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Ministry of Labor and Skills

FOUNDRY WORKS

Level-II

Based on March, 2022 Curriculum Version 1

Module Title: Manual Metal Arc Welding and Oxy - Acetylene Cutting

Module code: IND FDW2 M06 0322

Nominal duration: 190 Hour

Prepared by: Ministry of Labor and Skill

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Addis Ababa, Ethiopia

Table of Contents

Acknowledgments

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

Acronyms

TTLM	Teaching, Training, Learning Materials
TVT	Technical and Vocational Training
MMAW	Manual Metal Arc Welding
SMAW	Shielded Metal Arc Welding
LAP	Learning Activity Performance
DC	Direct Current
AC	Alternating Current

Introduction to the Module

In foundry work, Manual Metal Arc Welding (MMA or MMAW), also known as Shielded metal arc welding (SMAW), as flux shielded arc welding or informally as **stick welding**, is a manual arc welding process that uses a consumable electrode covered with a flux to lay the weld.

An electric current, in the form of either alternating current or direct current from a welding power supply, is used to form an electric arc between the electrode and the metals to be joined. The workpiece and the electrode melts forming a pool of molten metal (weld pool) that cools to form a joint. As the weld is laid, the flux coating of the electrode disintegrates, giving off vapors that serve as a shielding gas and providing a layer of slag, both of which protect the weld area from atmospheric contamination.

Because of the versatility of the process and the simplicity of its equipment and operation, shielded metal arc welding is one of the world's first and most popular welding processes. It dominates other welding processes in the maintenance and repair industry, and though flux-cored arc welding is growing in popularity, SMAW continues to be used extensively in the construction of heavy steel structures and in industrial fabrication. The process is used primarily to weld iron and steels (including stainless steel) but aluminum, nickel and copper alloys can also be welded with this method.

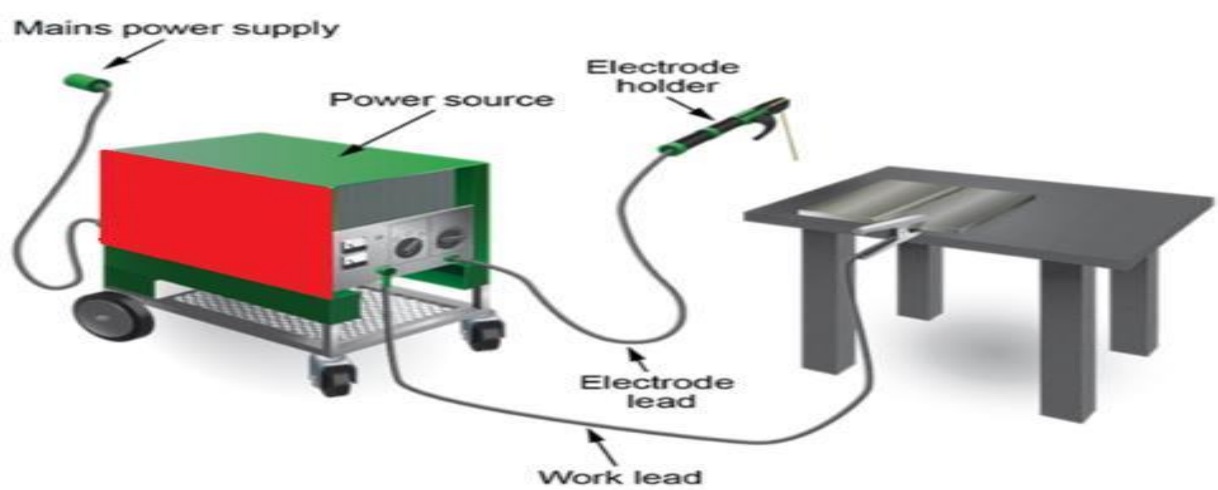


Figure Manual Metal Arc Welding

The shielded metal arc welding process is one of the simplest and most versatile arc welding processes. It can be used to weld both ferrous and non-ferrous metals, and it can weld thicknesses above approximately 18 gauge in all positions. The arc is under the control of the welder and is visible. The welding process leaves slag on the surface of the weld bead which must be removed.

