units:

- Preparation of Oxyacetylene welding and cutting equipment
- Setting up of oxyacetylene welding and cutting outfit
- Materials for Weld and Cut with Oxy acetylene

Learning Objective of the Module

- Identify Oxyacetylene welding and cutting equipment's
- Perform Set up of oxyacetylene welding and cutting outfit
- Identify materials for Weld and Cut in Oxy acetylene

Module Instruction

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

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

Unit One: Preparation of Oxyacetylene Welding and Cutting Equipment
This unit is developed to provide you the necessary information regarding the following content coverage and topics: • Personnel Protective Equipment (PPE) • OHS procedures • Selection of welding and cutting equipment • Materials Preparation for cut This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Identify Personnel Protective Equipment (PPE) • Understand Preventative OHS procedures • Perform to Select welding and cutting equipment • Perform proper materials preparation.

1.1. Preparation of oxyacetylene welding and cutting equipment

1.1.1. Personnel Protective Equipment (PPE)

A. Goggle

They are used to protect the eyes of the operator from harmful heat and radiation of infrared and ultraviolet rays produced during the welding. Welding/cutting goggles should be worn at all times when welding, brazing, cutting, or when a lot of heating is required. They should have a number 4, 5, or 6 shade filter lens in them and be C.S.A. approved. They are made to protect your eyes from sparks, dust, and damaging light rays that can be produced. At all times in a shop where there are potential sparks or fragments, safety glasses with a side shield should be worn

Figure 1.1. Goggles

B. 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.

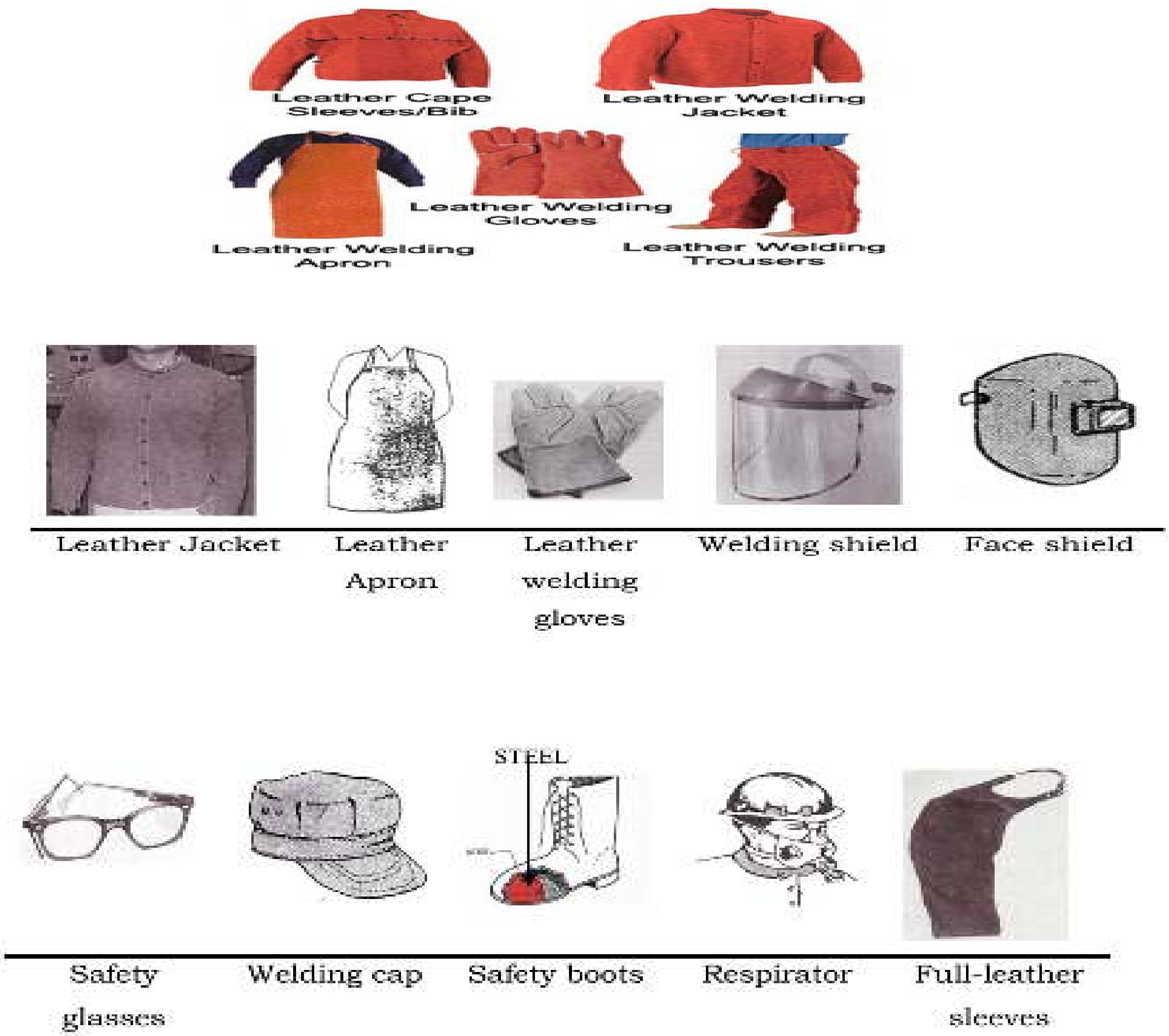
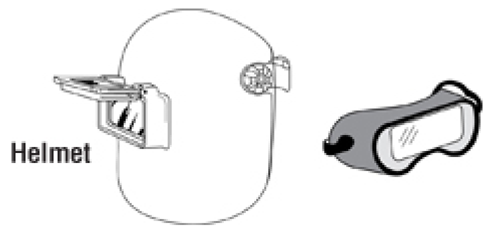
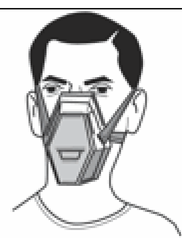
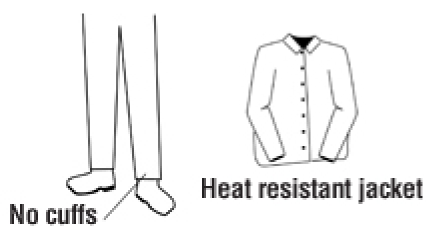


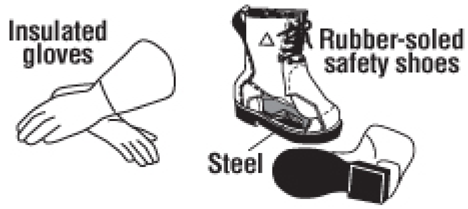
Figure 1.2. Safety equipment

1.1.2. Personal Protective Equipment and Clothing

The chart below summarizes the types of personal protective equipment that can be used when welding in oxyacetylene.

Table 1.1. Personal Protective Equipment

Personal Protective Equipment			
Body Part	Equipment	Illustration	Reason
Eyes and face	Welding helmet, hand shield, or goggles		Protects from: radiation flying particles, debris, hot slag, sparks, intense light, irritation and chemical burns, Wear fire resistant head coverings under the helmet where appropriate
Lungs (breathing)	Respirators		Protects against: fumes and oxides
Exposed skin (other than feet, hands, and head)	Fire/Flame resistant clothing and aprons		Protects against: heat, fires, burns, radiation **Notes:** pants should not have cuffs, shirts should have flaps over pockets or be taped closed
Ears hearing	Ear muffs, ear plugs		Protects against: noise, Use fire resistant ear muffs where sparks or splatter may enter the

			ear, rather than plugs.
Feet and hands	Boots, gloves		Protects against: electric shock, heat, burns and fires

1.1.3. Importance of eye protection

Eye injury can occur from the intense light and radiation that a welding arc can produce. Eye injury can also occur from hot slag and other metal debris that can fly off from the weld during cooling, chipping or grinding.

Protect your eyes from welding light by wearing a welder's helmet fitted with a filter shade that is suitable for the type of welding you are doing.

ALWAYS wear safety glasses with side shields or goggles when chipping or grinding a work piece if you are not wearing a welding helmet.

Figure 1.3. Safety goggle

Classifications of common protectors for welding operations are listed below:

- Class 2C – direct / non-ventilated goggles with non-ionizing radiation protection
- Classes 3 and 4 – welding helmets and hand shields
- Class 6B – face shields for non-ionizing radiation protection
- Class 7B – respirator face piece for non-ionizing radiation protection

1.2. OHS procedures

1.2.1. Safety

Safety is one of the most important concerns in welding. Welding, which is uses an electric current, generates intense heat, and emits an intense light. All of these factors demand a thorough knowledge of safety requirements. During arc welding, welders must be aware of their actions and surroundings at all times. There are many potential dangers, which is why safety is one of the most important concerns in welding.

Before welding, you must know the risks associated with arc welding and the proper safety precautions. Always read all warning labels for all of the components you will be using. Regardless of the situation, if you are ever in doubt about a safety issue, ask your supervisor for guidance. This class will teach you about the importance of arc welding safety. You will learn about the risks involved with gas welding and how to prevent accidents.

Figure 1.4. Safety precautions

1.2.2. General Safety procedures in the workshop

Safety first is a good slogan at any time, and everywhere. Safety means take care of oneself from injury, take care of his coco-worker and also take care of machines, equipment, tools and materials in the workshop from damage. Safety generally means the right way to do work. When working in any workshop, one must follow the rules and regulations of that specific workshop. As it is known in general mechanics workshops of different levels, different equipment, machines, tools and materials are in use and need careful handling to protect them from damage and prolong their service life. Therefore, the worker of this shop must follow the rules and regulations of this workshop. A skilled worker may be called skilled if he is a safe worker.

Figure 1.5. Safety rule

1.2.3. Need of safety

Safety is needed in the workshop for the following reasons.

1. To protect one self and the co-worker from badly harm, even death.
2. To minimize damage of equipment, machines, tools and material! As well as the working area and building where the workshop situated.
3. To enable the worker (technician) experiencing safety habits in hi! Professional activity and in general in his life.

- Safety is an attitude of mind and good work habits that should develop and practice in the workshop.

Everyday a large number of accidents occur in factories and workshops of various levels. These accidents may result in any of the following.

1.Body injury.	3. Death.
2.Permanent disability.	4. Damage the work or machine.

Causes of industrial and workshop accidents are due to the victim's faults. These accidents may be reached approximately up to two thirds of the whole accidents. The rest are caused by means which are beyond the workers control. **It** means that the person working in the workshop must always be conscious of hazardous or dangerous situations. The following are some of the factors that affect safety.

1. **The surroundings:**

- Are the work surrounding too cold or too hot?
- Is the noise level at the normal standard?
- Are any dangerous fumes, gases, chemicals or dust around the work area?
- Is the lighting adequate and free from glare?
- Is the lighting constant throughout the surrounding?

2. **The work area:**

- Can people of all sites get in to the work area?
- Is the physical appearance of the operator satisfactory-if seats are provided, are they correct height and shape?
- Is proper access provided for maintenance and cleaning of the machines, equipment and tools?

3. **The equipment:**

- Are the displays and controls easily distinguishable particularly the emergency control system or stops?
- Is the operation and layout similar to other equipment of the same type?
- Are working signals distinguishable from background noises and lights?
- Is too much force needed to operate the equipment?

4. **The operator:**

- Does the operator have to deal with a large amount of information at the same time?
- Does he have to remember information without aids?
- Are there influences from other jobs, equipment or other workers!
- Will the carrying out of the job require the worker to have special rest periods because of fatigue or the need for vigilance?
- Taking the above mention factors in to account the worker should develop good safety habits.

- If a worker develops negative attitude towards safety. i.e. if he is careless, disobeying the rules and become forgetful, then the result will be serious damage of machines, tools, equipment, material and serious injury on himself. This condition shows the senselessness of the worker.
- A worker should not do his job by trial and error. Should utilize the tools, equipment and machines properly and perform his activity step by step. If he is doing his job against the above mentioned procedure the result will be damage of tools, equipment, his job, wastage of materials and injure him.

The workshop, the working areas, the bench should always be kept clean, the tools and equipment should be placed in the correct place according to their type, size and shape properly. This is the main thing for the correct workshop handling and good working condition. Grease and oil on floors can cause dangerous falls.

1.6. Poor workshop handling

Having the attitude it can never happen to me is not a guarantee of safety. Safety is the responsibility of everyone.

1.2.4. Common causes of accidents

As mentioned earlier, maximum accidents may happen due to the operator's (worker's) fault. However, stressing on common causes of accidents is important. Improper clothing (dressing), poor handling of the workshop, poor and insensible behavior of the worker, incorrect procedural activity and improper handling and usage of the tools, equipment, machines and materials are common causes of accidents. Wearing loose cloths, neck ties, rings, wrist watches may caught the moving machines or parts and may bring disability of the worker.

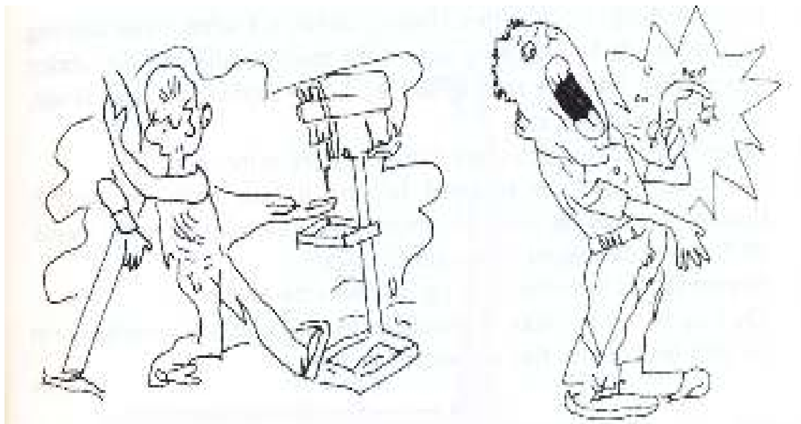


Figure 1.7. A. loose clothing can easily be caught B. wearing rings and watches can be the cause of serious injuries in moving parts of machinery

Most common hazards occur in the workshop are:

- Damages from sharp edges and points.
- Damages (injuries) because of confined or limited spaces.
- Coughs and kicks by moving parts and machines.
- Emissions of dangerous heat, sparks, fumes and dusts.
- Electrical shocks.
- Harmful extra bright light injuries.
- Chemical caused accidents of skin, eye or other body.

1.2.5. Accident prevention

Accidents in the workshop can be prevented using the proper safety rules and regulations. The following are the safety rules which must be attended by the shop workers (users) of general mechanics workshop.

Clothing: Unsuitable clothing is a source of danger in the workshop.

- **Be clean and neat:** A worker who keeps himself clean and neat is usually a safe worker. Dirty clothing is unhealthy and slows up the worker.

- **Loose clothing**: loose or tom clothing should not worn- loose clothing may be caught by a moving part of the machine and pull the worker into gears or blades or rotating motors. Loose clothing includes as ties, scarves, tom sleeves etc.
- Apron made of heavy canvas should be worn in the shop.
- A sweater should be removed because it over heats the worker, because it causes the worker to respire and to slow up his work. Sweat, air dust, and dirt cause some skin diseases.
- Sleeves should be rolled up or cut off above the elbow.
- The long or flowing neck tie should be removed entirely or tucked in to the shirt between the first and second buttons.

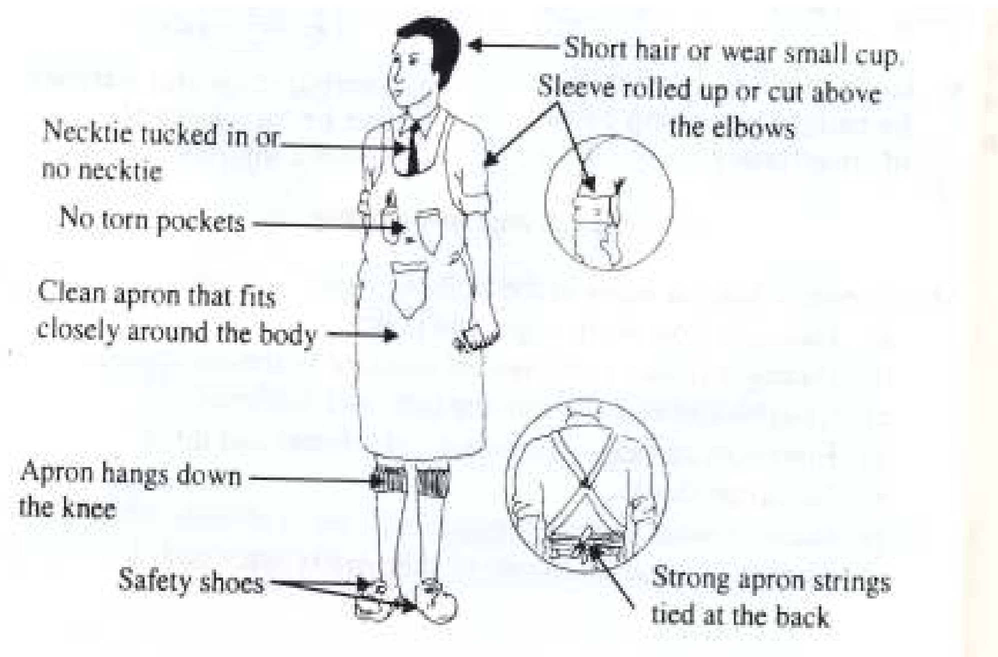


Figure 1.8. Clothing

1.2.6. Hand shields and helmets

Hand shields or helmets provide eye protection by using an assembly of components:

- Helmet shell: must be opaque to light and resistant to impact, heat and electricity.

- Outer cover plate made of polycarbonate plastic which protects from radiation, impact and scratches.

- Filter lens made of glass containing filler which reduces the amount of light passing through to the eyes. Filters are available in different shade numbers ranging from 2 to 14. The higher the number, the darker the filter and the less light pass through the lens.

- Clear retainer lens made of plastic prevents any broken pieces of the filter lens from reaching the eye.

- Gasket made of heat insulating material between the cover lens and the filter lens protects the lens from sudden heat changes which could cause it to break. In some models the heat insulation is provided by the frame mount instead of a separate gasket.

1.2.7. Eye protection

- Choose a tight fitting helmet to help reduce light reflection into the helmet through the space between the shell and the head.
- Wear the helmet correctly. Do not use it as a hand shield.
- Protect the shade lens from impact and sudden temperature changes that could cause it to crack.
- Use a cover lens to protect the filter shade lens. Replace the cover lens if it gets scratched or hazy.
- Make sure to replace the gasket periodically if your helmet uses one.
- Replace the clear retaining lens to protect your eyes from broken pieces.
- Clean lenses periodically.
- Discard pitted, cracked or damaged lenses

1.2.8. Protect skin from welding radiation

- Wear tightly woven work-weight fabrics to keep Ultra Violet radiation from reaching your skin.
- Button up your shirt to protect the skin on the throat and neck.

- Wear long sleeves and pant legs.
- Cover your head with a fabric cap to protect the scalp from UV radiation.
- Protect the back of your head by using a hood.
- Protect your face from UV radiation by wearing a tight-fitting, opaque welder's helmet.
- Make sure that all fabric garments are resistant to spark, heat and flame. Keep the fabrics clean and free of combustible materials that could be ignited by a spark.

1.2.9. Protective clothing

- Wear clothing made from heavyweight, tightly woven, 100% wool or cotton to protect from UV radiation, hot metal, sparks and open flames. Flame retardant treatments become less effective with repeated laundering.
- Keep clothing clean and free of oils, greases and combustible contaminants.
- Wear long-sleeved shirts with buttoned cuffs and a collar to protect the neck. Dark colors prevent light reflection.
- Tape shirt pockets closed to avoid collecting sparks or hot metal or keep them covered with flaps.
- Pant legs must not have cuffs and must cover the tops of the boots. Cuffs can collect sparks.
- Repair all frayed edges, tears or holes in clothing.
- Wear high top boots fully laced to prevent sparks from entering into the boots.
- Use fire-resistant boot protectors or spats strapped around the pant legs and boot tops, to prevent sparks from bouncing in the top of the boots.
- Remove all ignition sources such as matches and butane lighters from pockets. Hot welding sparks may light the matches or ignite leaking lighter fuel.
- Wear gauntlet-type cuff leather gloves or protective sleeves of similar material, to protect wrists and forearms. Leather is a good electrical insulator if kept dry.
- Using a shield can help keep any sparks spray away from your clothing.
- Wear leather aprons to protect your chest and lap from sparks when standing or sitting.

- Wear layers of clothing. To prevent sweating, avoid overdressing in cold weather. Sweaty clothes cause rapid heat loss. Leather welding jackets are not very breathable and can make you sweat if you are overdressed.
- Wear a fire-resistant skull cap or balaclava hood under your helmet to protect your head from burns and UV radiation.
- Wear a welder's face shield to protect your face from radiation and flying particles.

1.2.10. The following precautions will help to prevent leaks:

- Turn the gas supply off at the cylinder when the job is finished or before the cylinders are moved or transported;
- Isolate and purge or remove hoses and equipment from enclosed or poorly ventilated spaces when there is a break in work;
- Keep hoses away from sharp edges and abrasive surfaces or where vehicles can run over them;
- Do not allow hot metal or spatter to fall on hoses;
- Maintain all equipment and regularly check its condition.
- Regularly check all connections and equipment for faults and leaks. Equipment used in aggressive conditions such as demolition work or heavy engineering will normally need more frequent checks, e.g. weekly.
- Use a proprietary leak detecting spray or solution suitable for use with oxy/fuel systems. Do not use soapy water or solutions containing grease or oils on oxygen systems.
- Never look for gas leaks with a naked flame.
- Immediately repair or replace leaking components.
- Leaking hoses should not be repaired, but they can be shortened to remove a damaged section. Refit hose tails using crimp clips designed for that task. Screw tightened crimps (jubilee clips) are not recommended. There is a risk of leaks due to over tightening or under tightening them.

1.2.11. General safety recommendations for gas welding

Welding and cutting of metals involve the application of intense heat to the objects being welded or cut. This intense heat in welding is obtained from the use of inflammable gases, (e.g. acetylene, hydrogen, etc.) or electricity. The intense welding heat and the sources employed to produce it can be potentially hazardous. Therefore, to protect persons from injury and to protect building and equipment against fire, etc., a set of recommendations concerning safety and health measures for the welders and those concerned with the safety of the equipment's etc., have been published by BIS and many other similar but International organizations. By keeping in mind these recommendations or precautions, the risks associated with welding can be largely reduced. Therefore, it is suggested that the beginner in the field of gas welding must go through and become familiar with these general safety recommendations, which are given below.

1. Never hang a torch with its hose on regulators or cylinder valves.
2. During working, if the welding tip becomes overheated it may be cooled by plunging the torch into water; close the acetylene valve but leave a little oxygen flowing.
3. Always use the correct pressure regulators for a gas. Acetylene pressure regulator should never be used with any other gas.
4. Do not move the cylinder by holding the pressure regulator and also handle pressure regulators carefully.
5. Use pressure regulator only at pressures for which it is intended.
6. Open cylinder valves slowly to avoid straining the mechanism of pressure regulator.
7. Never use oil, grease or lubricant of any kind on regulator connections.
8. For repairs, calibrations and adjustments purposes, the pressure regulators should be sent to the supplier.
9. Do cracking before connecting pressure regulator to the gas cylinder.
10. Inspect union nuts and connections on regulators before use to detect faulty seats which may cause leakage of gas when the regulators are attached to the cylinder valves.
11. Hose connections shall be well fittings and clamped properly otherwise securely fastened to these connections in such a manner as to withstand without leakage a pressure twice as great as the maximum delivery pressure of the pressure regulators provided on the system.

12. Protect the hose from flying sparks, hot slag, hot work piece and open flame. If dirt goes into hose, blow through (with oxygen, not acetylene) before coupling to torch or regulator.
13. Store hose on a reel (an automobile wheel) when not in use.
14. Never allow the hose to come into contact with oil or grease; these deteriorate them rubber and constitute a hazard with oxygen.
15. Use the correct color hose for oxygen (green/black) and acetylene (red) and never use oxygen hose for acetylene or vice versa.
16. Always protect hose from being trampled on or run over. Avoid tangle and kinks.

Never leave the hose so that it can be tripped over. Hazards of fumes, gases and dusts can be minimized by (i) improving general ventilation of the place where welding is carried out (ii) using local exhaust units, and (iii) wearing individual respiratory protective equipment.

1.3. Selection of welding and cutting equipment

1.3.1. Introduction

Gas welding is one of the oldest methods of welding and, for many years, was the most widely used method of metal-melting; however, its use is a lot less common today. Nevertheless, it is a versatile method, using simple and relatively cheap equipment. It is suitable for repair and erection work, for welding pipes tubes and structures with a wall thickness of 0.54 rnm in materials particularly prone to cracking, such as cast iron and non-ferrous metals. It is also widely used for cladding and hard facing. The heat is generated by the combustion of acetylene in oxygen, which gives a flame temperature of about 3100 ^{o}C. This is lower than the temperature of an electric arc, and the heat is also less concentrated. The flame is directed onto the surfaces of the joint, which melt, after which filler material can be added as necessary. The melt pool is protected from air by the reducing zone and the outer zone of the flame. The flame should therefore be removed slowly when the weld is completed. The less concentrated flame results in slower cooling, which is an advantage when welding steels that have a tendency to harden, although it does make the method relatively slow, with higher heat input and the added risk of thermal stresses and distortion. In addition to welding, gas flames are also often used for cutting, and are very useful for heating and flame.

1.3.2. Characteristics of Acetylene

- Hydrocarbon: It burns in two stages with primary combustion zone (cone flame) and secondary combustion zone (envelope flame);
- Acetylene is a colorless gas with a very distinctive, nauseating odor that is highly combustible when mixed with oxygen.
- Acetylene gas is formed by the mixture calcium carbide and water and is composed of carbon and hydrogen having the chemical formula C_2H_2.
- Neutral flame temperature of 5420°F at the end of the inner cone. This can be increased to a maximum of about 5800°F by increasing the oxygen quantity through the torch (oxidizing flame);
- Combustible intensity is 12700 BTU/sec. /sq. ft. of cone area in a one to one mixture of acetylene and oxygen through the torch

1.3.3. Advantages of Oxyacetylene Process

- Does not require electricity;
- The equipment is portable, easy to transport;
- 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;
- Oxyacetylene process is ideally suited to the welding of thin sheet, tubes, and small diameter pipe. It is also used for repair work, maintenance and in body shops;
- Dissimilar metals can easily be joined;
- Can also be used for preheating, cutting metal, case hardening, soldering and annealing.

1.3.4. Limitations of Acetylene

- Acetylene becomes extremely dangerous if used above 15 pounds pressure. Pure acetylene is self-explosive if stored in the Free State under a pressure of 29.4 pounds per square inch (psi)
- The process is typically slower than the electrical arc-welding processes.

1.3.5. Gas Welding Equipment

An arrangement of oxy acetylene welding set up is shown in Fig.1.9. The basic tools and equipment's used for oxy-acetylene welding are following: The basic equipment used to carry out gas welding and cutting is:

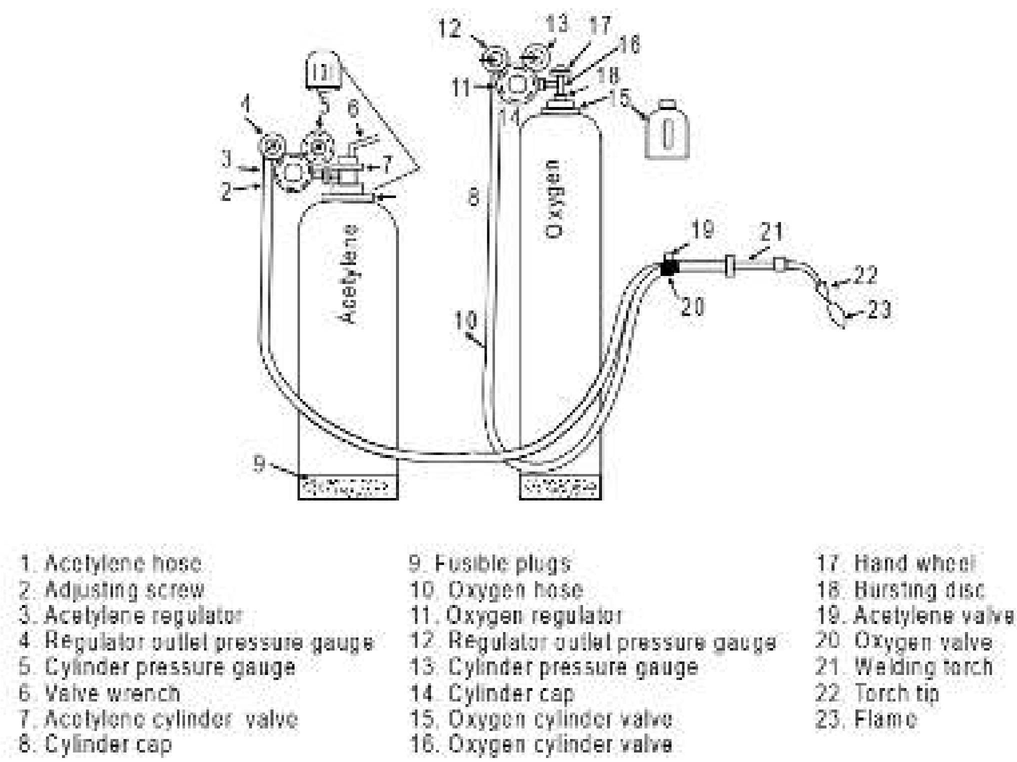


Figure 1.9. Oxy acetylene welding equipment set up

Acetylene and oxygen gas is stored in compressed gas cylinders. These gas cylinders differ widely in capacity, design and colour code. However, in most of the countries, the standard size of these cylinders is 6 to 7 m3 and is painted black for oxygen and maroon for acetylene. An acetylene cylinder is filled with some absorptive material, which is saturated with a chemical solvent acetone. Acetone has the ability to absorb a large volume of acetylene and release it as the pressure falls. If large quantities of acetylene gas are being consumed, it is much cheaper to generate the gas at the place of use with the help of acetylene gas generators. Acetylene gas is generated by carbide-to-water method.

Oxygen gas cylinders are usually equipped with about 40 litres of oxygen at a pressure of about 154 Kgf/cm^2 at 21°C. To provide against dangerously excessive pressure, such as could occur if the cylinders were exposed to fire, every valve has a safety device to release the oxygen before there is any danger of rupturing the cylinders. Fragile discs and fusible plugs are usually provided in the cylinders valves in case it is subjected to danger.

A. Acetylene Gas Cylinder

The cylinders of acetylene gas are made of steel with concave bottom to prevent explosion and to ensure safely. 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).

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 Portland 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.

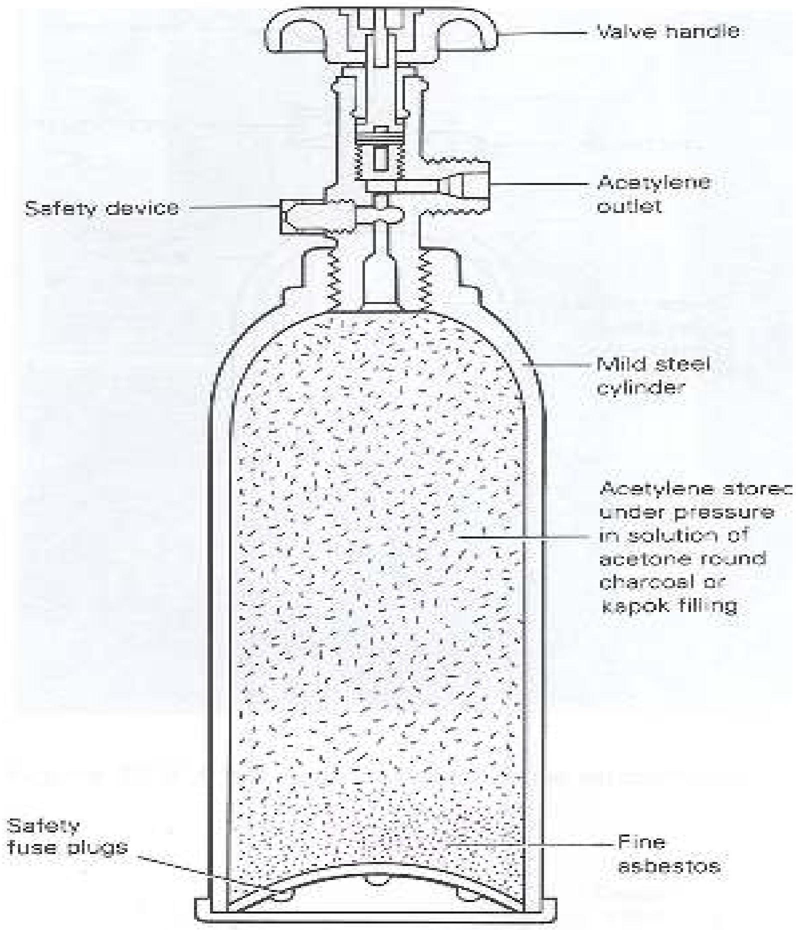


Figure 1.10. Acetylene cylinder

B. Oxygen Gas Cylinder

This cylinder also made of steel to store liquefied oxygen gas under pressure with taller size. It is fitted with right hand screw thread and painted black or blue.

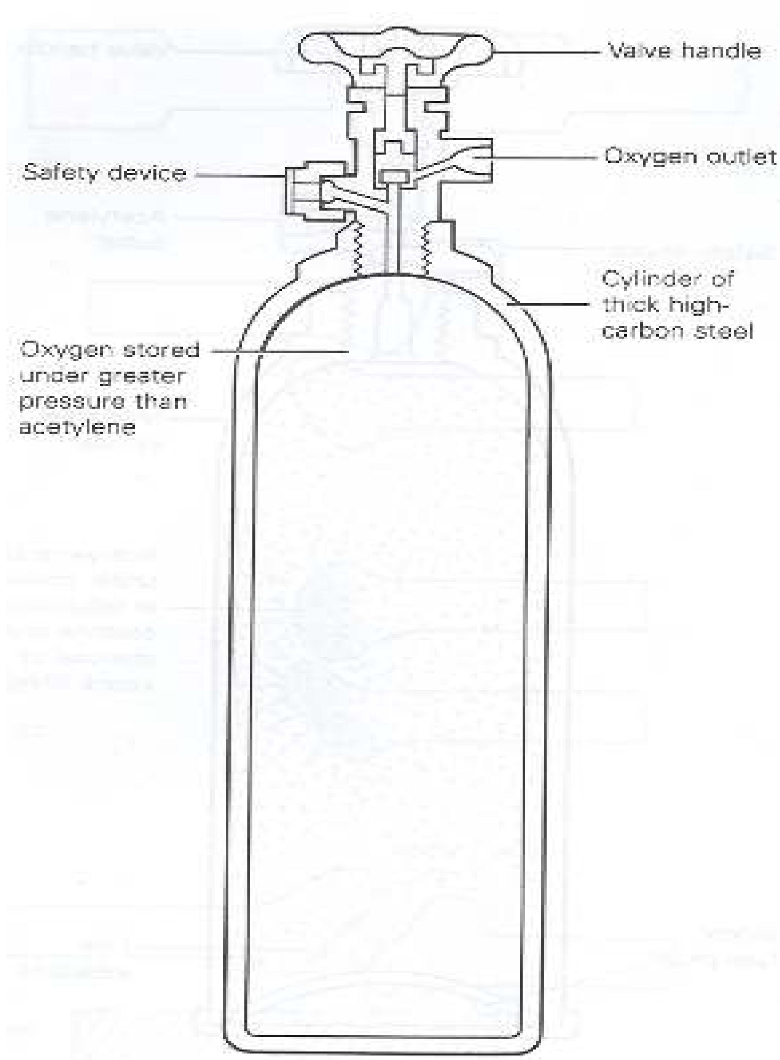


Figure 1.11. Oxygen cylinder

Oxygen cylinder is drawn from a piece of high strength steel plate and is available in common sizes of: 244 cu ft (for industrial plants), 122 cu ft and 80 cu ft. 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 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.

C. Oxygen Cylinder Valves

The oxygen cylinder valve is made largely of brass with right hand threads. Its outlet is threaded and machined. 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.

D. Pressure Regulator

Pressure regulator performs two functions.

- Reduce high storage pressure from the cylinder to the suitable working pressure
- Help in maintaining constant gas pressure at the blowpipe.

Two types of pressure regulator are used to set up oxyacetylene welding unit:

- Acetylene pressure regulator and
- Oxygen pressure regulator

Most regulators have two gauges. The right gauge measures the pressure of gas in the cylinder (supply pressure) and the left one measure the gas coming in to the blowpipe (working pressure).

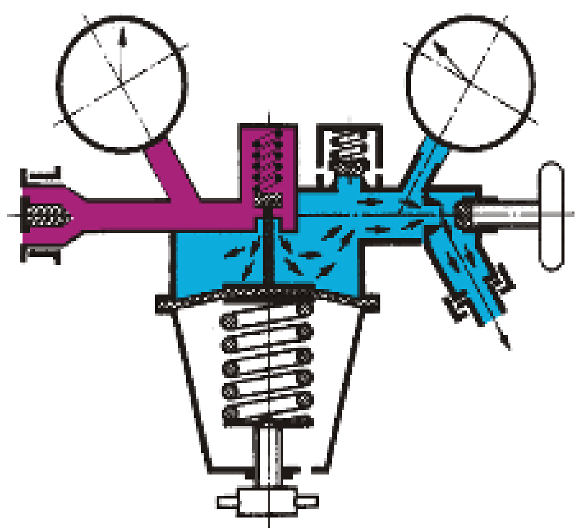


Figure 1.12. Gas regulator and Pressure regulator

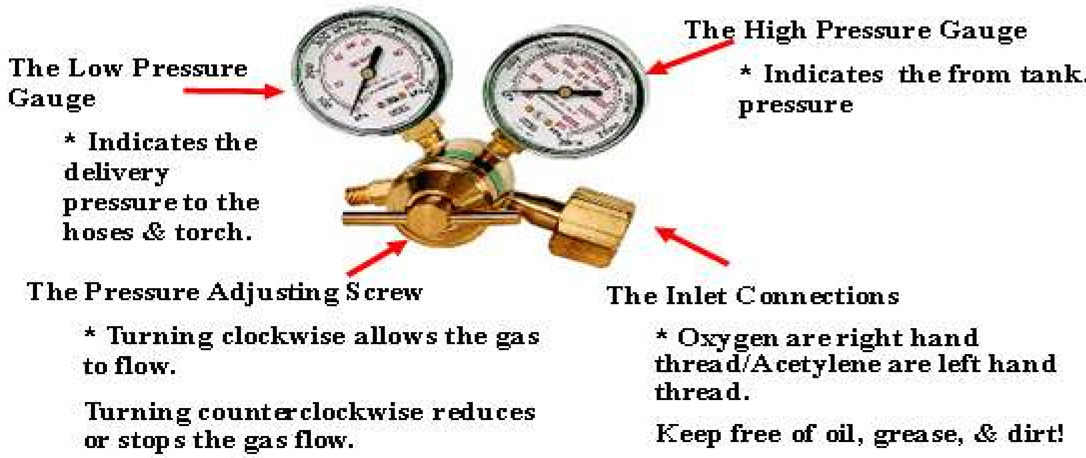


Figure 1.13. Oxygen and acetylene Pressure regulator

Table 1.2. Difference between Oxygen and Acetylene Pressure Regulators

Acetylene Regulator	Oxygen Regulator
The cylinder and hose connections have left handed threads on the acetylene regulator	There are right hand threads in this case
Acetylene connection nuts have chamfers or grooves cut in them.	Nuts are plain, i.e., with no chamfer or grooves.
Color band on acetylene regulator in maroon or red.	It is either blue or black on the oxygen regulator.
The inlet or high pressure gauge on the regulator reads up to 8bar.	The inlet or high pressure gauge on the regulator reads up to 100bar.
The outlet or low pressure gauge on the regulator reads up to 1bar.	The outlet or low pressure gauge on the regulator reads up to 4.8bar.

1.3.6. 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.

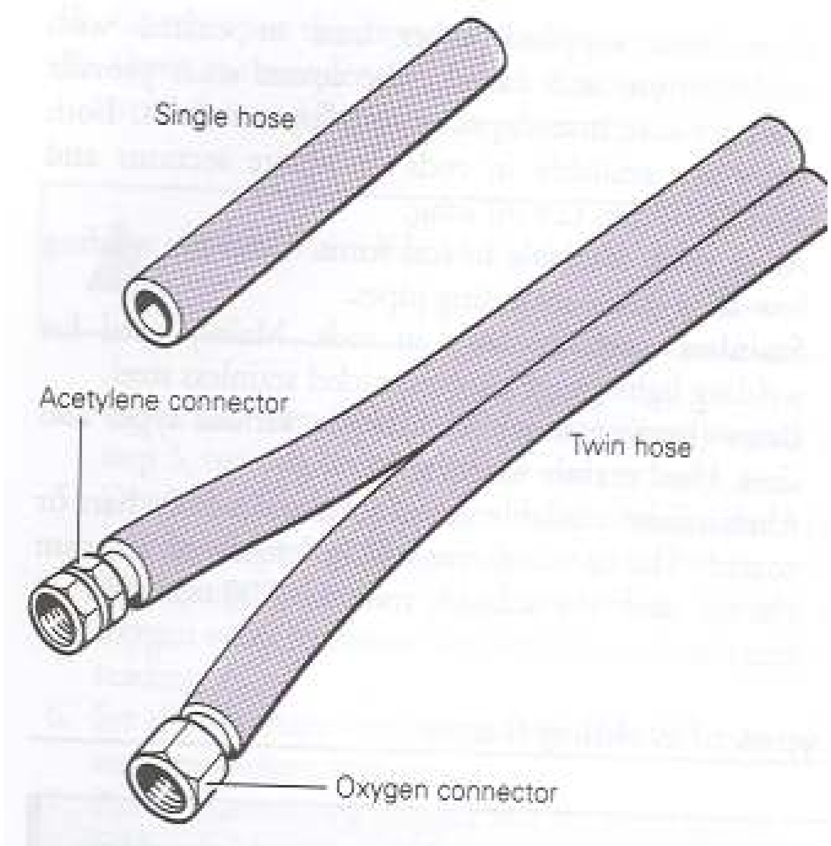


Figure 1.14. Oxygen and acetylene Gas hoses and connectors

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.