This module is designed to meet the industry requirement under the foundry works occupational standard, particularly for the unit of competency: **Manual Metal Arc Welding and Oxy Acetylene Cutting.**

This module covers the units:

- Manual metal arc welding (MMAW) requirements
- Set-up welding machine / equipment and accessories
- Minimize and rectify distortion
- Manual metal arc welding (MMAW)
- Ensure weld conformance
- Oxy acetylene cutting requirements
- Oxy acetylene cutting and inspection
- Clean up

Learning Objective of the Module:

At the end of the module the trainee will be able to:

- Prepare the requirements for manual metal arc welding (MMAW)
- Adjust and Set-up of manual metal arc welding machine / equipment and accessories
- Minimize and rectify distortion
- Weld to job specification using MMAW
- Understand and Ensure weld conformance
- Identify oxy acetylene cutting requirements
- Perform oxy acetylene cutting and inspection
- Clean up tools, equipment's and work area

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 more resources and Examples and exercise

Unit One: Materials for Manual Metal Arc Welding (MMAW)

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

- Safety (OHS) requirement.
- Welding requirements.
- Materials and welding preparation
- Welding consumables

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

- Apply Safety (OHS) requirement.
- Identify Welding requirements.
- Select Materials and welding preparation
- Identify Welding consumables

1.1. Safety (OHS) Requirement

Introduction

To achieve safe working conditions in the metal fabrication and welding industry, all personnel should be able to recognize the hazards which apply to their particular occupation. Welding operators must also know the correct operating procedures for the equipment.

An operator can be subjected to many safety hazards associated with the industry. As with any other industrial worker, they may be injured through incorrect lifting practices, falling or tripping, or incorrect use of hand tools and machines. The operator will also encounter particular hazards associated with welding.

A clean, tidy workplace, free from combustible materials, is an essential requirement for the safety of welding personnel.

Additionally, others working in the vicinity of welding operations are at risk from hazards such as electrocution, fumes, radiation, burns or flying slag and noise. They too must be protected if their health and safety is not to be put at risk. In this sub unit you will look at the following:

Figure 1.1. Safety slogan

1.1.1. General Safety Precautions

A. Pre-operation/task:

1. Ensure task (e.g. Drawings, instructions, specifications etc.) is clearly understood.
2. Ensure the work area is clean and clear of grease, oil and any other flammable materials.
3. Keep the welding equipment, work area and gloves dry to avoid electric shocks.
4. Stand on rubber insulating matting during operation (where supplied).

5. Ensure the gloves, welding gun and work leads are in good condition (i.e. no exposed wiring).
6. Check that other work areas are protected from flash (e.g. welding curtains).
7. Ensure appropriate ventilation is in place prior to use as welding of aluminum, zinc etc. Will release harmful fumes.
8. Ensure appropriate PPE is worn.
9. Identify ON/OFF switch and emergency stop button (if applicable).

B. Operation/task:

1. Keep hands clear of work piece and away from electrode and ensure operator does not wrap electrode leads around themselves.
2. Ensure power is turned off (from wall socket) before inserting or removing electrode from electrode holder/handle.
3. Ensure current is correctly set according to electrode selection.
4. Never leave the welder running unattended.

C. Post-operation/task:

1. Ensure sufficient time for materials to cool before handling.
2. Switch off machine and fume extraction (if relevant).
3. Hang up electrode holder and welding cables.
4. Practice good housekeeping and ensure the area is clean and tidy.

1.1.2. Potential Hazards:

Fire and electrical hazard with the potential to cause:

1. Harm through exposure to impact and cutting,
2. Heat,
3. Projectiles,
4. Sparks,
5. Sharp objects,
6. Electric shock,
7. Fumes,
8. Radiation and
9. Flame.
10. Fire and explosion
11. Burns

1.1.3. Personal Protective Equipment (PPE) for Manual Metal Arc Welding

Safety is a major issue for day laborers and skilled laborers. Each year, accidents frequently happen in the construction industry and oftentimes it is due to the absence of Personal Protective

Equipment (PPE) or failure to wear the provided PPE. PPE is equipment that will protect workers against health or safety risks on the job. The purpose is to reduce employee exposure to hazards when engineering and administrative controls are not feasible or effective to reduce these risks to acceptable levels. These hazard risks can be anything from wet floors to falling debris and everything in between. PPE includes items such as protective helmets, eye protection, high-visibility clothing, safety footwear, safety harnesses and, sometimes, respiratory protective equipment. Let's explore some PPE commonly used on construction sites and their benefits eyes.