1.3.7. 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 1.15. Hose clamps

1.3.8. Welding Torch or 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.

There are two types of blowpipe or torch:

- Welding blowpipe
- Cutting blowpipe

The difference is an extra oxygen control valve, which is used to produce an oxygen jet, which does the cutting. Welding blowpipe have the ejector or law pressure types that will be the mixing chamber I the nozzle tube and balance types which used with high pressure cylinder.

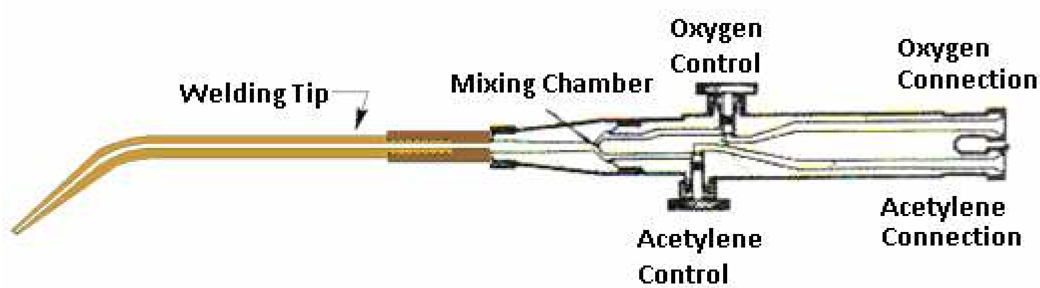


Figure 1.16. High pressure (equal Pressure) type of welding torch

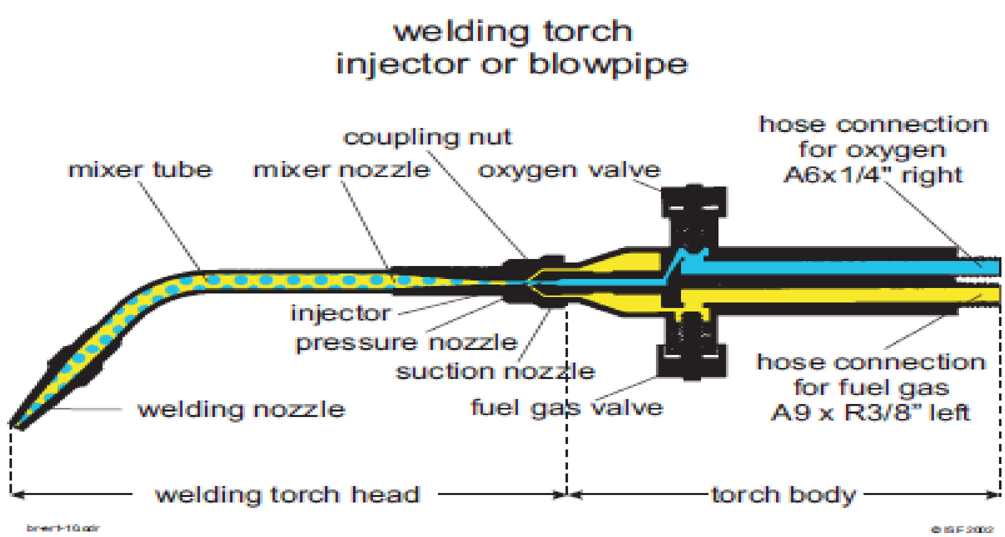


Figure 1.17. Injector Type of welding torch

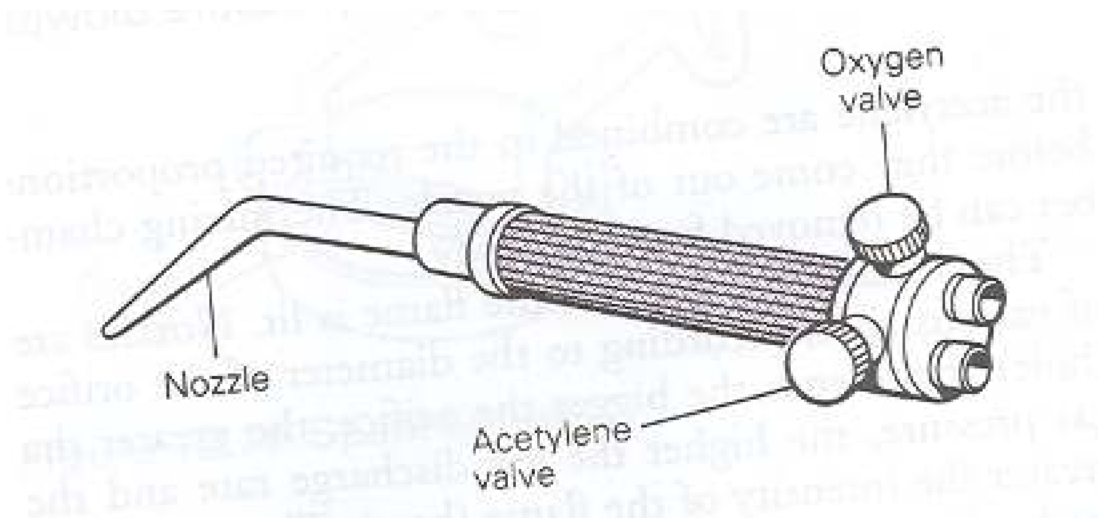


Figure 1.18. Welding blowpipe

1.3.9. 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

Figure 1.19. Welding and cutting Nozzles or Tips

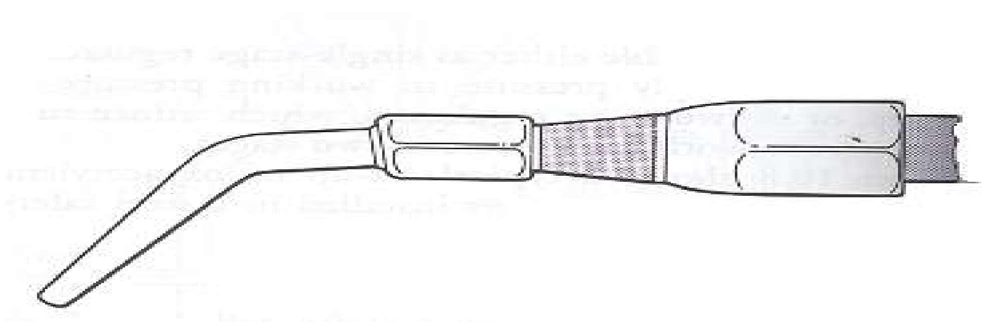


Figure 1.20. Detachable nozzle

Table 1.3. Material thickness with nozzle tip size

Material Thickness inches (millimeters)	Cutting Tip Number	Oxygen Cutting Pressure (psig)	MAPP Gas Pressure (psig)
1/8 (3)	75	40-50	2-10
3/16 (4.8)	72		
1/4 (6.4)	68		
1/2 (12.7)	61		
3/4 (19)	56		
1 (25.4)			
1 1/4 (31.8)	54	50-60	
1 1/2 (38)			
2 (50.8)	52		
2 1/2 (63.5)	48		6-10
3 (76)			
4 (101)	46	60-70	

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

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

Care of Welding tips

- All welding tips are made of copper and may be damaged by careless handling.
- Nozzles should never be dropped or used for moving or holding the work.
- Nozzle seat and threads should be absolutely free from foreign matter in order to prevent any scoring when tightening on assembly.
- Nozzle orifice should only be cleaned with tip cleaners specially designed for this purpose.

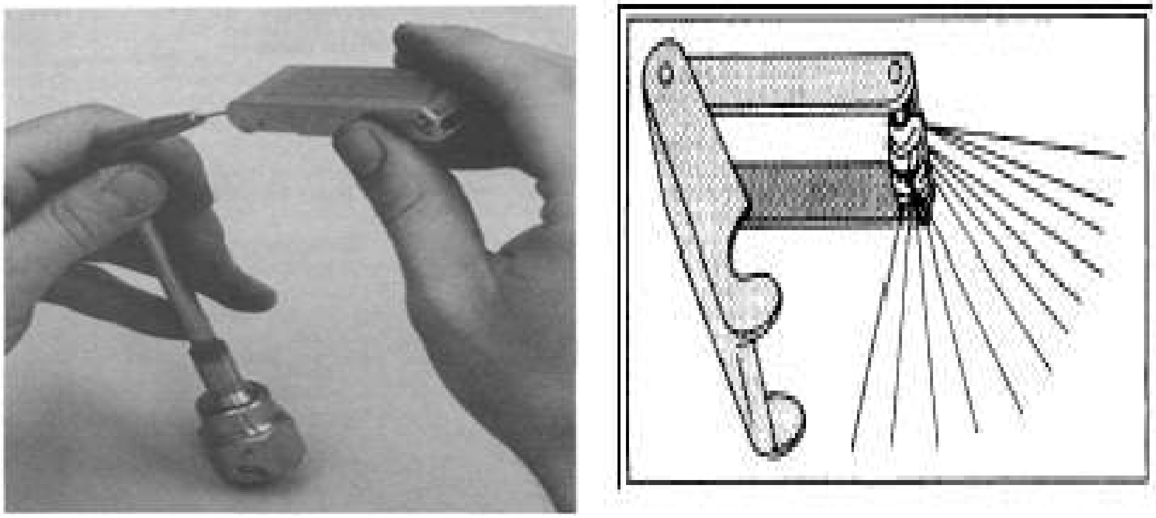


Figure 1.21. Welding Tip cleaner

1.3.10. Gas Lighter

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

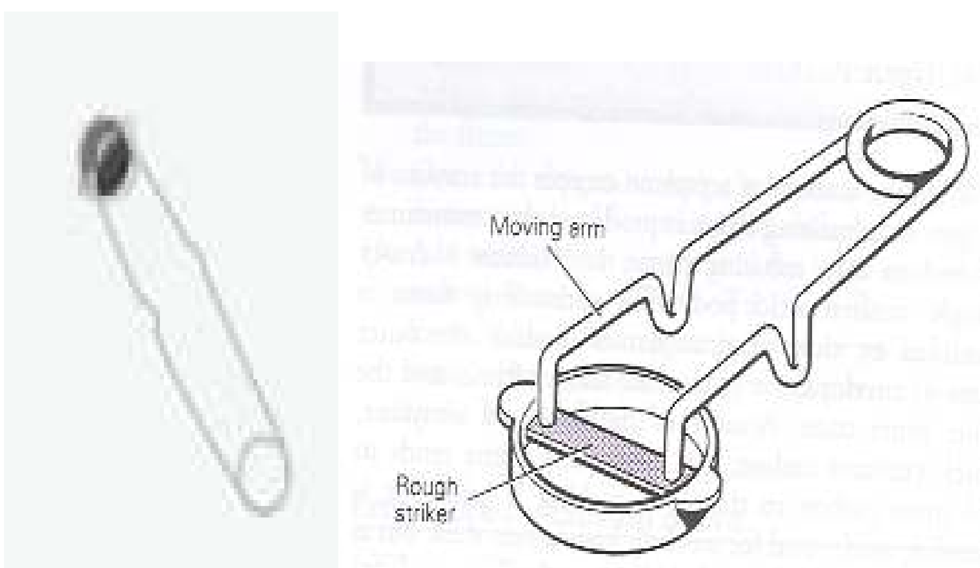


Figure 1.22. Spark lighter

1.3.11. Cutting torch

The torch is usually made of forged brass and brasses tubing, for hand-manipulated flame-cutting operations, the tips are made of copper. If the tip of the torch is used as a hammer, lever, or crowbar, permanent damage is done. A cutting torch head is used to cut materials. It is similar to a welding torch, but can be identified by the oxygen blow out trigger or lever.

The metal is first heated by the flame until it is cherry red. Once this temperature is attained, oxygen is supplied to the heated parts by pressing the "oxygen-blast trigger". This oxygen reacts with the metal, forming iron oxide and producing heat. It is this heat that continues the Cutting process. The cutting torch only heats the metal to start the process; further heat is provided by the burning metal.

The melting point of the iron oxide is around half that of the metal; as the metal burns, it immediately turns to liquid iron oxide and flows away from the cutting zone. However, some of the iron oxide remains on the work piece, forming a hard "slag" which can be removed by gentle tapping and/or grinding.

Figure 1.23. Cutting torch

1.3.12. Flash back arrestors

Not all oxyacetylene setups will have flashback arrestors or one-way check valves on them, but they are highly recommended and in some places, safety laws require them. This is to stop the travel of a spark up a hose and into a cylinder; which may result in an explosion.

Figure 1.24. Flashback Arrestors

1.3.13. Cutting outfit equipment and its accessories

You have to select the following correct cutting outfit equipment including its accessories to start cutting procedures for using oxy acetylene cutting process.

Figure 1.25. Oxyacetylene Cutting Set

1.4. Materials Preparation for cut

The equipment and accessories for oxy-gas cutting are the same as for oxy-gas welding except that you use a cutting torch or a cutting attachment instead of a welding torch. The main difference between the cutting torch and the welding torch is that the cutting torch has an additional tube for high-pressure oxygen, along with a cutting tip or nozzle. The tip is provided with a center hole through which a jet of pure oxygen passes. Mixed oxygen and acetylene pass through holes surrounding the center holes for the preheating flames. The number of orifices for oxyacetylene flames ranges from 2 to 6, depending on the purpose for which the tip is used. The cutting torch is controlled by a trigger or lever operated valve. The cutting torch is furnished with interchangeable tips for cutting steel from less than ¼” to more than 12.0” in thickness. If equipment from other manufacturers is used, refer to the chart, “Comparison Guide of Cutting Tips uses and chooses a tip with a cutting or orifice size comparable to that indicated below:

Table 1.4. Comparison Guide of Cutting Tips uses and size

THICKNESS OF STEEL	1/4"	3/8"	1/2"	3/4"	1"	1/4"	1 1/2"	2"	2 1/2"	3"	4"	5"	6"
AIRCO TIP SIZE	0	1	1	2	2	2	3	3	4	5	5	6	6
GAGE PRESSURE OXYGEN P.S.I.	30	30	40	40	50	60	45	50	50	45	60	50	55
GAGE PRESSURE ACETYLENE P.S.I.	3	3	3	3	3	3	3	3	3	4	4	5	5
SPEED IN INCHES PER MIN.	20	19	17	15	14	13	12	10	9	8	7	6	5
OXYGEN CON-SUMPTION CU. FT. PER HOUR	50	75	90	120	140	160	185	200	250	310	385	460	495
ACETYLENE CON-SUMPTION CU. FT. PER HOUR	9	12	12	14	14	14	16	16	17	22	22	28	28
APPROXIMATE WIDTH OF KERF IN INCHES	.075	.095	.095	.110	.110	.110	.130	.130	.145	.165	.165	.190	.190
CUTTING ORIFICE CLEANING DRILL SIZE	64	57	57	55	55	55	53	53	50	47	47	42	42
PREHEAT ORIFICE CLEANING DRILL	71	69	69	68	68	68	66	66	65	63	63	61	61

Self-check: One

Part one: Choose the correct answer.

1. ___________ is used reduce the high cylinder pressure down to a suitable working pressure (5point).

A. torch (blow pipe) B. Regulator C. cylinder D. tip (nozzles)

2. Mixing _____________and water will produce acetylene gas

A.Potassium carbonates B. Calcium carbide C. Carbon dioxide D. Acetylene carbide

3. ________________ Protects from: radiation flying particles, debris and hot slag, spark

A Welding helmet or goggles B. leather apron C. Ear muff D. none

4. Which one of the following tool is used for mixing and delivers the mixed gas to the tip where they are burned?

A. Regulator B. Nozzles C. Torch or blow pipe D. Hose

5. One of the following safeties is not considered as machine or equipment safety precaution in the gas cutting process.

A. Wearing goggles with colored lenses B. Fasten cylinders with a section of chains

C. Inspecting fittings and connections of hoses D. keeping sparks and flames a way from cylinders

Part two: Matching

A	B
1. Used to light the torch	A. Oxygen hose
2. for tightening or loosening and adjusting hose regulators torch together	B. Acetylene hose
3. for cleaning the tip	C. Spark lighter
4. Pressure vessels	D. Tip cleaner
5. for checking gas leaks	E. Soap water
6. Painted green color	F. Acetylene Cylinder
7. Acetylene gas	
8. Painted red color	

Part three: Give short answer

1. List out personal protective equipment
2. Classify and explain oxy acetylene gauges?

Operation sheet: One

Operation title: Protection eyes in oxy acetylene operation

Purpose: the main purpose of the operation is how to utilize the eye protection tools in operation.

Instruction: put the correct way of protecting eyes in oxy acetylene operation.

Tools and requirement: goggle, hand shield, and filter shade lens

Steps in doing the task:

1. Choose a tight fitting helmet
2. Wear the helmet correctly
3. Protect the shade lens from impact and sudden temperature
4. Use a cover lens to protect the filter shade lens
5. Make sure to replace the gasket periodically if your helmet uses one
6. Clean lenses periodically
7. Discard pitted, cracked or damaged lenses

Precaution: Check the proper utilization of eye protection tools before doing the work.

Quality criteria: The welder must have properly wear and use the safety tools in the operation.

LAP Test: One

Task 1. Apply the correct utilization of safety tools

Task 2. Perform to change filter shade lens

Unit Two: Set Up of Oxyacetylene Welding and Cutting Outfit

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

- Oxy-acetylene welding and cutting symbols and specifications
- Assembly of cutting equipment
- Assembly of welding equipment
- Materials Preparation for weld

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

- Identify Oxy-acetylene welding and cutting symbols
- Perform to Assembly of cutting equipment
- Perform to Assembly of welding equipment
- Perform proper materials preparation.

2.1. Oxyacetylene Welding and Cutting Symbols and Specifications

2.1.1. Welding Symbols on Drawings

Engineering drawings are descriptions of manufactured objects in terms of shape surface, finish and material. In many industries it is customary to draw the shape of the component without indicating how that shape is achieved. The drawing is a description of a requirement produced by the designer for the instruction of the manufacturer. In theory, the manufacturer knows best how to produce an object with the resources he has in practice, of course. The designer compromises and produces designs which are capable of production by the techniques, of which he is aware. For example, a round hole can be drilled, bored or punched and can be finished by reaming, but whichever method is used, the lines on the drawing are the same and whichever method is used, the material is not changed in its characteristics. A welded joint offers a range of considerations which do not arise in other forms of manufacture. Firstly, there are far more techniques for making a welded joint than in many other manufacturing operations. This means that the designer has far less chance of foreseeing the manufacturer's methods. Secondly, the properties and integrity of the joint will depend on the manner in which the weld is made despite this; the designer can still indicate the type of

Joint he requires. Provided that he is prepared to accept that he may not be able to completely define the joint in the earlier stages of a design. In some industries it is customary for the manufacturer to produce shop

Drawings which contain details of weld preparations and reference to established welding procedures not shown in detail on the designer's drawings. The range of British Standard symbols which can be used on a drawing to indicate a weld detail are described here.

2.1.2. Symbolic representation of welds on drawings

A welding symbol on a drawing consists of:

- An arrow line

- One or two reference lines
- An elementary symbol
- Possible supplementary symbols and Dimensions of the weld

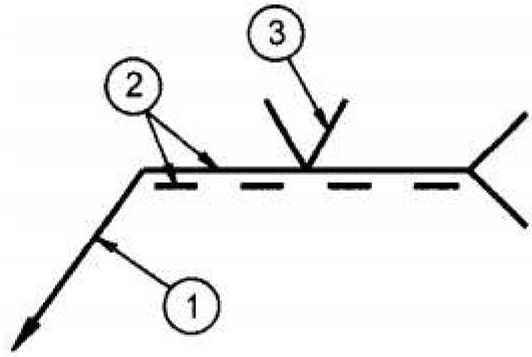


Figure 2.1. Symbols used on welding drawings.

Symbolic presentation of welds on drawings are given in IS0 2553

Table 2.1. Symbolic presentation of welds

No	Designation	Weld	Symbol
1	Weld in plates with raised edges		
2	Square butt weld		||
3	Single V-butt weld		V
	Singel-bevel butt weld		V
5	Single-V butt weld with broad root face		Y
6	Single-bevel butt weld with broad root face		
7	Single-U butt weld (parallell or sloping sides)		
8	Single-J butt weld		
9	Backing run		
10	Fillet weld		
11	Plug weld		
12	Spot weld		O
13	Seam weld		

2.1.3. Basic Welding Symbol

The basic welding symbol consists of a reference line, a leader line and arrow, and, if needed, a tail. The tail is added for specific information or notes in regard to welding specifications, processes or reference information. The reference line of the basic welding symbol is usually drawn horizontally. Any welding symbol placed on the upper side of the reference line indicates Weld Opposite Side.

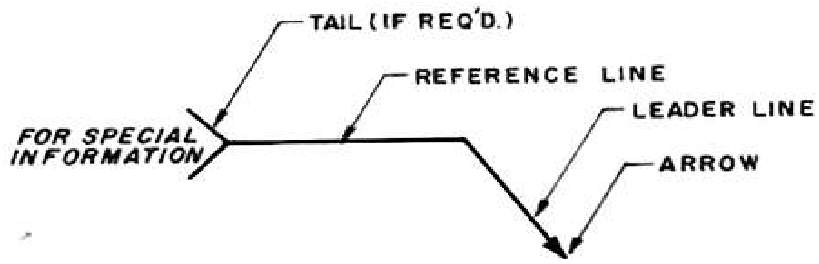


Figure 2.2. Welding Symbol

Any welding symbol placed on the lower side of the reference line indicates weld arrow side. The direction of the leader line and arrow had no significance what so ever to the reference line. A fillet weld symbol (see Figure 2.3) is added above or below the reference line with the left leg always. According to the figure 2.3 below, a welding symbol placed above the reference line means to weld the opposite side.

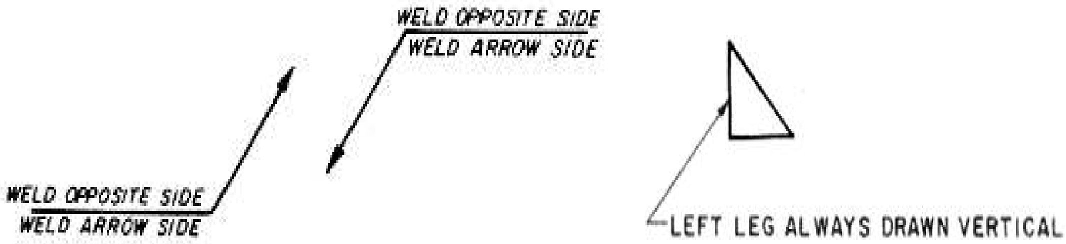
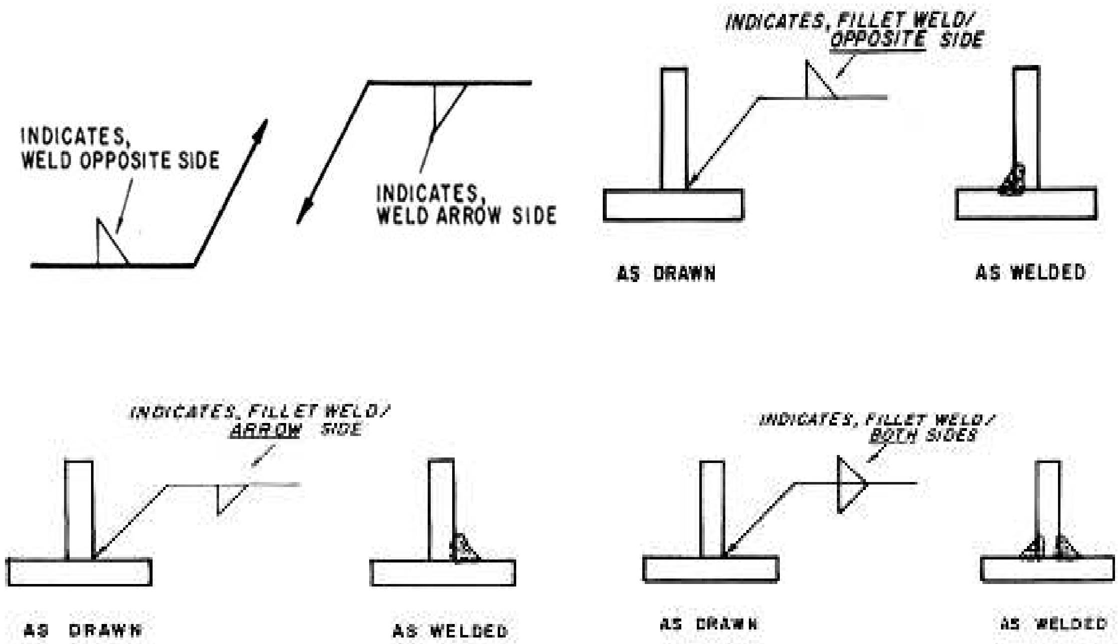


Figure 2.3. Fillet weld symbol

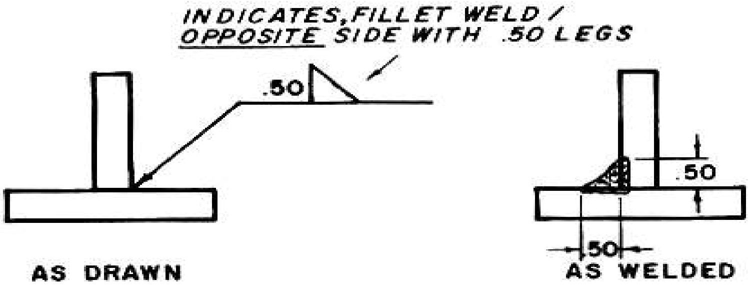
As indicated in the above figure 2.3, seen that a weld symbol placed below the reference line means to weld **Arrow** side.

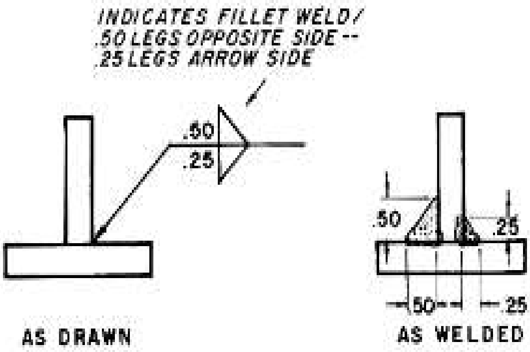


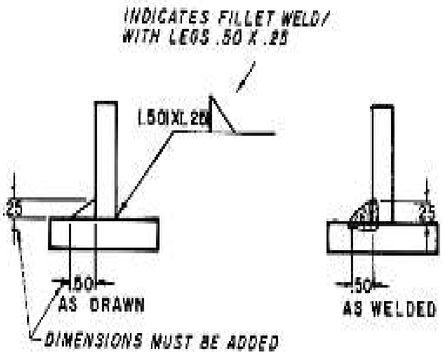
Figures 2.4. The positions as drawn and as welded

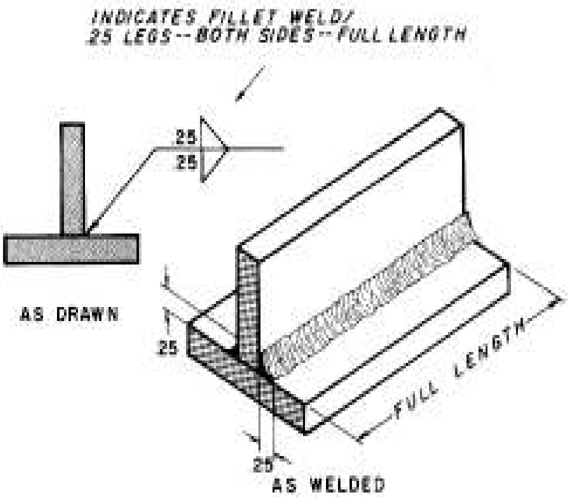
2.1.4. Size of weld

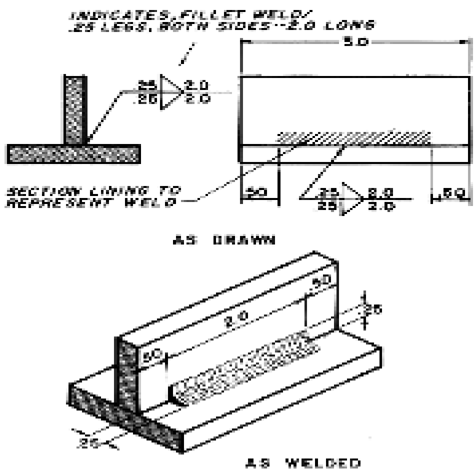
The weld must be fully dimensioned so that there is no question whatsoever as to its intended and designed size. The size of a weld refers to the length of the leg or side of the weld. The size is placed directly to the left of the welding symbol.

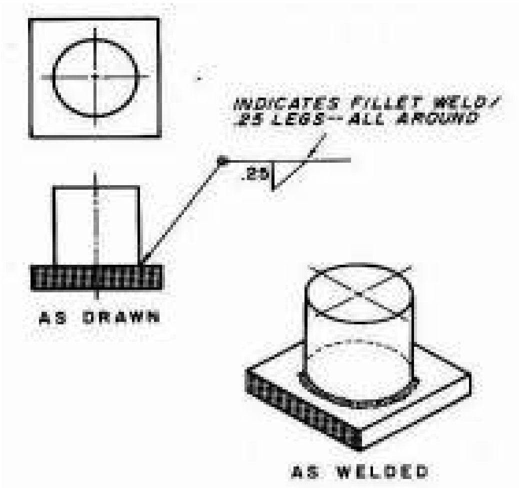


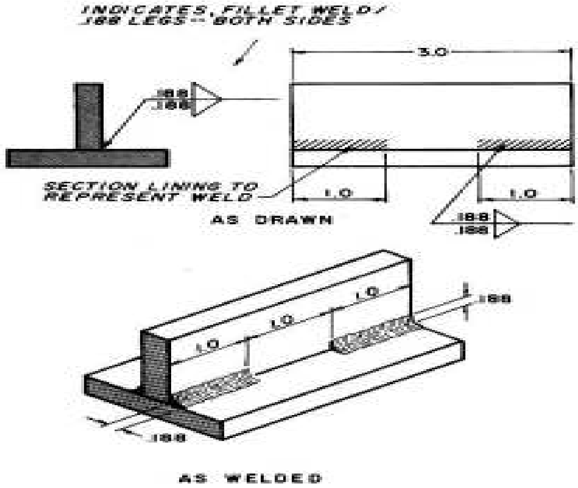









INDICATES FILLET WELD/
.25 LEGS--ALL AROUND
.25
AS DRAWN
AS WELDED


INDICATES FILLET WELD/
.188 LEGS--BOTH SIDES
3.0
.188
.188
SECTION LINING TO
REPRESENT WELD
1.0
1.0
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.188
AS DRAWN
1.0
1.0
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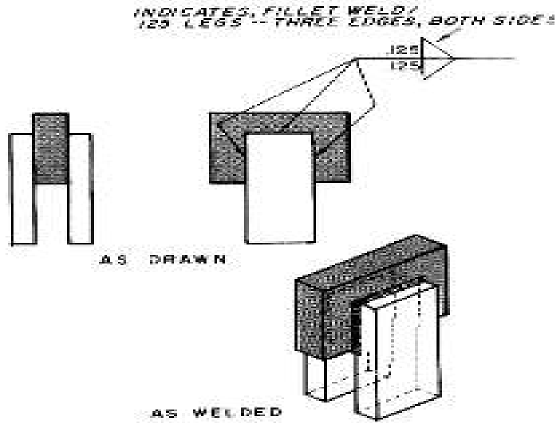
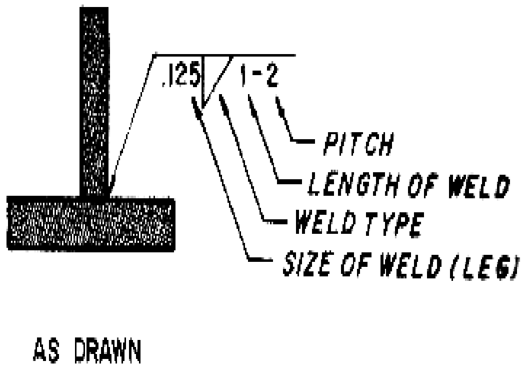
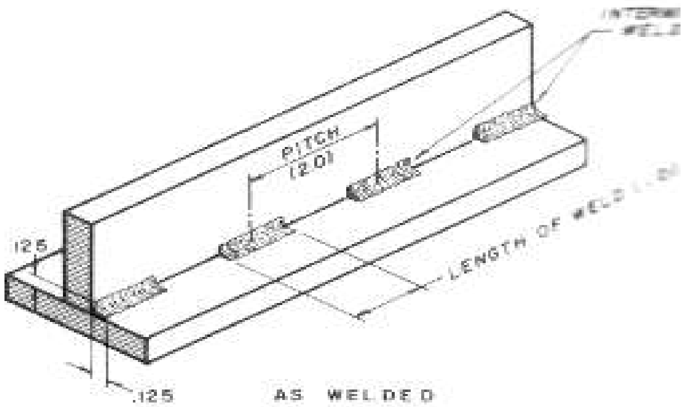
.188
.188
AS WELDED


INDICATES FILLET WELD/
.125 LEGS--THREE EDGES, BOTH SIDES
.125
.125
AS DRAWN
AS WELDED


.125
1-2
PITCH
LENGTH OF WELD
WELD TYPE
SIZE OF WELD (LEG)
AS DRAWN


PITCH
(2.0)
.125
LENGTH OF WELD
.125
AS WELDED

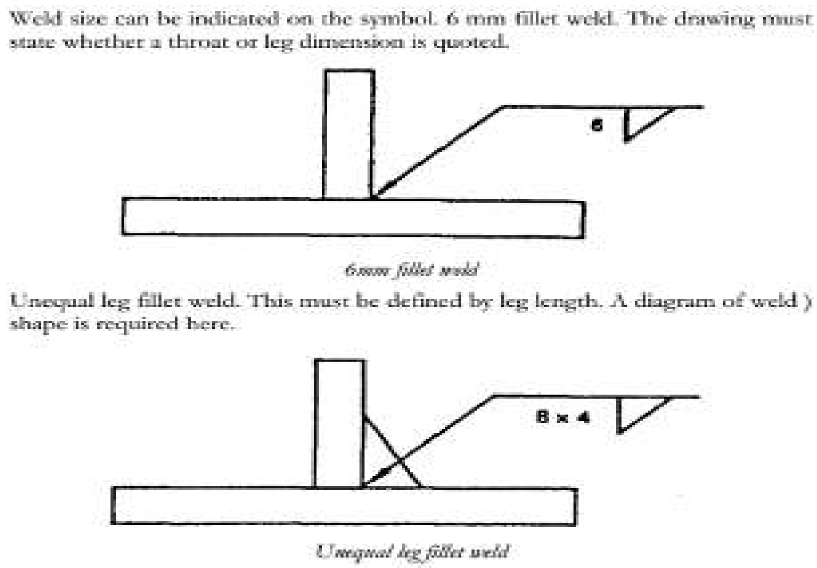


Figure 2.5. Different Size of Weld

2.1.5. Welding Standards Drawing Notation

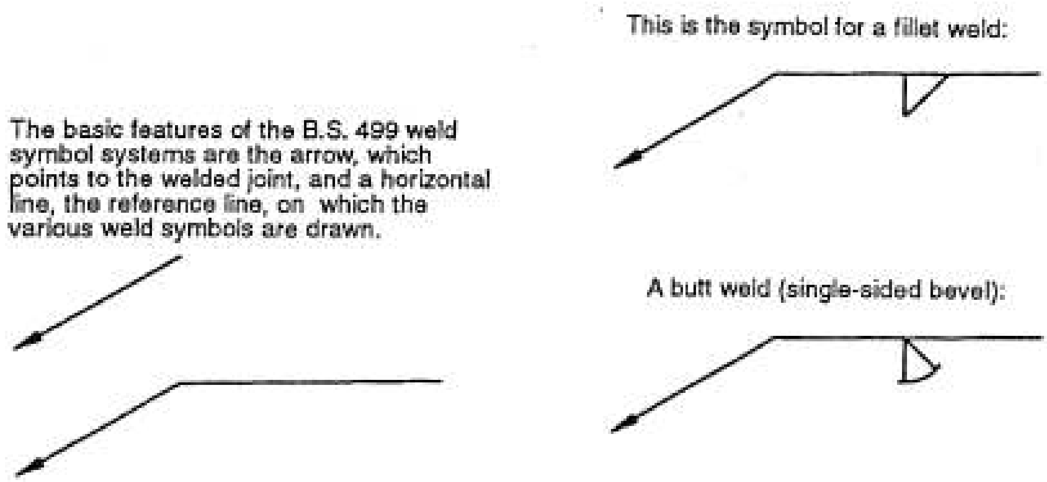


Figure 2.16. Weld features

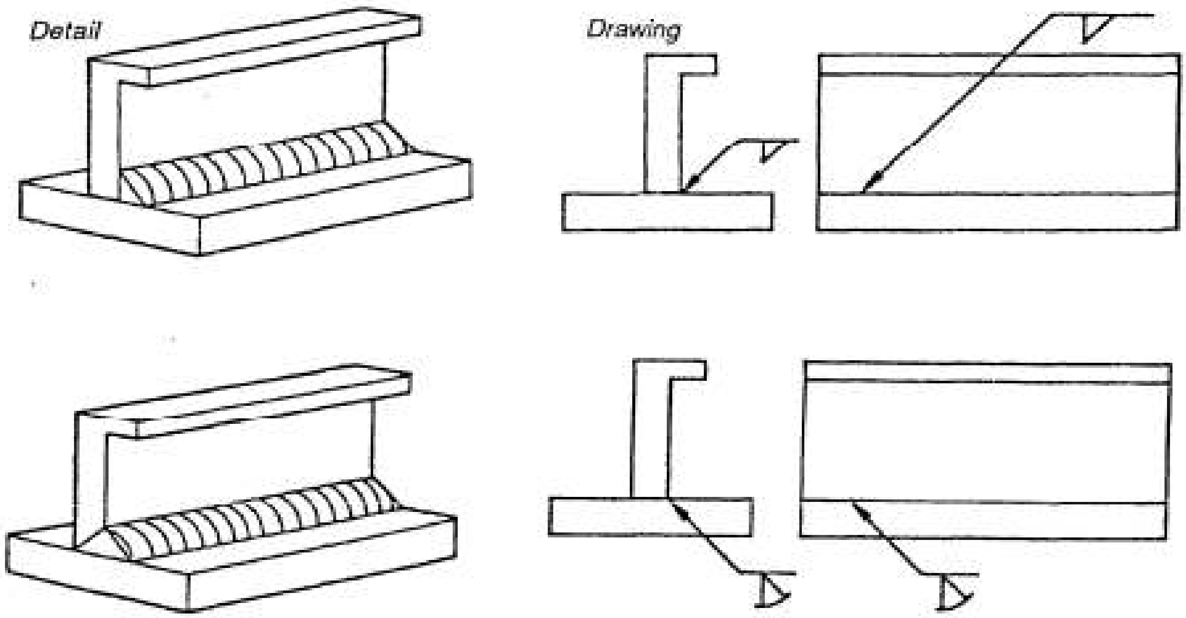
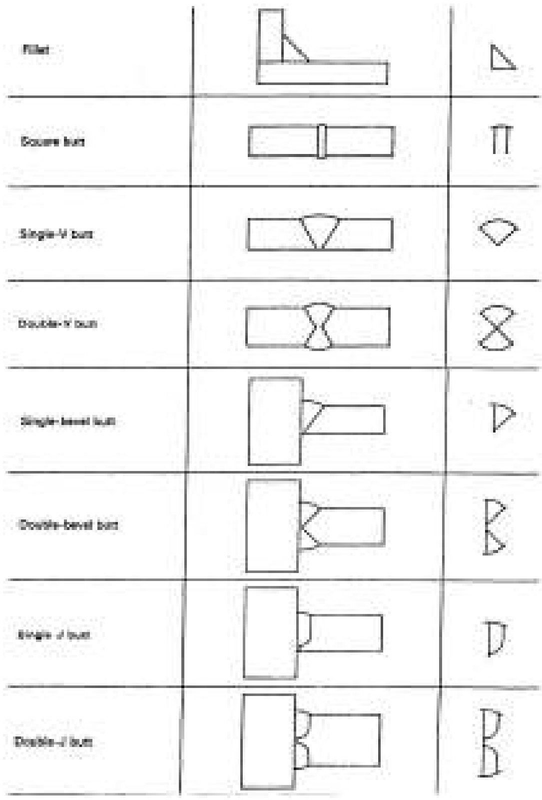


Figure 2.7. The arrow points towards the prepared edge

2.1.6. Explanation for Standard Weld Symbols



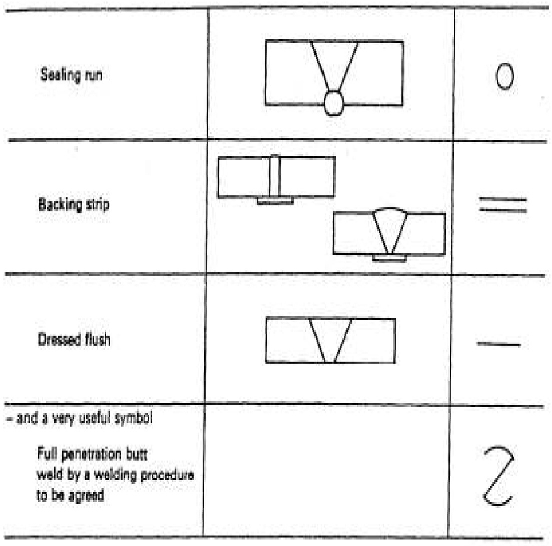


Figure 2.8. Standard Weld Symbols

2.2. Assembly of Cutting Equipment

2.2.1. Procedures of assembly for cutting equipment

- Secure the oxygen and acetylene tanks in the torch cart. This step is an important one for the safety of you and others in the vicinity so don't skip it. If you don't have a cart yet, secure the tanks to an upright beam or some other vertical solid object.
- Remove the covers protecting the tank valves and attach the regulators to the valves. Screw the fittings into the valves as far as you can by hand and then tighten securely with a wrench.
- Attach the hoses to the regulators. Connect the green hose to the oxygen regulator and the red hose to the acetylene regulator.
- Connect the other end of the hoses to the torch handle.
- Push the cutting torch in to the torch handle and hand-tighten the nut.
- Close the valves on the torch handle and the cutting torch.
- Turn the valve on the oxygen tank completely open. The valve has a seal on the shaft that works when the valve is fully open and helps prevent oxygen loss when the torch is in operation.