The Personal Protective Equipment (PPE) for Manual Metal Arc Welding are:

- Welding Gloves.
- Helmet with Eye Protection.
- Heat Resistant Welder's Jacket.
- Welding Pants (No cuff)
- Welding Respirator or Lung protection.
- Ear Muff or Plugs.
- Welding Work Boots

Figure 1.2. Personal protective equipment’s

1.1.4. FIRST AID

The welding area should always be equipped with a fire blanket and a well-stocked first aid kit. It is desirable that one person be trained in first aid to treat the minor injuries that may occur. All injuries, no matter how minor they may seem can become more serious if not properly treated by trained medical personnel.

Figure 1.3. First aid kit

1.2. Welding requirement's

Manual Metal Arc (MMA) welding is the most flexible and one of the most widely used arc welding processes. It involves striking an arc between a covered metal electrode and a workpiece.

The heat of the arc melts the parent metal and the electrode which mix together to form, on cooling, a continuous solid mass. The central metal electrode or core wire acts as a consumable, providing the filler metal for the weld. MMA welding can be used to join most steels, stainless steels, cast irons and many non-ferrous materials. For many mild and high-strength carbon steels, it is the preferred joining method.

Arc welding uses an electric phenomenon called arc discharge. An arc discharge is an electric discharge phenomenon of a gas and refers to current released in air. When the voltage applied to two spatially separated electrodes is gradually increased, the air insulation finally breaks and current flows between the electrodes, emitting bright light and high heat at the same time. The generated arc-shaped light is called an electric arc or arc. Arc welding is welding using the heat of an arc as a heat source. In arc welding, positive voltage is applied to the electrode (welding rod/wire) and negative voltage is applied to the base material. This makes an arc occur from the base material to the electrode.

The output current of the arc is about 5 to 1,000 A and the output voltage is about 8 to 40 V. The temperature of the arc is about 5,000°C to 20,000°C. The melting temperature of iron is about 1,500°C. Consequently, the base material and electrode are heated to a high temperature and fuse together.

Basic requirements for the successful manual metal arc welding are:

- The correct electrode
- The correct electrode size for the job
- Correct welding current
- Correct arc length
- Correct angle of electrode to work
- Correct travel speed
- Correct preparation of work to be welded