- Turn the adjusting screw on the oxygen regulator clockwise until the small gauge on the regulator registers somewhere in the 40 to 60 psi range.
- Turn the valve on the acetylene tank counterclockwise a quarter turn to open.
- Adjust the acetylene regulator until the small gauge on the regulator registers 10 psi.
- Open the oxygen valve on the torch handle completely by turning counterclockwise until it stops.
- Slightly open the oxygen valve on the cutting torch. Open just enough to start the flow of oxygen through the torch.
- Open the acetylene valve on the torch handle about 1/8 turn.
- Light the torch with a spark lighter and adjust the acetylene valve on the torch handle and the oxygen valve on the cutting torch until the flame has no yellow areas and the center is bright blue and well defined.
- Check the regulator gauges and adjust as necessary to maintain the proper pressures.

2.3. Assembling welding equipment

2.3.1. Parts and adjusting of the basic oxy-acetylene outfit

- Oxygen Cylinder - A tall tank cylinder where oxygen gas is stored.
- Acetylene Cylinder – A tank of lesser height where acetylene gas is store
- Regulator (Oxygen) – Separate regulator for oxygen pressure gauge
- Regulator (Acetylene) – A separate regulator with acetylene gas pressure gauge that indicates the direction of the flow towards the torch body.
- Acetylene Hose (Red) – A type of hose wherein acetylene gas flows towards the direction of the torch body.
- Oxygen Hose (Green) – A type of hose wherein oxygen gas flows towards the direction of the torch body.
- Safety Chain - A metal chain wrapped around the body of the cylinders and tied securely in the metal frame stand.

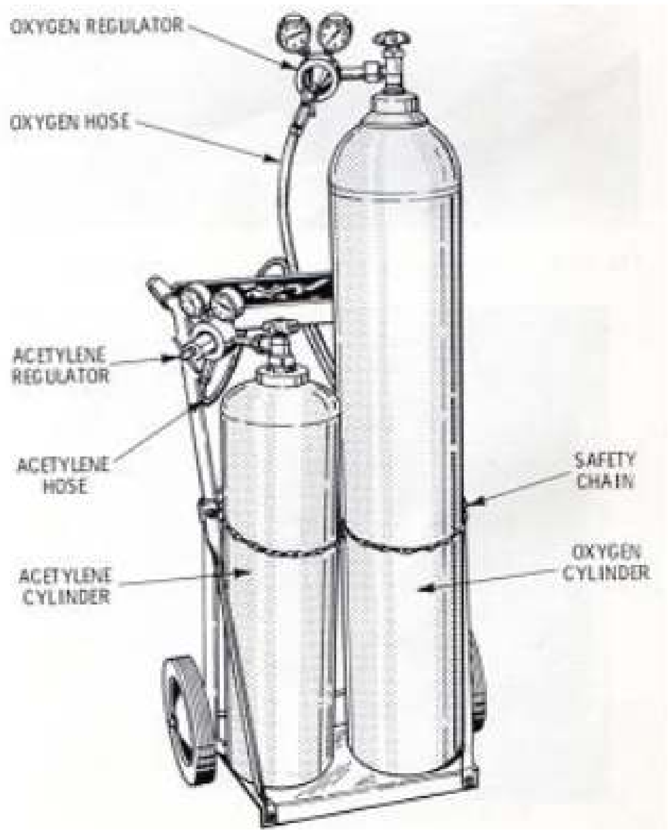


Figure 2.9. Assembly welding equipment

2.4. Materials Preparation for weld

2.4.1. Essential equipment

- Cylinder for compressed oxygen gas
- Cylinders for compressed acetylene gas
- Acetylene generators
- Regulators (for gases) and valves
- Hose with fittings
- Torches (blow pipe)
- Tips (nozzles)
- Tip cleaner

2.4.2. Preparing materials

- Low carbon steel
- Plate, pipe
- Tube and round bar

2.4.3. Filler Metals

When welding two pieces of metal together, you often have to leave a space between the joint. The material that you add to fill this space during the welding process is known as the filler metal, or material. Two types of filler metals commonly used in welding are:

- Welding rods
- Welding electrodes.

Table 2.2. Adjustment of welding flame for various materials

Flame setting	Excess of acetylene	Normal	Excess of oxygen
Steel	-	+	-
Cast iron	+	o	-
Copper	-	+	-
Brass	-	-	+
Aluminium	+	o	-

+ Good o acceptable -bad

2.4.4. Types of joints

- Butt joint
- Corner joint
- Edge joint
- Lap joint
- T joint

The types of welds, joints, and welding positions used in oxyacetylene welding are very similar to those used in manual-shielded metal arc welding. The techniques are somewhat different because of the equipment involved is different.

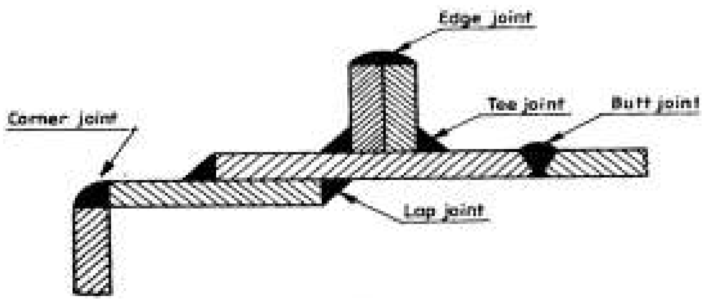


Figure 2.10. Type of joints

There are four positions used in oxyacetylene welding process

1. Flat -The flat position produces welds that are stronger than in any other position.
2. Overhead
3. Vertical
4. Horizontal.

Flat position (Butt, Tee, Lap, Corner), Light and heavy steel plates.

Butt Joint: In Forehand welding (figure 2.10) the rod is kept ahead of the flame in the direction in which the weld is being made. You point the flame in the direction of travel and hold the tip at an angle of about 45 degrees to the working surfaces.

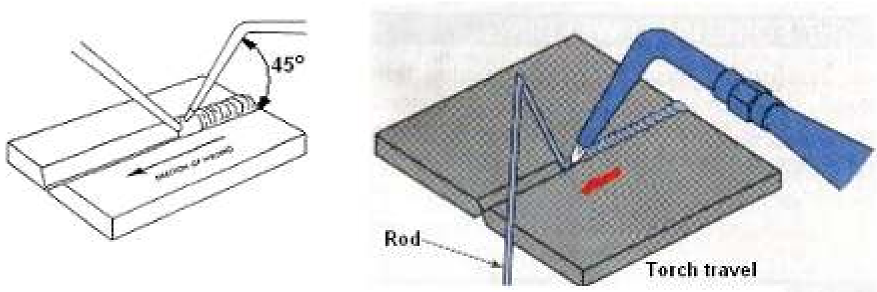


Figure 2.10. Butt joint

Tee joint: 45 degrees or less respect to the horizontal plate.

Corner joint: $45^0 - 60^0$ angle with the weld.

Lap joint: In lap joint the edge of a plate melts more readily than the centre of the plate, therefore, in this weld there is a tendency for the top plate to melt back too far. This is overcome by placing the rod in the puddle weld tilting it toward the top place. The rod absorbs then some of the heat and eliminates excessive melting of the top plate.

2.4.5. Welding Techniques

1. **Leftward or forward welding Techniques**

This method is used nowadays for welding steel plate under 6.5 mm thick and for welding non-ferrous metals. The welding rod precedes the blowpipe along the seam, and the weld travels from right to left when the pipe is held in the right hand. The inner cone of the flame, which is adjusted to the neutral condition, is held near the metal, the blowpipe making an angle of 60 to 70° with the plate, while the filler rod is held at an angle of 30 to 40°. This gives an angle of approximately 90° between the rod and the blowpipe. The flame is given a rotational, circular, or side-to-side motion, to obtain even fusion on each side of the weld. The flame is first played on the joint until a molten pool is obtained and the weld then proceeds, the rod being fed into the molten pool and not melted off by the flame itself. If the flame is used to melt the rod itself into the pool, it becomes easy to melt off too much and thus reduce the temperature of the molten pool in the parent metal to such an extent that good fusion cannot be obtained. Figure 2.11, will make this clear.

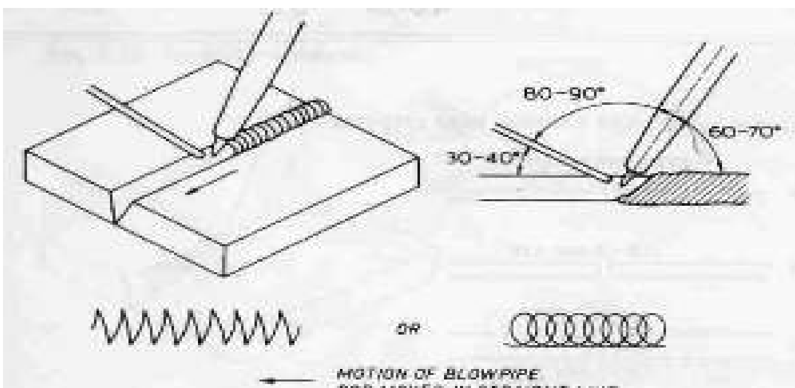
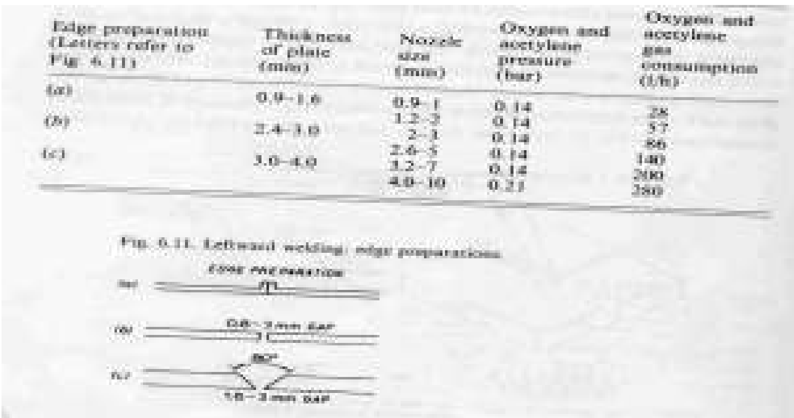


Figure 2.11. Leftward or forward techniques

The first exercise in welding with the filler rod is done with the technique just described and consists of running lines of weld on 1.6 or 2 mm plate, using the filler rod. Butt welds of thin plate up to 2.4 mm can be made by flanging the edges and melting the edges down. When a uniform weld is obtained, with good penetration, the exercises can be repeated on plate up to 3.2 mm thick, and butt welds on this thickness attempted. Above 3.2 mm thick, the plates are bevelled, chamfered, or V'd to an angle of 80 to 90° (Figure 2.12). The large area of this V means that a large quantity of weld metal is required to fill it. If, however, the V is reduced to less than 80°, it is found that as the V becomes narrower the blowpipe flame tends to push the molten metal from the pool, forward along onto the unmelted sides of the V, resulting in poor fusion or adhesion. This gives an unsound weld, and the narrower the V the greater this effect.

As the plate to be welded increases in thickness, a larger nozzle is required on the blowpipe, and the control of the molten pool becomes more difficult; the volume of metal required to fill the V becomes increasingly greater, and the size of nozzle which can be used does not increase in proportion to the thickness of the plate, and thus welding speed decreases. Also with thicker plates the side-to-side motion of the blowpipe over a wide V makes it difficult to obtain even fusion on the sides and penetration to the bottom, while the large volume of molten metal present causes considerable expansion. As a result it is necessary to weld thicker plate with two or more layers if this method is used. From these considerations it can be seen that above 6.4 mm the leftward method suffers from several drawbacks. It is essential, however, that the beginner should become efficient in this method before proceeding to the other methods, since for general work, including the non-ferrous metals, it is the most used.



Edge preparation (Letters refer to Fig. 6.11)	Thickness of plate (mm)	Nozzle size (mm)	Oxygen and acetylene pressure (bar)	Oxygen and acetylene gas consumption (l/h)
(a)	0.9–1.6	0.9–1	0.14	28
(b)	2.4–3.0	1.2–2	0.14	57
		2–3	0.14	86
(c)	3.0–4.0	2.6–5	0.14	140
		3.2–7	0.14	200
		4.0–10	0.21	280

Fig. 6.11. Leftward welding: edge preparations

Figure 2.12. Leftward or forward techniques preparations

2. **Rightward Welding techniques**

This method was introduced some years ago to compete with electric arc welding in the welding of plate over 4.8 mm thick, since the leftward method has the disadvantage just mentioned on welding thick plate. This method has definite advantages over the leftward method on thick plate, but the student should be quite aware of its limitations and use it only where it has a definite advantage.

In this method the weld progresses along the seam from left to right, the rod following the blowpipe. The rod is given a rotational or circular motion, while the blowpipe moves in practically a straight line, as illustrated in Figure 2.13. The angle between blowpipe and rod is greater than that used in the leftward method.

When using this method good fusion can be obtained without a V up to 8 mm plate. Above 8 mm the plates are prepared with a 60° V, and since the blowpipe has no side motion the heat is all concentrated in the narrow V, giving good fusion, The blowpipe is pointing backwards towards the part that has been welded and thus there is no likelihood of the molten metal being pushed over any of the unheated surface, giving poor fusion.

A larger blowpipe nozzle is required for a given size plate than in leftward welding, because the molten pool is controlled by the pipe and rod but the pipe has no side to side motion. This larger flame gives greater welding speed, and less filler rod is used in the narrower v. The metal is under good control and plates up to 16 mm thick can be welded in one pass. Because the blowpipe does not move except in a straight line, the molten metal is agitated very little and excess oxidation is prevented. The flame playing on the metal just deposited helps to anneal it, while the smaller volume of molten metal in the V reduces the amount of expansion.

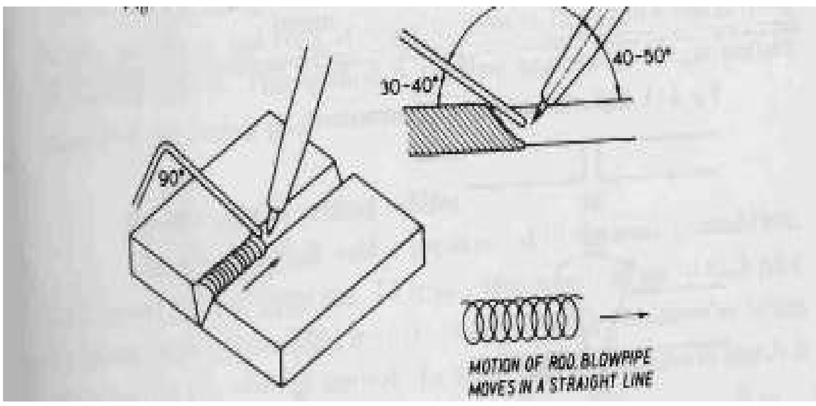


Figure 2.13. Rightward techniques

In addition, a better view is obtained of the molten pool, resulting in better penetration. It is essential however, in order to ensure good welds by this method, that blowpipe and rod should be held at the correct angle, the correct size nozzle and filler rod used, and the edges prepared properly (Figure 2.14). The rod diameter is about half the thickness of the plate being welded up to 8 mm plate, and half the thickness + 0.8 mm when welding V'd plate. The blowpipe nozzle is increased in size from one using about 300 litres per hour, with the leftward method, to one using about 350 litres per hour, when welding 3.2 mm plate. If too large diameter filler rods are used, they melt too slowly causing poor penetration and poor fusion. Small rods melt too quickly and reinforcement of the weld is difficult. Rightward welding has no advantage on plates below 6.4mm thick and is rarely used below this thickness, the leftward method being preferred. The advantages of the rightward method on thicker plate are:

(1) Less cost per metre run due to less filler rod being used and increased speed.

(2) Less expansion and contraction.

(3) Annealing action of the flame on the weld metal.

(4) Better view of the molten pool, giving better control of the weld.

Edge preparation (Letters refer to Fig. 6.13)	Thickness of plate (mm)	Nozzle size (mm)	Oxygen and acetylene pressure (bar)	Oxygen and acetylene gas consumption (l/h)
(a)	4.8–8.2	5.5–13	0.28	370
		6.5–18	0.28	520
(b)	8.2–15	8.2–25	0.42	710
		10–35	0.63	1000
		13–45	0.35 (heavy duty mixer)	1300

Fig. 6.13. Rightward welding: edge preparations.

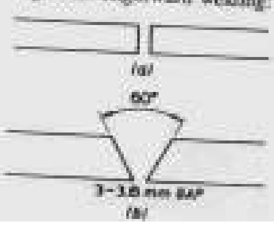


Figure 2.14. preparation of Rightward techniques

Self-check: Two

<u>Part one</u>: Choose the correct answer.

1. Which one following is not consists of welding symbol on a drawing:

A. Arrow line B. One or two reference lines C. Special information D. None

2. Is created by allowing calcium carbide (a manmade product) to react with water.

A. oxygen gas B. argon gas C. acetylene gas D. none

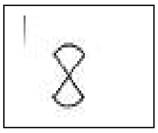
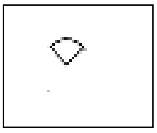
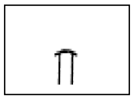
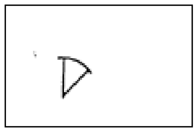
3. _______ are used to supply additional material to the pool to assist in filling the gap

A. chips B. electrode C. filler metal D. all

4. What are the color type of oxygen hose

A. Green B. Red C. Brown D. White

5. Which one of the following is the symbolical representation of double V-butt joint

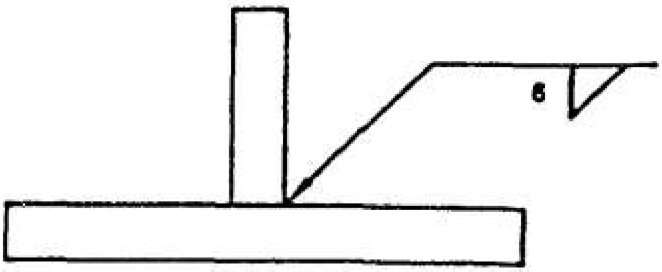
A.  B.  C  D. 

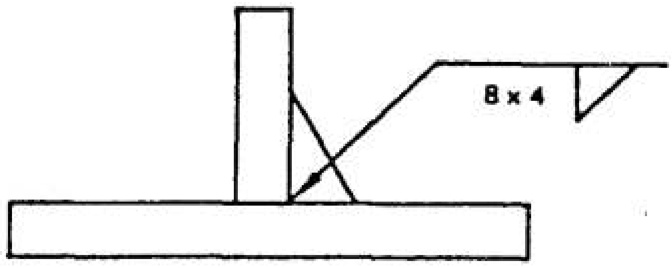
<u>Part two:</u> Matching

<u>A</u>	<u>B</u>
1. Separate regulator for oxygen pressure gauge	A.Safety Chain
2. Welding rods	B.Acetylene hose
3. tied securely in the metal frame stand.	C.Filler Metals
4. Welding rods	D. Drawn horizontally
5. Gas flows towards the direction of the torch body.	E.Oxygen Regulator
6. Reference line	F.Arrow
	G.Ladder line

<u>Part three</u>: Give short answer

1. Describe the following welding symbol ?





2. Two types of filler metals commonly used in welding are?
3. Describe about four types of welding joints?
4. Describe about four types of welding positions?

Operation sheet: Two

Operation title: Assembling welding equipment

Purpose: to perform properly to assembly the oxy acetylene welding equipment.

Instruction: follow the correct procedures to assemble the equipment.

Tools and requirement: gas cylinder, regulators, hoses, wrench, valve, torch, and nozzle.

Steps in doing the task:

Step 1: Connect the fuel-gas regulator to the fuel-gas cylinder and the oxygen regulator

Step 2: Back off the regulator screws to prevent damage to the regulators

Step 3: Open the fuel-gas valve only one-half turn and the oxygen valve all the way

Step 4: Leave the wrench in place while the cylinder is in use so the fuel-gas bottle

Step 5: Connect the RED hose to the acetylene regulator and the GREEN hose to the oxygen regulator

Step 6: To blow out the oxygen hose, turn the regulator screw in (clockwise) and adjust the pressure between 2 and 5 psig

Step 7: Select the correct cutting tip and install it in the cutting torch head

Step 8: Adjust the working pressures

Step 9: Adjust the regulator to the working pressure needed for the particular tip size

Precaution: apply the correct safety to assembly the equipment.

Quality criteria: install the oxy acetylene welding equipment to properly abled for the operation.

Lap Test: Two

Task 1. Set up oxy-acetylene welding equipment.

Unit three: Materials for Weld and Cut with Oxy acetylene

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

- Properties and applications of Fuel gas
- Cutting and welding procedures
- Types of materials for Cut and weld
- Inspection of the components

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

- Identify Properties and applications of Fuel gas
- Apply Cutting and welding procedures
- Identify types of materials for Cut and weld
- Perform Inspection on the components.

3.1. Properties and Applications of Fuel Gas

3.1.1. Consumable Fuel gas

Oxy-fuel welding (commonly called oxyacetylene welding, oxy welding, or gas welding.) and oxy-fuel cutting are processes that use fuel gases and oxygen to weld and cut metals, respectively. Pure oxygen, instead of air (20% oxygen/80% nitrogen), is used to increase the flame temperature to allow localized melting of the work piece material (e.g. steel) in a room environment. A common propane/air flame burns at about 3.630 °F (2.000 °C), a propane/oxygen flame burns at about 4.530 °F (2.500 °C), and an acetylene/oxygen flame burns at about 6.330 °F (3.500 °C). Oxy-fuel is one of the oldest welding processes, though in recent years it has become less popular in industrial applications. However, it is still widely used for welding pipes and tubes, as well as repair work. It is also frequently well-suited, and favored, for fabricating some types of metal-based art work.

3.1.2. Liquid-Air Process

The following is a simplified but adequate description of the liquid air process. Atmospheric air, as mentioned earlier, consists of about 20 percent pure oxygen, 78 percent nitrogen, and 2 percent other gases (by volume). Oxygen and nitrogen have different boiling temperatures. In the liquid-air process, the two gases are Oxygen and acetylene.

3.1.3. Oxyacetylene Welding Fuels

Oxyacetylene welding fuels is separated by heating atmospheric air to a certain temperature and holding it at this temperature until the nitrogen which has a boiling point of 295°F, boils off. After the nitrogen has been removed from atmospheric air, oxygen and a small amount of other gases remain. These include carbon dioxide, argon, hydrogen, neon, and helium. Oxygen has the highest boiling point of all these gases; thus to separate it completely, the remaining mixture is further heated until only pure oxygen remains. The pure oxygen is then stored as either a gas or liquid, depending on its eventual use. The liquid-air process is probably the most widely used method of producing pure oxygen.

A. Acetylene Gas

Is created by allowing calcium carbide (a manmade product) to react with water, the nice thing about the calcium carbide method of producing acetylene is that it can be done on almost any scale desired. Placed in tightly-sealed cans, calcium carbide keeps indefinitely. For years, miners' lamps produced acetylene by adding water, a drop at a time, to lumps of carbide.

Before acetylene in cylinders became available in almost every community of appreciable size produced their own gas from calcium carbide.

B. Oxygen Gas

Oxygen is present in small amounts in the air we breathe. About one fifth of our atmosphere is oxygen. Oxygen used in the welding process is about as pure as possible over 99 percent pure. The method used to produce pure oxygen for welding and medical purposes is called the liquid-air process.

3.1.4. Fluxes

Before performing any welding process, you must ensure the base metal is clean. Base metals contain impurities. These impurities, called oxides, result from oxygen combining with the metal and other contaminants in the base metal. Unless these oxides are removed by using a proper flux, a faulty weld may result. The term flux refers to a material used to dissolve oxides and release trapped (trapper) gases and slag (impurities) from the base metal. There are different types of fluxes used with different types of metals; therefore, you should choose a flux formulated for a specific base metal and fluxes are available in many different forms. These fluxes usually come in the form of a paste, powder, or liquid.

- Powders can be sprinkled on the base metal, or the fuller rod can be heated and dipped into the powder.
- Liquid and paste fluxes can be applied to the filler rod and to the base metal with a brush.
- For shielded metal arc welding, the flux is on the electrode. In this case, the flux combines with impurities in the base metal, floating them away in the form of a heavy slag which shields the weld from the atmosphere.

Figure 3.1. Flux powder

A. 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.

B. 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.

3.1.5. 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. 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.

- Filler rod is use as the same as the electrode during the welding in oxy-acetylene to fill the gap by milting using the different flames. in oxy-acetylene welding process a bar electrode which is filler rod is used as additional metal added to the joint to be welded
- Metals used as filler rod like braes mild steel and bronze In welding process the selection of filler rod is depend on the work to be welded the diameter of the filler rod the same as the thickness of the work

3.2. Cutting and welding procedures

3.2.1. Oxy-Acetylene welding

In Oxy-acetylene welding process, acetylene is mixed with oxygen in correct proportions in the welding torch and ignited. The flame resulting at the tip of the torch is sufficiently hot to melt and join the parent metal. The oxy-acetylene flame reaches a temperature of about 3300°C and thus can melt most of the ferrous and non-ferrous metals in common use. A filler metal rod or welding rod is generally added to the molten metal pool to build up the seam slightly for greater strength.

3.2.2. Types of Welding Flames

In oxy-acetylene welding, flame is the most important means to control the welding joint and the welding process. The correct type of flame is essential for the production of satisfactory welds.

The flame must be of the proper size, shape and condition in order to operate with maximum efficiency. There are three basic types of oxy-acetylene flames.

1. Neutral welding flame (Acetylene and oxygen in equal proportions)
2. Carburizing welding flame or reducing (excess of acetylene).
3. Oxidizing welding flame (excess of oxygen).

The gas welding flames are shown in figure 3.2, below:

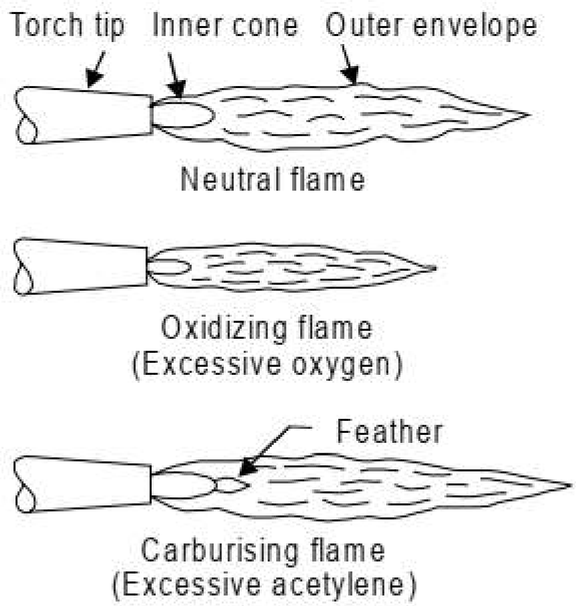


Figure 3.2. Gas welding flames

1. **Neutral Welding Flame**

A neutral flame results when approximately equal volumes of oxygen and acetylene are mixed in the welding torch and burnt at the torch tip. The temperature of the neutral flame is of the order of about 5900°F (3260°C). It has a clear, well defined inner cone, indicating that the combustion is complete. The inner cone is light blue in color. It is surrounded by an outer flame envelope, produced by the combination of oxygen in the air and superheated carbon monoxide and hydrogen gases from the inner cone. This envelope is Usually a much darker blue than the inner cone. A neutral flame is named so because it affects no chemical change on the molten metal and, therefore will not oxidize or carburize the metal. The neutral flame is commonly used for the welding of mild steel, stainless steel, cast Iron, copper, and aluminum.

2. **Carburizing or Reducing Welding Flame**

The carburizing or reducing flame has excess of acetylene and 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. With iron and steel, carburizing flame produces very hard, brittle substance known as iron carbide. A reducing flame may be distinguished from carburizing flame by the fact that a carburizing flame contains more acetylene than a reducing flame. A reducing flame has an approximate temperature of 3038°C. A carburizing-flame is used in the welding of lead and for carburizing (surface hardening) purpose. 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.

3. **Oxidizing Welding flame**

The oxidizing flame has an excess of oxygen over the acetylene. An oxidizing flame can be recognized by the small 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. Such a flame makes a loud roaring sound. It is the hottest flame (temperature as high as 6300°F) produced by any oxy-fuel gas source. But the excess oxygen especially at high temperatures tends to combine with many metals to form hard, brittle, low strength oxides.

Moreover, an excess of oxygen causes the weld bead and the surrounding area to have a scummy or dirty appearance. For these reasons, 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 (i) Copper-base metals (ii) Zinc-base metals and (iii) A few types of ferrous metals such as manganese steel and cast iron. The oxidizing atmosphere in these cases, create a base metal oxide that protects the base metal.

3.2.3. Welding procedure

According to in the Welding Procedure and Specification Purge fuel by opening torch knob and allow a 3-5 second flow. Then close the fuel gas valve. Purging must take place each time prior to igniting the torch flame.

- Assemble all of the materials needed to make the weld. This includes parts, OA equipment, fixturing, tools, safety mask, gloves, and filler rod.
- Clean the parts to be welded to remove any oil, rust, or other contaminants. Use a wire brush if needed to remove any rust.

- Assemble and fixture the parts in place - the parts need to be stable for a good weld line. Ceramic bricks, vise grips, pliers, and clamps are available in a file cabinet in the weld room for fixturing.
- Select the nozzle you plan to use for welding. Nozzles come in a variety of sizes, from 000 (for a very small flame - typically used for thin materials) to upwards of 3 (for a large flame - needed for thick materials). Larger nozzles produce larger flames and, in general, are more appropriate for thicker material. Choosing the right size nozzle becomes easier with more experience. Ask a TA or make some test welds to determine if you are using the right size nozzle.
- Clean the nozzle. Carbon deposits can build up on the nozzles which interfere with flame quality and cause backfiring. The cleaning tool has a wide flat blade (with a file-like surface) which is used to clean carbon deposits on the exterior of the nozzle. Use it to scrape any deposits from the flat face of the tip. Use the wire-like files to clean the interior of the nozzle. Pick the largest wire which will fit inside the nozzle, and the scrape the edges of the hole to remove any carbon buildup.
- Attach the nozzle to the gas feed line by hand. Don't over-torque - the nozzle and hose fitting are both made of brass which doesn't stand up well to abuse. A snug, finger tight fit is the sufficient.
- Check the pressure levels in the oxygen and acetylene tanks. There should be at least 50 psi in the acetylene tank. The oxygen tank can be used until it is completely empty. If needed, ask a TA to change bottles. Note: The oxygen used in OA welding in NOT for human consumption. It contains contaminants that could be unhealthy if taken in large quantities.

3.2.4. Procedures lighting the flame

- Open the main valve on the acetylene tank ~1/2 turn. This charges the pressure regulator at the top of the tank.
- Open the pressure regulator valve on the acetylene tank (turn clockwise to open) and adjust the pressure in the acetylene line to 5 psi. DO NOT pressurize the acetylene over 15 psi - it will explode.
- Open the acetylene pin valve on the handle of the welding tool, letting acetylene escape. Tweak the pressure regulator valve until the regulator pressure is constant at 5 psi. Close the acetylene pin valve.
- Open the main valve on the oxygen tank. Turn the valve until it is fully open (until it stops turning).
- Open the pressure regulator valve on the oxygen tank (turn clockwise to open) and adjust the pressure in the oxygen line to 10 psi.

- Open the oxygen pin valve on the handle of the welding tool, letting oxygen escape. Tweak the pressure regulator valve until the regulator pressure is constant at 10 psi. Close the oxygen pin valve.
- Slightly open the acetylene valve (~1/8), until you can just barely hear acetylene escaping.
- Make sure there is no person or anything flammable in the path of the nozzle. Use the striker to ignite the acetylene. The flame should be yellow and will give off a lot of soot.

3.2.5. Adjusting the flame

- Open the acetylene valve further and watch the flame near the nozzle tip. Add more acetylene until the flame is just about to separate from the tip. (The flame will separate from the tip of the nozzle if you add too much acetylene.) If so, reduce the flow until the flame reattaches to the tip, and then open the valve again to the near separation point.
- Slightly open the oxygen pin valve. If the flame goes out, turn off the gases and try again. Do Not try and ignite the flame with both oxygen and acetylene pin valves open. As the oxygen is added the flame will turn bluish in color.
- The blue flame will be divided into 3 different color regions - a long yellowish tip, a blue middle section, and a whitish-blue intense inner section.

There are three types of flames as described below:-

- **Neutral** - This type of flame is the one you will use most often in the shop. It is called **"neutral"** because it has no chemical effect upon the metal during welding. It is achieved by mixing equal parts oxygen and acetylene and is witnessed in the flame by adjusting the oxygen flow until the middle blue section and inner whitish-blue parts merge into a single region.
- **Reducing flame** - If there is excess acetylene, the whitish-blue flame will be larger than the blue flame. This flame contains white hot-carbon particles, which may be dissolved during welding. This "reducing" flame will remove oxygen from iron oxides in steel.
- **Oxidizing flame** - If there is excess oxygen, the whitish-blue flame will be smaller than the blue flame. This flame burns hotter. A slightly oxidizing flame is used in brazing, and a more strongly oxidizing flame is used in welding certain brasses and bronzes.

3.2.6. Shutting Down Procedure

- Once you're done, turn off the flame. Close the oxygen pin valve first, and then the acetylene valve.

- With the flame extinguished and the pin valves closed, close the main valve on the oxygen tank. It should be firmly seated at the bottom.
- Open the oxygen pin valve to bleed off all of the oxygen in the regulator and feed line. Close the pin valve once the feed line pressure has gone to zero.
- Fully back out the oxygen regulator valve so there is no pressure in the line. DO NOT close the valve, as this will pressurize the line once the tank is open again.
- Repeat steps 2 through 4 for the acetylene line.

3.2.7. Cutting Procedures of Oxyacetylene

Setting up the oxyacetylene equipment and preparing for cutting must be done carefully and systematically to avoid costly mistakes. Refer below the Step-by-Step instructions, before any attempt is made to light the torch:

1. Secure the cylinders so they cannot be accidently knocked over. A good way do this is to either put them in a corner or next to a vertical column or then secure them with a piece of line. After securing the cylinders, remove protective caps.
2. Standing to one side, crack each cylinder valve slightly and then immediately close the valve again. These blow any dirt or other foreign matter out of the cylinder valve nozzle. Do not bleed fuel gas into a confined area because it may ignite. Ensure the valves are closed and wipe the connections with a clean cloth.
3. Connect the fuel-gas regulator to the fuel-gas cylinder and the oxygen regulator to the oxygen cylinder. Using a gang wrench, snug the connection nuts sufficiently to avoid leaks.
4. Back off the regulator screws to prevent damage to the regulators and gauges and open the cylinder valves slowly. Open the fuel-gas valve only one-half turn and the oxygen valve all the way. Some fuel-gas cylinders have a hand-wheel for opening the fuel-gas valve while others require the use of a gang wrench or T- handle wrench. Leave the wrench in place while the cylinder is in use so the fuel- gas bottle can be turned off quickly in an emergency. Read the high-pressure gauge to check the contents in each cylinder.
5. Connect the RED hose to the fuel-gas regulator and the GREEN hose to the oxygen regulator. Notice the left-hand threads on the fuel-gas connection.
6. To blow out the oxygen hose, turn the regulator screw in (clockwise) and adjust the pressure between 2 and 5 psig. After the hose has been purged, turn the screw back out again (counterclockwise) to shutoff the oxygen. Do the same for the fuel-gas hose, but do it ONLY in a well-ventilated place that is free from sparks, flames, or other possible sources of ignition.

7. Connect the hoses to the torch. The RED (fuel-gas) hose is connected to the connection gland with the needle valve marked “FUEL.” The GREEN (oxygen) hose is connected to the connection gland with the needle valve marked “OXY.”
8. With the torch valves closed, turn both regulator screws clockwise to test the hose connections for leaks. If none are found, turn the regulator screws Counterclockwise and drain the hose by opening the torch valves.
9. Select the correct cutting tip and install it in the cutting torch head. Tighten the assembly by hand, and then tighten with your gang wrench.
10. Adjust the working pressures. The fuel-gas pressure is adjusted by opening the torch needle valve and turning the fuel-gas regulator screw clockwise. Adjust the regulator to the working pressure needed for the particular tip size, and then close the torch needle valve. To adjust acetylene gas, you should set the gauge pressure with the torch valves closed. To adjust the oxygen working pressure, You should open the oxygen torch needle valve and proceed in the same manner as in adjusting the fuel-gas pressure.
11. In lighting the torch and adjusting the flame, always follow the manufacturer’s directions for the particular model of torch being used. This is necessary because the procedure varies somewhat with different types of torches and, in some cases, even with different models made by the same manufacturer. In general, the procedure used for lighting a torch is to first open the torch oxygen needle valve a small amount and the torch fuel-gas needle valve slightly more, depending upon the type of torch. The mixture of oxygen and fuel gas coming from the torch tip is then lighted by means of a spark igniter or stationary pilot flame. Adjust the preheating flame to neutral.
12. Hold the torch so that the cutting oxygen lever or trigger can be operated with one hand. Use the other hand to steady and maintain the position of the torch head to the work. Keep the flame at a 90 degree angle to work in the direction of travel. The inner cones of the preheating flames should be about 1/16 in. (1.6 mm) above the end of the line to be cut. Hold this position until the spot has been raised to a bright red heat, and then slowly open the cutting oxygen valve.
13. Cutting is initiated by heating the edge or leading face (as in cutting shapes such as round rod) of the steel to the ignition temperature (approximately bright red heat) using the pre-heat jets only, then using the separate cutting oxygen valve to release the oxygen from the central jet. The oxygen chemically combines with the iron in the ferrous material to instantly oxidize the iron into molten iron oxide.

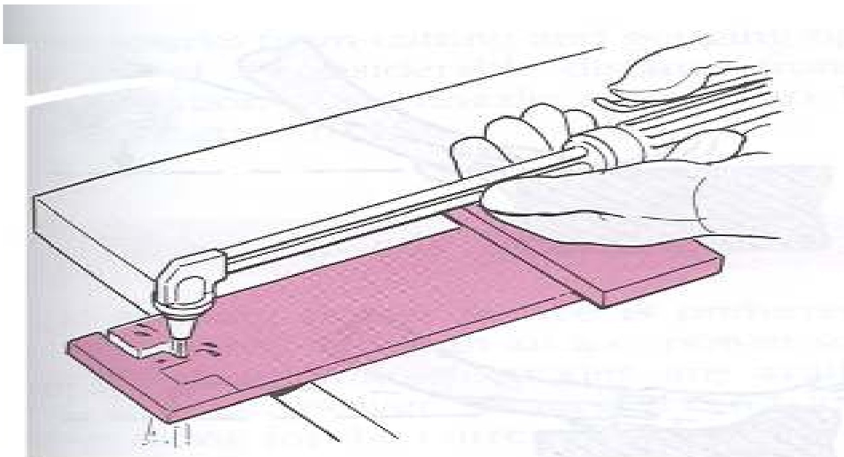
Figure 3.3. Assembled oxy acetylene cutting out fit

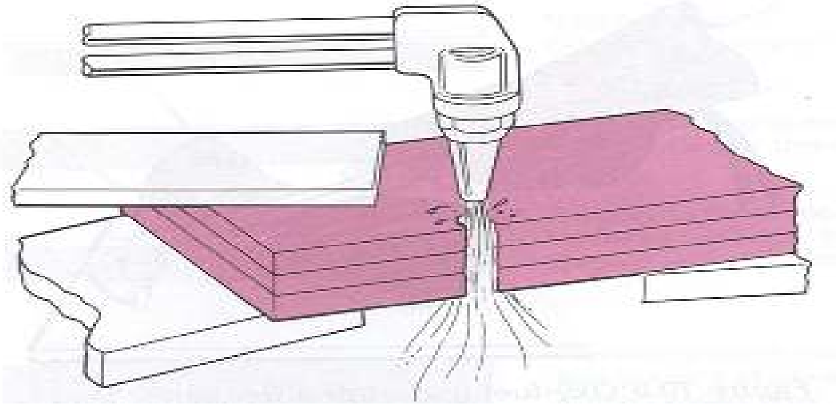
Gas cutting is available to cut plates mostly greater than 40mm thickness that is difficult to metal shears. The cutting operation is performed at rapid oxidized flame with highly pressured oxygen jet of 300KPA. The oxy-acetylene gas cutting out fit is similar to that of the oxy-acetylene welding except for the torch type.