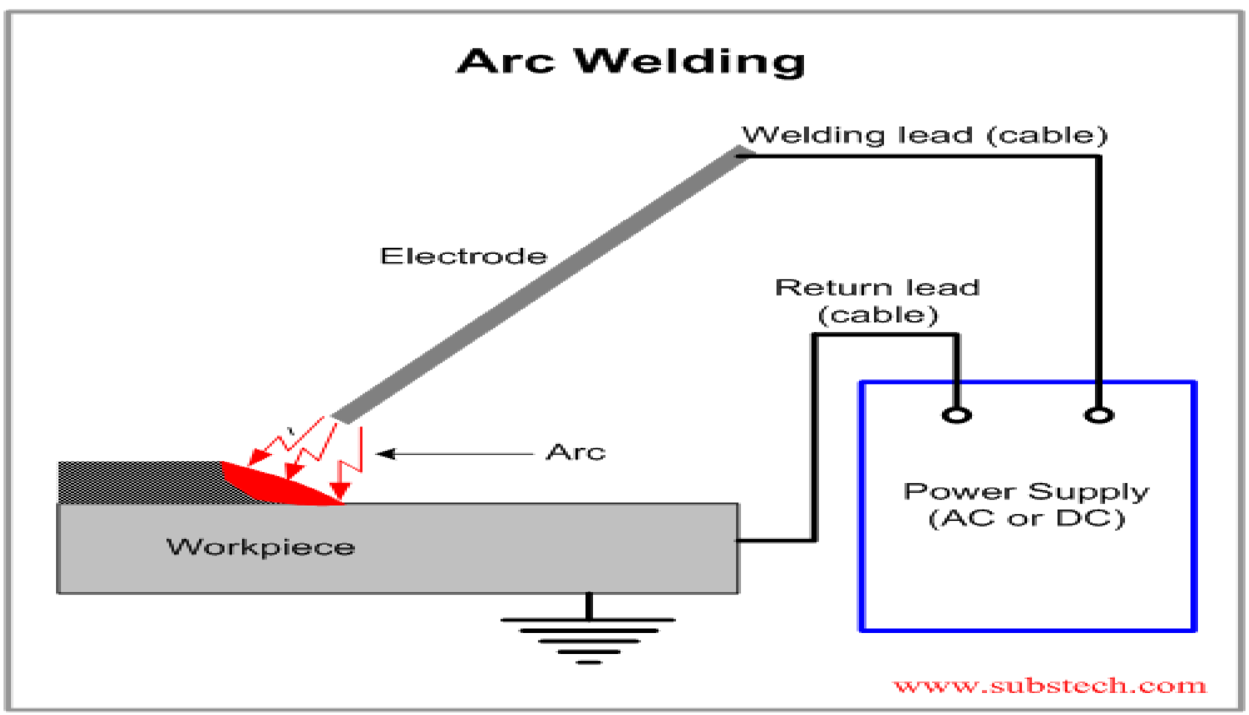


Figure 1.3 principles of MMAW

1.3. Materials and Welding Preparation

1.3.1. Materials

Weld Materials for MMA welding may include ferrous materials including carbon or stainless steel, as well as non-ferrous metals and alloys.

1. Ferrous materials

Ferrous metals refer to metals with iron content. It includes iron (cast, pig, wrought) and steel.
Differences between cast iron and steel are the amount of carbon in the constituency of the metal.
Types of ferrous metals include iron, steel and tungsten carbide.
One simple test to see if the metal has iron content is if it attracts a magnet.

A. Cast iron

A cast iron is an alloy of iron, carbon, and silicon, in which the amount of carbon is usually more than 1.7 percent and less than 4.5 percent.

B. High yield strength, low alloy structural steels

High yield strength, low alloy structural steels (constructional alloy steels) are special steels that are tempered to obtain extreme toughness and durability.

C. High hardness alloy steels

A large number and variety of obtain high strength, high hardness, corrosion alloy steels have been developed to resistance, and other special properties.

D. Tool steels

Steels used for making tools, punches, and dies are perhaps the hardest, strongest, and toughest steels used in industry. In general, tool steels are medium to high carbon steels with specific elements included in different amounts to provide special characteristics.

E. High carbon steels

High carbon steels include those with a carbon content exceeding 0.55 percent. The unfinished surface of high carbon steels is dark gray and similar to other steels. High carbon steels usually produce a very fine grained fracture, whiter than low carbon steels.

F. Medium carbon steels

Medium carbon steels are non-alloy steels which contain from 0.30 to 0.55 percent carbon. These steels may be heat treated after fabrication and used for general machining and forging of parts which require surface hardness and strength.

G. Low carbon steels

The low carbon (mild) steels include those with a carbon content of up to 0.30 percent. In most low carbon steels, carbon ranges from 0.10 to 0.25 percent, manganese from 0.25 to 0.50 percent, phosphorous 0.40 percent maximum, and sulfur 0.50 percent maximum. Steels in this range are most widely used for industrial fabrication and construction.

2. Nonferrous materials

Nonferrous metals are non-iron-based metals that are used in manual metal arc welding such as

- Aluminum and aluminum alloys,
- Copper and copper alloys,
- Nickel and nickel alloys,
- Titanium and titanium alloys,
- Refractory metals and
- Magnesium, and magnesium alloys.

Today, nonferrous metals are used in various welding constructions for diverse industrial applications

1.3.2. Prepare joints and cleaning materials

Introduction

Manual Metal Arc Welding (MMAW) is one the earliest of the arc welding processes, but has remained popular despite the introduction of newer and more sophisticated processes. Indeed, this lack of sophistication is one of the major attractions of the process.