Table 3.1. Tip size for cutting carbon steel

Plate thickness in mm	Oxygen orifice diameter in mm
Up to 3	0.65
3 to 6	0.90

6 to 25	1.25
25 to 50	1.60
50 to 100	2.25
100 to 200	3.00
200 to 300	4.25
300 to 400	5.00
400 to 500	6.00





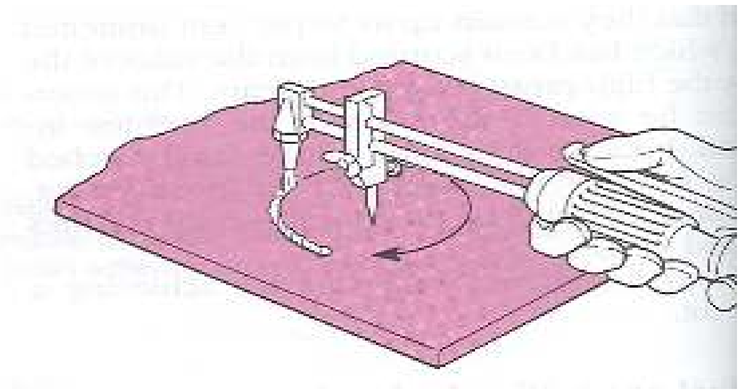


Figure 3.4. Oxyacetylene cutting operation

3.3. Materials types for Cut and weld

3.3.1. Oxyacetylene Welding of Ferrous Metals

Low-carbon steel, low-alloy steel, cast steel, and wrought iron is easily welded by the oxyacetylene process. A flux is not necessary with these metals because their oxides melt at a lower temperature than the base metal. During the welding process, you should enclose the molten puddle with the flame envelope to ensure the molten metal does not contact the air. If the metal is exposed to the air, it will oxidize rapidly. You also should avoid overheating the metal.

The proper flame adjustment is required to make a good weld Adjust the flame to a neutral or slightly reducing (carburizing) flame. Do not use an oxidizing flame. Manipulate the torch and rod so the tip of the oxygas cone is about 1/16 to 1/8 of an inch from the surface of the metal. Melt the end of the filler rod in the puddle, not with the flame. The welding of low-carbon steels and cast steels presents no special problems other than the selection of the proper filler rod Low-alloy steels usually require pre-welding and post-welding heat treatment. This heat treatment relieves the stresses developed during the welding phase and produces the desired physical properties of the metal.

As the carbon content of a steel increases, welding becomes more difficult. Steels whose carbon content is within the 0.3-percent to 0.5-percent range are welded with a slightly carburizing flame. These low-carbon steels require post-welding heat treatment to develop their best physical properties.

High-carbon steel and tool steel require a slightly different technique. While protecting the parts from drafts, slowly preheat them to about 1000°F. Complete the weld as rapidly as possible using a carburizing flame and no flux. Do not manipulate either rod or torch and add the filler metal in small amounts, as it is needed. You should use a smaller flame and lower gas pressure than that used for low-carbon steel. This is to ensure you do not overheat the steel. You must heat-treat high-carbon steels and tool steels after welding to develop the physical properties required.

The procedure for oxygas welding of **wrought iron** is the same as that for low-carbon or mild steel; however, you should keep several points in mind. Wrought iron contains a slag that was incorporated in it during the manufacturing stage. This slag gives the surface of the molten puddle a greasy appearance. Do not confuse this greasy appearance with the appearance of actual fusion. Continue heating until the sidewalls of the joint break down into the puddle. Best results with wrought iron are obtained when the filler metal (usually mild steel) and base metal are mixed in the molten puddle with a minimum of agitation

Oxygas welding of **cast iron** is not difficult, but does require a modification of the procedure used with steel. For material that does not exceed 3/16 of an inch in thickness, you do not need to make a V-groove. Metal that is between 3/16 of an inch and 3/8 of an inch should have a single V-butt joint with an included angle of 60 degrees. For metal over 3/8 of an inch, use a double V-butt joint with 60-degree included angles.

Before you begin welding, preheat the entire weldments to a temperature between 750°F and 900°F. The welding should be done with a neutral flame using the backhand method. Use a cast-iron filler metal and the appropriate flux. The flux is necessary, but uses it sparingly as needed Add filler metal by directing the inner cone of the flame against the rod instead of dipping the tip of the rod into the puddle. The filler metal should be deposited in layers not exceeding 1/8 of an inch thick. Upon completion of the weld, you must stress relieve the weldments by heating it to a temperature between 1100°F and 1150°F and then cool it slowly. Oxygas welding cast iron gives a good colour match and good machinability; however, if colour match is not essential, a cast-iron repair can be made more easily and economically by braze welding.

Oxygas welding can be used with some **chromium nickel steels (stainless steels**). As a rule, oxygas welding is used only for light sheet; heavier pieces of these steels are usually joined by one of the electric arc welding processes. On material 20 gauge (0.040 of an inch) or less in thickness, a flange equal to the thickness of the metal is turned up and the weld is made without filler metal. Before welding, you should clean the joint surfaces of the metal with sand-paper or other abrasives and then apply a stainless steel flux. The torch tip used for welding stainless steel is usually one or two sizes smaller than the tip used to weld mild steel of the same thickness. Adjust the torch so you have a carburizing flame, as seen through your goggles, with an excess fuel-gas feather extending about 1/16 of an inch beyond the tip of the inner cone. Hold the torch so the flame makes an angle of 80 degrees to the surface of the sheet. The tip of the cone should almost, but not quite touch the molten metal. Make the weld in one pass, using a forehand technique. Do not puddle or retrace the weld. A uniform speed of welding is essential. If it is necessary to stop the welding process or re-weld a section, wait until the entire weld has cooled.

3.3.2. Oxyacetylene Welding of Nonferrous Metals

Although brazing and braze welding are used extensively to make joints in nonferrous metals, there are many situations in which oxygas welding is just as suitable. The joint designs are the same for nonferrous metals as for ferrous metals in most cases. Oxygas welding of nonferrous metals usually requires mechanical cleaning of the surfaces before welding and the use of flux during welding. Filler metals must be suitable for the base metal being welded A separate section on aluminium and aluminium alloys is included as part of this chapter since you may need more detailed instructions in welding these materials.

A. **Copper**

Pure copper can be welded using the oxygas torch. Where high-joint strength is required you should use **deoxidized** copper (copper that contains no oxygen). A neutral flame is used and flux is required when welding copper alloys. Because of the high thermal conductivity of copper, you should preheat the joint area to a temperature ranging between 500°F to 800°F and use a larger size torch tip for welding. The larger size tip supplies more heat to the joint and thus makes it possible to maintain the required temperature at the joint. After welding is completed, cool the part slowly. Other than the extra volume of heat required, the technique for welding copper is the same as for steel.

B. **Copper-Zinc Alloy (Brasses)**

Copper-zinc alloys (brasses) can be welded using the same methods as deoxidized copper; however, a silicon-copper rod is used for welding brasses. The rods are usually flux-coated so the use of additional flux is not required. Preheat temperatures for these metals range between 200°F to 300°F.

C. **Copper-Silicon Alloy (Silicon Bronze)**

Copper-silicon alloy (silicon bronze) requires a different oxygas welding technique from that used for copper and copper-zinc. You weld this material with a slightly oxidizing flame and use a flux having a high boric acid content. Add filler metal of the same composition as the base metal; as the weld progresses, dip the tip of the rod under the viscous film that covers the puddle. Keep the puddle small so the weld solidifies quickly. A word of caution: when welding copper-zinc, you should safeguard against zinc poisoning by either doing all the welding outdoors or by wearing a respirator or by both, depending on the situation

D. **Copper-Nickel Alloy**

Oxygas welding of copper-nickel alloys requires surface preparation and preheating. The flux used for this welding is a thin paste and is applied by brush to all parts of the joint and to the welding rod. Adjust the torch to give a slightly carburizing flame; the tip of the inner cone should just touch the base metal. Do not melt the base metal any more than necessary to ensure good fusion. Keep the end of the filler rod within the protective envelope of the flame, adding the filler metal without disturbing the molten pool of weld metal. If possible, run the weld from one end of the joint to the other without stopping. After you complete the weld, cool the part slowly and remove the remaining traces of flux with warm water.

E. **Nickel and High-Nickel Alloys**

Oxygas welding of nickel and high-nickel alloys is similar to that for copper-nickel alloys. Good mechanical cleaning of the joint surfaces is essential. The joint designs are basically the same as steel of equivalent thickness. The included angle for V-butt welds is approximately 75 degrees. You may weld plain nickel without a flux, but high-nickel alloys require a special boron-free and borax-free flux. The flux is in the form of a thin paste and should be applied with a small brush.

You should flux both sides of the seam, the top and bottom, and the filler rod. Adjust the torch to give a very slightly carburizing flame; the tip selected should be the same size or one size larger than for steel of the same thickness. The flame should be soft and the tip of the cone kept in contact with the molten pool. Use a rod suitable for the base metal, and always keep the rod well within the protective envelope of the flame. After the weld is completed, post-heat the part and cool it slowly. Then remove the flux with warm water.

F. **Lead**

Oxygas welding of lead requires special tools and special techniques. Although you do not require a flux, you must ensure that the metal in the joint area is scrupulously clean. You may accomplish this by shaving the joint surfaces with a scraper and wire brushing them to remove oxides and foreign matter. In the flat-welding position, a square butt joint is satisfactory. In other positions, a lap joint is used almost exclusively. When you use a lap joint, the edges should overlap each other from 1/2 of an inch to 2 inches, depending upon the thickness of the lead.

To weld lead, use a special, lightweight, fingertip torch, with tips ranging from 68 to 78 in drill size. Adjust your torch to a neutral flame with the gas pressure ranging from 1 1/2 psig to 5 psig, depending on the thickness of the lead. The length of the flame varies from about 1 1/2 inches to 4 inches, depending upon the gas pressures used. When you are welding in the horizontal and flat positions, a soft, bushy flame is most desirable. But, when you are welding in the vertical and overhead positions, better results are obtained with a more pointed flame.

For oxygas welding of lead, you should ensure that the filler metal has the same composition as the base metal. The molten puddle is controlled and distributed by manipulating the torch so the flame moves in a semi-circular or V-shaped pattern. Each tiny segment of the weld is made separately, and the torch is flicked away at the completion of each semi-circular or V-shaped movement. Joints are made in thin layers. Filler metal is not added during the first pass, but it is added on subsequent passes. When welding lead or lead alloys, you should wear a respirator of a type approved for protection against lead fumes.

Warning: lead fumes are poisonous.

G. **Aluminium and Aluminium Alloys**

When assigned to work with nonferrous metals; you can expect jobs that involve the welding of aluminium and aluminium alloys. Pure aluminium has a specific gravity of 2.70 and a melting point of 1210°F. Pure aluminium is soft and seldom used in its pure form because it is not hard or strong enough for structural purposes; however, the strength of aluminium can be improved by the addition of other elements to form aluminium alloys.

Aluminium alloys are usually 90-percent pure. When elements, such as silicon, magnesium, copper, nickel, and manganese, are added to aluminium, an alloy stronger than mild steel results; whereas pure aluminium is only about one fourth as strong as steel.

A considerable number of aluminium alloys are available. You may use some of the aluminium alloys in sheet form to make and repair lockers, shelves, boxes, trays, and other containers. You also may have to repair chairs, tables, and other items of furniture that are made of aluminium alloys.

Oxygas welding of aluminium alloys is usually con-fined to materials from 0.031 of an inch to 0.125 of an inch in thickness. Also, thicker material can be welded by the oxygas process if necessary; however, thinner material is usually spot or seam welded.

Melting characteristics: Before attempting to weld aluminium alloy for the first time, you should become familiar with how the metal reacts when under the welding flame.

A good example of how aluminium reacts when heated can be seen if you place a small piece of sheet aluminium on a welding table and heat it with a neutral flame. Hold the flame perpendicular to the surface of the sheet and bring the tip of the inner cone almost in contact with the metal. Observe that almost without warning the metal suddenly melts and runs away, leaving a hole in the sheet. Now repeat the operation with the torch held at an angle of about 30 degrees to the plane of the surface. With a little practice, you will be able to melt the surface metal without forming a hole. Now try moving the flame slowly along the surface of the sheet, melting a small puddle. Observe how quickly the puddle solidifies when the flame is removed. Continue this practice until you are able to control the melting. When you have mastered this, proceed by practicing actual welding. Start with simple flanged and notched butt joints that do not require a welding rod. Next, you should try using a welding rod with thin sheet and then with castings.

Welding rods: Two types of welding rods available for gas welding aluminium alloys are the 1100 and 4043 rods. The 1100 rod is used when maximum resistance to corrosion and high ductility are of primary importance. The 1100 rod is used for welding 1100 and 3003 type aluminium alloys only. The 4043 rod is used for greater strength and minimizes the tendency for cracking. It also is used for all other wrought aluminium alloys and castings.

Welding Fluxes: The use of the proper flux in welding aluminium is extremely important. Aluminium welding flux is designed to remove the aluminium oxide by chemically combining with it. In gas welding, the oxide forms rapidly in the molten metal. It must be removed or a defective weld will result. To ensure proper distribution, you should paint flux on the welding rod and the surface to be welded.

Aluminium flux is usually in powder form and is prepared for use by mixing with water to form a paste. The paste should be kept in an aluminium, glass, or earthenware container because steel or copper containers tend to contaminate the mixture.

It is essential that plenty of flux be applied to the edges of flanged joints because no filler rod is used in these joints. In all cases, the flux should be applied to both the bottom and top sides of the sheet in the area of the weld. After you finish welding, it is important that you remove all traces of flux. You can do this by using a brush and hot water. If aluminium flux is left on the weld, it will corrode the metal.

3.4. Inspection of The Components

3.4.1. Inspect the cutting equipment

The following procedures are to inspect the gas welding equipment before doing any welding or cutting operation:

1. Inspect the cone end, coupling nut, and torch head for dirt, dust, oil, grease, or damaged parts. Dirt and dust can be removed with a clean cloth. CAUTION: If oil, grease or

damaged parts are detected, contact your authorized service repair station for cleaning or repairs.

2. Inspect the cutting attachment cone end for missing or damaged "O" rings. There must be two (2) "O" rings on the cone end. Damaged or missing "O" rings can allow gases to mix and will cause backfires or back flash. Severe damage can result.
3. Inspect the torch head. The tapered seating surfaces must be in good condition. If dents, burns or burned seats are present, the seat must be resurfaced. If the torch is used with poor seating surfaces, backfire or back flash may occur.
4. Connect the cutting attachment to the welding torch handle and tighten the coupling nut, using hand pressure only. Wrench tightening may damage "O" rings and create a faulty seal.

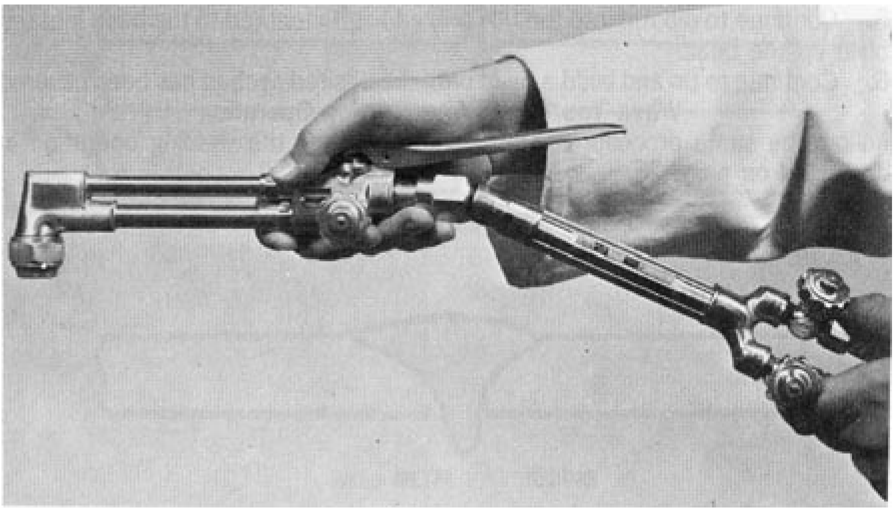


Figure 3.5. Cutting attachment

5. Select the required size and type of cutting tip. Inspect the tip seating surfaces for damage. **Remember**: these seating surfaces prevent premature mixing of gases that can cause fires and explosions. IF the tapered seats on the tip are damaged, DON'T USE! Inspect the pre-heat and cutting oxygen holes. Splatter can stick on or in these holes. If holes are clogged or obstructed clean them out with proper size tip cleaner.
6. Insert the tip in the cutting attachment head and tighten securely with wrench (15 to 20 pounds pressure).

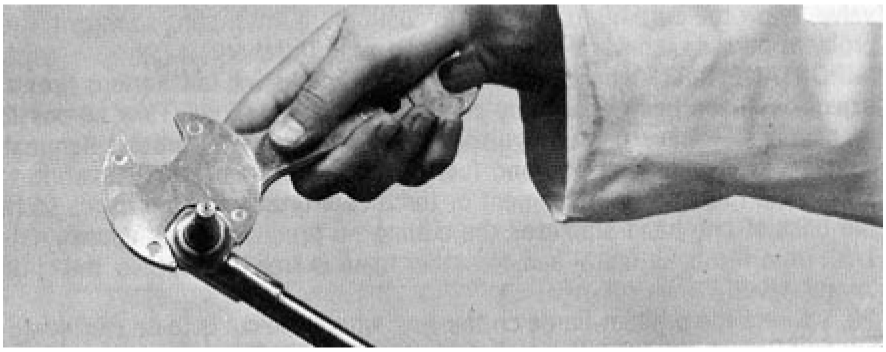


Figure 3.6. Tip tightens

(NOTE: If using a straight cutting torch as opposed to an attachment, disregard inapplicable parts of procedures 1 - 6)

7. Refer to cutting tip selection chart for correct cutting tip, regulator pressures, and travel speed.
8. Follow cylinder and regulator safety and operating procedures.
9. Open the oxygen valve on the welding torch completely.
10. Open the preheat oxygen control valve on the cutting attachment and adjust the oxygen regulator to the desired delivery pressure.
11. Close the preheat oxygen control valve.
12. Open the fuel valve on the welding torch handle and adjust the fuel regulator delivery range.
13. Close the fuel control valve on the torch handle.
14. Momentarily depress the cutting oxygen lever to purge the high pressure cutting oxygen passage.
15. Open the fuel valve on the torch handle approximately one-half turn and ignite with a spark lighter. NOTE: Wear protective goggles to shield the eyes from bright light.
16. Continue to increase the fuel supply at the torch handle until the flame clears the end of the tip about 1/8", then reduce the supply slightly to return the flame to the tip.
17. Slowly open the preheat oxygen control valve on the cutting attachment until the preheat flames establish a sharp inner cone. The configuration of the short inner cone is called the Neutral Flame.
18. Depress the cutting oxygen lever. Note that the preheat flame changes slightly to a carburizing flame. Continue to depress the cutting oxygen lever and incase the preheat oxygen at the cutting attachment until the preheat flames are again neutral.

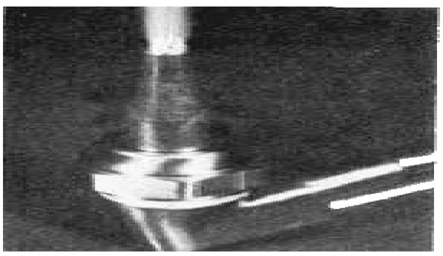


Figure 3.7. Cutting oxygen lever

3.4.2. Inspecting Welding joints

In the fabrication or repair of equipment, tests are used to determine the quality and soundness of the welds. Many different tests have been designed for specific faults. The type of test used depends upon the requirements of the welds and the availability of testing equipment. In this section, non-destructive and destructive testing are briefly discussed.

A. **Visual Inspection**

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

B. **Magnetic Particle Inspection**

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

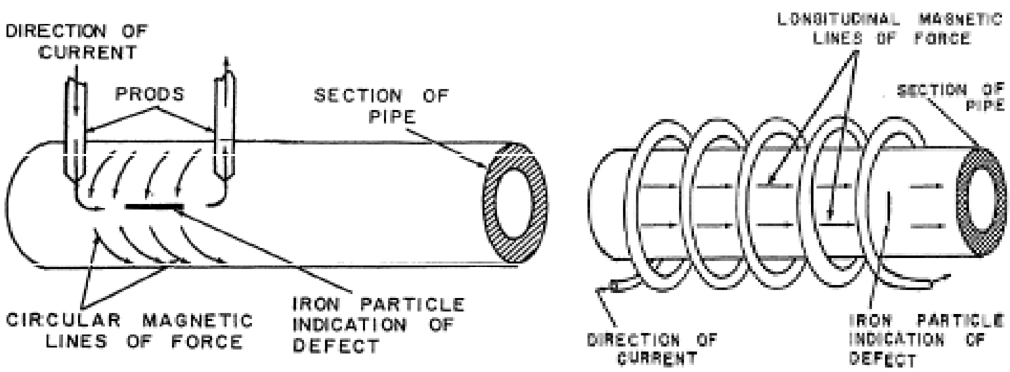


Figure 3.8. Circular and longitudinal magnetization

You can magnetize the test piece by either having an electric current pass through it, or by having an electric current pass through a coil of wire that surrounds the test piece, as shown in figure 3.5. When an electric current flows in a straight line from one contact point to the other, magnetic lines of force are in a circular direction. When the current flow is through a coil around the test piece, as shown in figure 3.5, the magnetic lines of force are longitudinal through the test piece.

When a defect is to show up as a disturbance in the pattern of the iron particles, the direction of the magnetic field must be at right angles to the major axis of the defect. A magnetic field having the necessary direction is established when the current flow is parallel to the major axis of the defect. Since the orientation of the defect is unknown, different current directions must be used during the test. As shown in figure 3.5,, circular magnetism is induced in the test piece so you can inspect the piece for lengthwise cracks, while longitudinal mag-netism, is induced so you can inspect the piece for transverse cracks. In general, magnetic particle inspection is satisfactory for detecting surface cracks and subsurface cracks that are not more than 1/4 inch below the surface.

One type of magnetic particle inspection unit is a portable low-voltage unit having a maximum magnetizing output of 1,000 amperes, either alternating or direct current. It is ready to operate when plugged into the voltage supply specified by the manufacturer. The unit consists of a magnetizing current source, controls, metering, three 10-foot lengths of flexible cable, and a prod kit. The prod kit includes an insulated prod grip fitted with an **ON-OFF** relay or current control switch, a pair of heavy copper contact prods, and two 5-foot lengths of flexible cable. Cable fittings are designed so that either end of the cable can be connected to the unit, to the prods, or to any other cable. The three outlets on the front of the unit make changing from alternating to direct current or vice versa very easy. The outlets are labeled as follows: left is ac, the center is **common,** and the right is dc. One cable will always be plugged into the **common** outlet, while the other cable is plugged into either the ac or dc outlet, depending upon what type of current the test requires. For most work, alternating current magnetization effectively locates fatigue cracks and similar de-fects extending through to the surface. When you require a more sensitive inspection to detect defects below the surface, use direct current.

C. Liquid Penetrant Inspection

Liquid penetrant 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 penetrant inspection reveals only those defects that are open to the surface. Four groups of liquid penetrants are presently in use. Group I is a dye penetrant that is nonwater washable. Group II is a water washable dye penetrant. Group III and Group IV are fluorescent penetrants. Carefully follow the instructions given for each type of penetrant since there are some differences in the procedures and safety precautions required for the various penetrants.

Before using a liquid penetrant 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 penetrant 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 penetrant inspection after the specified finish has been given.

Before using a liquid penetrant, 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 penetrant.

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

After thoroughly cleaning and drying the surface, coat the surface with the liquid penetrant. Spray or brush on the penetrant or dip the entire piece into the penetrant. To allow time for the penetrant 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 penetrant for a minimum of 15 or 30 minutes, depending upon the penetrant being used.

After keeping the surface wet with the penetrant for the required length of time, remove any excess penetrant from the surface with a clean, dry cloth, or absorbent paper towel. Then dampen a clean, lint-free material with penetrant remover and wipe the remaining excess penetrant 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 sur-face, 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.

The following actions take place when using dye penetrants. First, the penetrant that is applied to the surface of the material will seep into any passageway open to the surface, as shown in figure 7-60, view A.

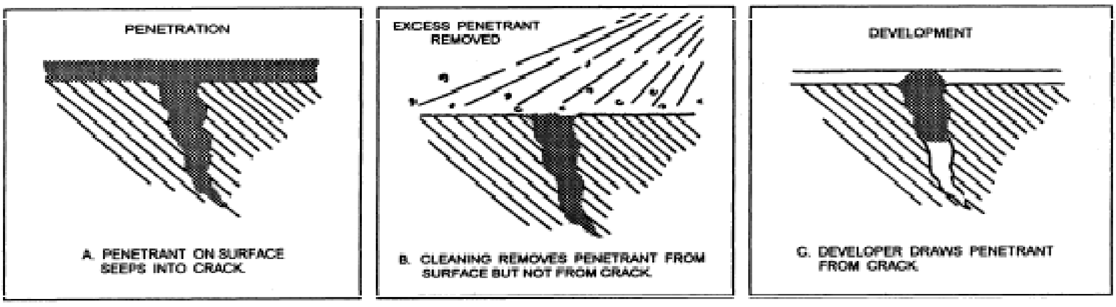


Figure 3.9. Liquid penetrant inspection

The penetrant is normally red in color, and like penetrat-ing oil, it seeps into any crack or crevice that is open to the surface. Next, the excess penetrant is removed from the surface of the metal with the penetrant remover and a lint-free absorbent material. Only the penetrant on top of the metal surface is removed (figure 3.6, view B), leaving the penetrant that has seeped into the defect.

Finally, the white developer is applied to the surface of the metal, as shown in figure 3.6, view C. The developer is an absorbing material that actually draws the penetrant from the defect. Therefore, the red pene-trant indications in the white developer represent the defective areas. The amount of red penetrant drawn from the defective areas indicates the size and some-times the type of defect. When you use dye penetrants, the lighting in the test area must be bright enough to enable you to see any indications of defects on the test surface.

The indications you see during a liquid penetrant inspection must be carefully interpreted and evaluated. In almost every inspection, some insignificant indica-tions are present. Most of these are the result of the failure to remove all the excess penetrant from the surface. At least 10 percent of all indications must be removed from the surface to determine whether defects are actually present or whether the indications are the result of excess penetrant. When a second inspection does not reveal indications in the same locations, it is usually safe to assume that the first indications were false.

Remove all penetrant inspection materials as soon as possible after the final inspection has been made. Use water or solvents, as appropriate. Since some of the liquid penetrant materials are flammable, do not use them near open flames, and do not apply them to any surface that is at a temperature higher than 100°F. In addition to being flammable, many solvents are poison-ous in the vapor form and highly imitating to the skin in the liquid form.

D. **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 these tests. As Seabees, you will rarely come in contact with these procedures.

E. Ultrasonic Inspection

Ultrasonic inspection of testing uses high-fre-quency 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. Irregu-larities, such as gas pockets or slag inclusions, cause the signal to reflect back sooner and will be displayed on the screen as a change in depth. When you use this system, most all types of materials can be checked for defects. Another advantage of this system is that only one side of the weld needs to be exposed for testing.

F. Eddy Current Testing

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

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

G. 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 testis 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 3.7, view B. Measure the distance, in inches, between the lines to the nearest 0.01 inch and let the resulting measurement equal (x).

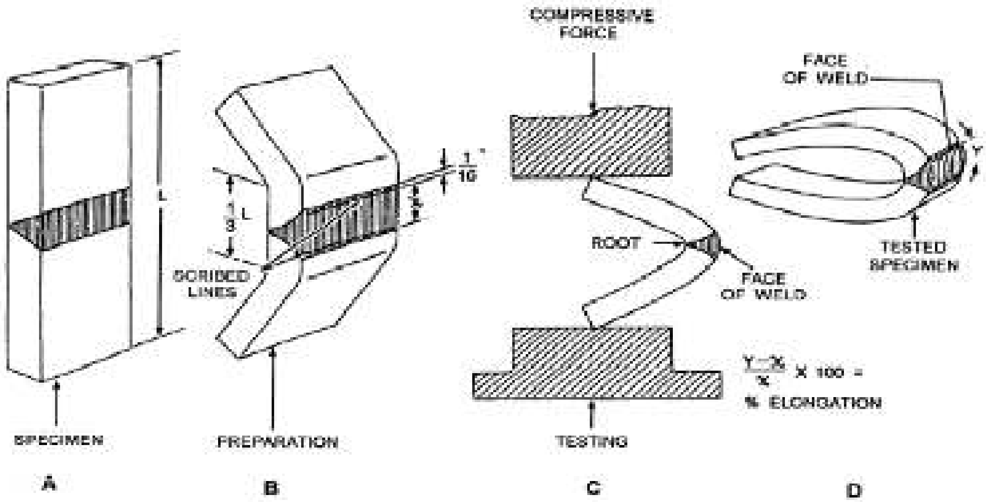


Figure 3.10. Free bend test

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.

When the proper precautions are taken, a blacksmith's forging press or hammer can be used to complete the bending operation. If a crack more than 1/16 inch develops during the test, stop the bending because the weld has failed; otherwise, bend the specimen flat. After completing the test, measure the distance between the scribed lines and call that measurement (y). The percentage of elongation was also determined properly with in the standard formula.

3.4.3. Identify Weld Defects and Their Causes

1. **Lack of Penetration**

Lack of penetration is the failure of the filler metal to penetrate into the joint. It is caused by:

- Incorrect edge penetration.
- Incorrect welding technique.
- Inadequate de-slagging

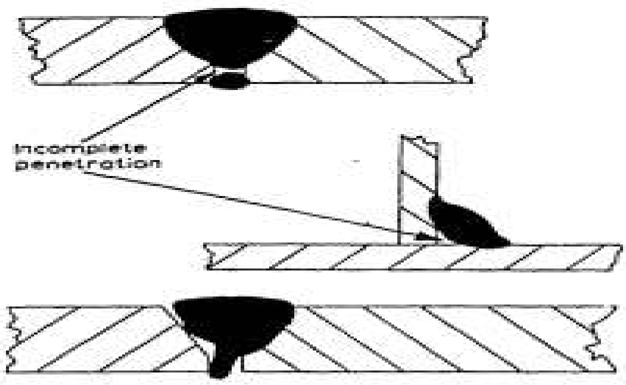


Figure 3.11. Lack of penetration

2. **Lack of Fusion**

Lack of fusion is the failure of the filler metal to fuse with the parent metal. It is caused by:

- Insufficient heat.
- Too fast a travel
- Incorrect welding technique.

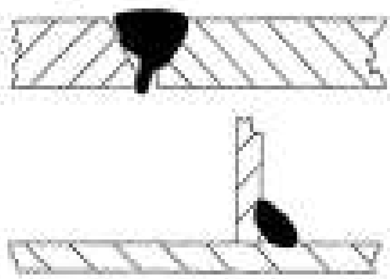


Figure 3.12. Lack of fusion

3. **Porosity**

Porosity is a group of small holes throughout the weld metal. It is caused by the trapping of gas during the welding process, due to chemicals in the metal, dampness, or too rapid cooling of the weld.

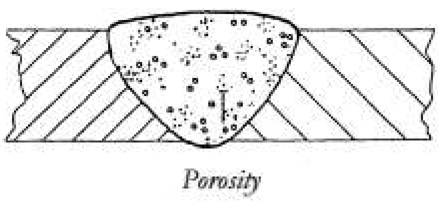


Figure 3.13. Porosity

4. **Slag Inclusion**

Slag inclusion is the entrapment of slag or other impurities in the weld. It is caused by the slag from previous runs not being cleaned away, or insufficient cleaning and preparation of the base metal before welding commences.

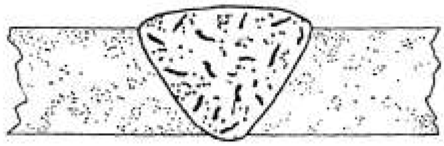


Figure 3.14. Slag inclusion

5. **Undercut**

Undercuts are grooves or slots along the edges of the weld caused by:

- Too fast a travel.
- Too great a heat build-up.
- Bad welding technique.

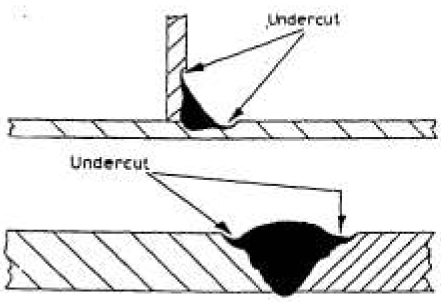


Figure 3.15. Undercut

6. **Overlays**

Overlays consist of metal that has flowed on to the parent metal without fusing with it. The defect is caused by:

- Insufficient heat
- Contamination of the surface of the parent metal.
- Bad welding technique.

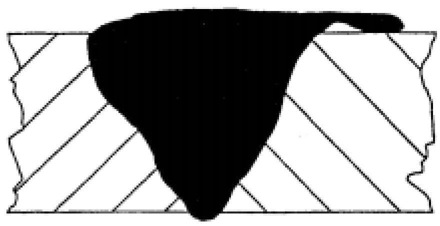


Figure 3.16. Overlays

7. **Crackling**

Cracking is the formation of cracks either in the weld metal or the parent metal. It is caused by:

- Bad welding technique.
- Unsuitable parent metals used in the weld.

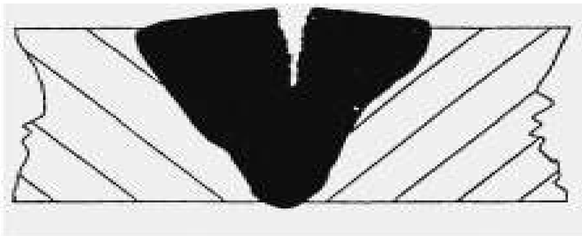


Figure 3.17. Cracking

8. **Blowholes**

Blow holes are large holes in the weld caused by:

- Gas being trapped, due to moisture.
- Contamination of either the filler or parent metals.

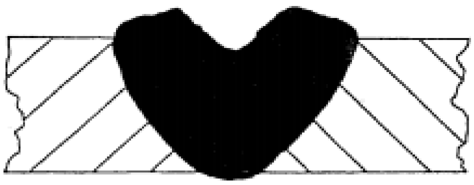


Figure 3.18. Blowholes

9. **Burn through**

Burn through is the collapse of the weld pool due to:

- Poor edge preparation.
- Too great a heat concentration.

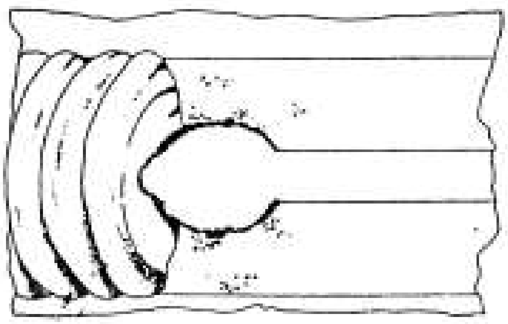


Figure 3.19. Burn through

10. **Excessive Penetration**

Excessive penetration is where the weld metal protrudes through the root of the weld. It is caused by:

- Too big a heat concentration.
- Too slow a travel.

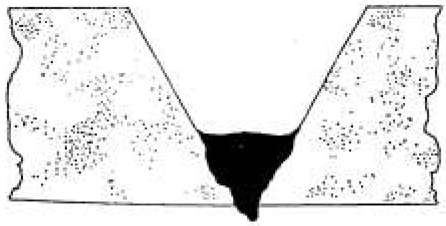


Figure 3.20. Excessive penetration

3.4.4. Welding defect and removing techniques

Table 3.2. Oxyacetylene welding defect and its solutions

Why	What to do
1.Porous Welds 1. Short arc with exception of low hydrogen and stainless. 2. Insufficient paddling time. 3. Impaired base metal. 4. Poor electrode. 5. Improper shield coverage.	1. Hold longer arc. 2. Allow sufficient paddling time for gases to escape. Use proper current 3. Check impurities of the base metal 4. Use proper electrode for the job. 5. Weave your weld to eliminate pin holes.
2.Poor Penetration 1.Speed too fast 2.Electrode too large 3. Current too low 4. Faulty preparation	1. Use enough current to obtain desired penetration weld slowly. 2. Select electrode according to welding groove size. 3. Leave proper gap at the bottom of weld.
3. Warping 1. Shrinkage of weld metal 2. Faulty clamping of parts. 3. Faulty preparation. 4. Overheating at joint	1. Peen joint edges before welding. 2. Weld more rapidly. 3. Avoid excessive space between parts. 4. Use proper sequence. 5. Clamp or track parts properly back up tool. 6. Adopt a proper welding procedure.
4. Undercutting 1. Faulty electrode of gun manipulation.	1. Use a uniform weave in butt welding. 2. Use proper electrode animator.

2. Faulty electrode usage. 3. Current too high	3. Avoid excessive weaving. 4. Use moderate current, weld slowly. 5. Hold electrode at safe distance from the vertical plane in making horizontal fillet weld.
5. Crack Welds 1. Wrong electrode 2. Weld parts size unbalanced 3. Faulty weld 4. Faulty preparation 5. Rigid joint	1. Design structure to eliminate rigid joints 2. Heat parts before welding (preheating) 3. Avoid weld on string beads 4. Keep end free to move as long as possible 5. Make sound weld of good fusion 6. Adjust weld size to part size 7. Allow joint to proper and uniform gap 8. Work with amperage as low as possible.
6. Poor Appearance 1. Faulty electrode 2. Overhang 3. Improper use of electrode 4. Wrong arc voltage and current	1. Use proper welding techniques 2. Avoid overheating 3. Use uniform weaves 4. Avoid overly high current design
7.Poor Fusion 1. Wrong speed 2. Current improperly adjusted 3. Faulty preparation 4. Improper electrode size	1. Adjust electrode to match the joint. 2. Weave must be sufficient to melt side joint. 3. Select proper current and voltage. 4. Keep welds metal from flowing away from plates.
8. Brittle Welds 1. Wrong electrode 2. Faulty preheating 3. Metal hardened by air	1. Preheat at 30ºF. If welding on medium carbon steel or certain alloy steels. 2. Make a multiple layer welds 3. Stress relieving after welding 4. Use low hydrogen processes for increased weld ductility.
9. Spatter 1. Arc blow 2. Current too high 3. Arc too long 4. Faulty electrode	1. Clean parts in weld area. 2. Adjust current properly 3. Adjust voltage 4. Pick suitable electrode
10. Magnetic Blow 1. Magnetic fields cause the arc to deviate from its intended course.	1. Use steel block to alter magnetic path around the arc. 2. Divide the ground into parts 3. Weld in same direction the arc blow 4. Use the short arc length 5. Locate the ground properly on the work

	6. Use A.C welding
11. Weld Stresses 1. Faulty weld 2. Faulty sequence 3. Rigid joints	1. Allow parts to move free as long as practical 2. Make as few passes as practical 3. Peen the deposit 4. Stress relieve according to thickness of weld 5. Move parts slightly when welding the rigid joint to reduce stresses.

Self-check: Three

Part one: Choose the correct answer.

1. --------------------is a method of testing that does not destroy or impair the usefulness of a welded item.

A.Nondestructive testing   B. Destructive testing   C. A and B   D. None

2. the most common preheat flame for oxy gas cutting is :(5point)

A. carburizing flame   B. oxidizing flame   C. Neutral flame   D. all of the above

3. ----------------is a group of small holes throughout the weld metal. It is caused by the trapping of gas during the welding process, due to chemicals in the metal, dampness, or too rapid cooling of the weld.

A. Blowholes   B. Poor Penetration   C. Crack   D. all

4. ----------test to check the ability of a weld to absorb energy under impact without fracturing.

A. Impact B.Eddy current C. Tensile D. all

5.-------------------------------is defined as resistance to indentation and is commonly used as a measure of resistance to abrasion or scratching.(4 point)

A. Hardness test B. Bend test C.Impact test D. all

Part two : Give short answer

1. What are the types of oxyacetylene flames?

2. List the types of destructive and non-destructive test?

Operation sheet: Three

Operation title: Cutting Procedures of Oxyacetylene

Purpose: to perform properly cutting the oxy acetylene welding.

Instruction: follow the correct procedures to cut the material.

Tools and requirement: gas cylinder, regulators, hoses, wrench, valve, torch, and nozzle.

Steps in doing the task:

Step 1: Secure the cylinders so they cannot be accidently knocked over.

Step 2: Standing to one side, crack each cylinder valve slightly and then immediately close the valve again.

Step 3: Connect the fuel-gas regulator to the fuel-gas cylinder and the oxygen regulator to the oxygen cylinder.

Step 4: Back off the regulator screws to prevent damage to the regulators and gauges and open the cylinder valves slowly.

Step 5: Connect the RED hose to the fuel-gas regulator and the GREEN hose to the oxygen regulator.

Step 6: To blow out the oxygen hose, turn the regulator screw in (clockwise) and adjust the pressure

Step 7: Connect the hoses to the torch.

Step 8: torch valves closed, turn both regulator screws and test the hose connections for leaks.

Step 9: Select the correct cutting tip and install it in the cutting torch head.

Step 10. Adjust the working pressures.

Step 11.In lighting the torch and adjusting the flame.

Step 12. Hold the torch so that the cutting oxygen lever or trigger can be operated with one hand.

Step 13. Cutting is initiated by heating the edge

Precaution: apply the correct safety to weld the material.

Quality criteria: perform the quality oxyacetylene welding products.

LAP Test: Three

Task 1. Perform the oxyacetylene fillet welding.