A. Cleaning materials

Before you set up your welder and strike an arc, you'll need to first prepare your metal for welding. Sometimes you'll need to make a quick cut and other times you'll need to make a long cut through thick metal. No matter how long or thick your metal, you'll also need to clean the joint where you plan on welding. Before workpieces are welded together, weld joints must be cleaned of oil, grease, wax layers and paint. The welding joints must be metallically clean so that the workpieces can be joined together in an optimum manner. When cleaning mechanically, it is essential to ensure that no coolants or lubricants are used.

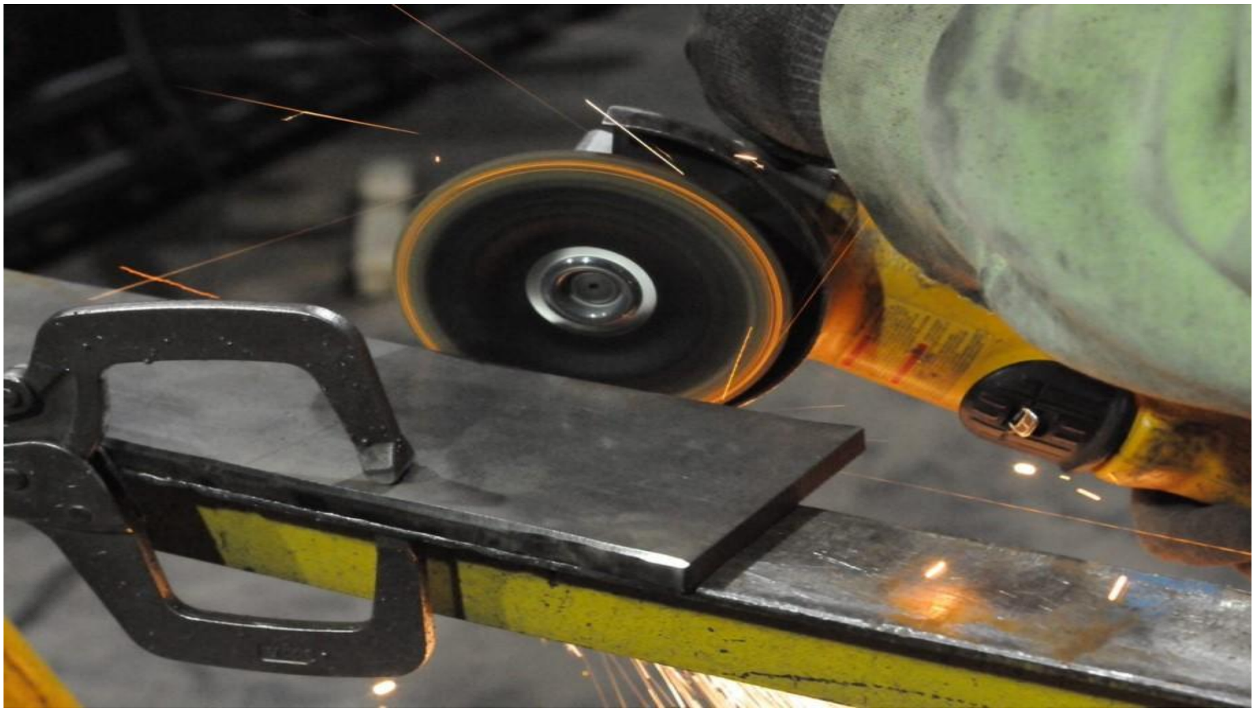


Figure 1.4 material cleaning

Here are 3 ways you can prep metal for welding

a. Wire Brush

A wire brush is good for removing thick layers of mill scale, slag, or any other thick impurities on a metal work piece. You'll especially want to keep a wire brush handy for stick welding since you'll need to brush off the flux when you're done welding. Keep in mind that certain metals will call for specific brushes. For example: a metal such as aluminum will require a steel brush.

Figure 1.5 Wire Brush

b. Sand Paper

Sand paper is another way to remove impurities and imperfections from metal before welding. However, make sure you use the right kind of sandpaper for the metal and welding application so that you don't leave sand paper residue or damage the metal.

Figure 1.6 Sand Paper

c. Angle Grinder

An angle grinder is one of the most versatile tools you can own in a welding shop since you can change the wheels in order to clean metal or to cut small or thin pieces of metal. Welders tend to use 4-4.5" angle grinders for metal prep work. While there are larger angle grinders available, they're more useful for applications other than welding. A 4-4.5" angle grinder is a great choice for cutting a small piece of metal, cleaning metal, or smoothing off rough edges.

Figure 1.7 Angle Grinder

B. Joint preparation

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

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

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

Fusion occurs when your filler metal fusses with your base metal. You get good fusion when the base metal side walls melt and fuse with the molten weld metal (filler metal) you are using to weld with.

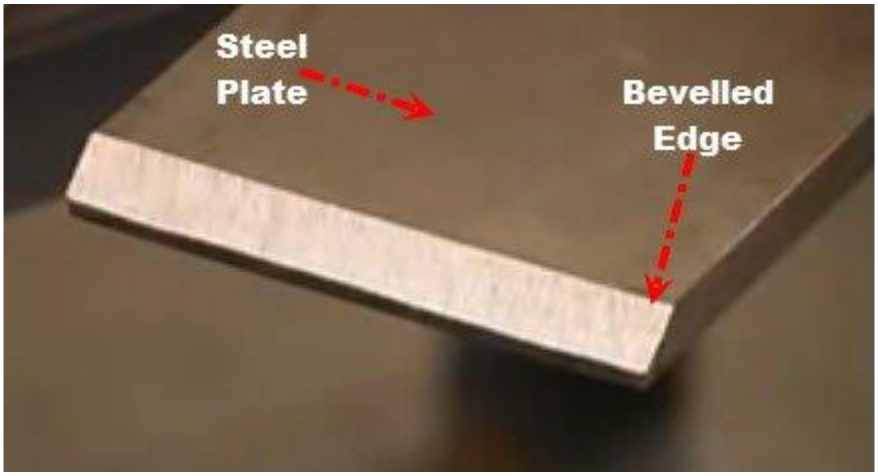


Figure 1.8 Joint preparation

A. Steps for Weld Joint Preparation

1. Choose the Right Filler Material

The most critical step in joint preparation for field welding services is the selection of the right filler material. The replacement or filler material that is used to make repairs can have a direct impact on the durability and longevity of the weld joint.

2. Clean the Joint

Once the proper filler material has been selected, the second step in joint preparation for field welding is to clean the joint. Any dirt or debris that remains in the joint could compromise the integrity of the finished weld. Any rust, oils, or paint present near the weld joint must be ground down and removed.

3. Preheat the Weld Area

A hot welding arc cannot successfully be applied to cold steel. The differences in temperature will lead to imperfections in the weld. The easiest way to resolve temperature differences between the weld area and the welding arc is to preheat the parent material

B. Types of joint

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

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

As we need to prepare welding joints, there are 5 joints types that you will be creating for your jobs:

- Butt
- Corner
- Edge
- Lap
- Tee joint

1. Butt Joint:

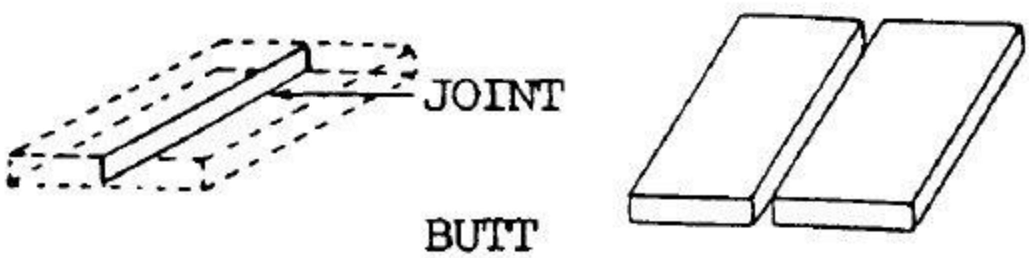


Figure 1.9 Butt Joint

You can prepare a butt joint by using several different techniques including using a flame, chipping, shearing, cutting, and more. For most metal preparation you will use a standard grinder. For welding light sheep metal 3/8 of an inch to 1/2 inch plate you can use the single V groove joint or single U groove joint (in other words, the beveled edges look like a V or a U in a cross section view. See second image below)...

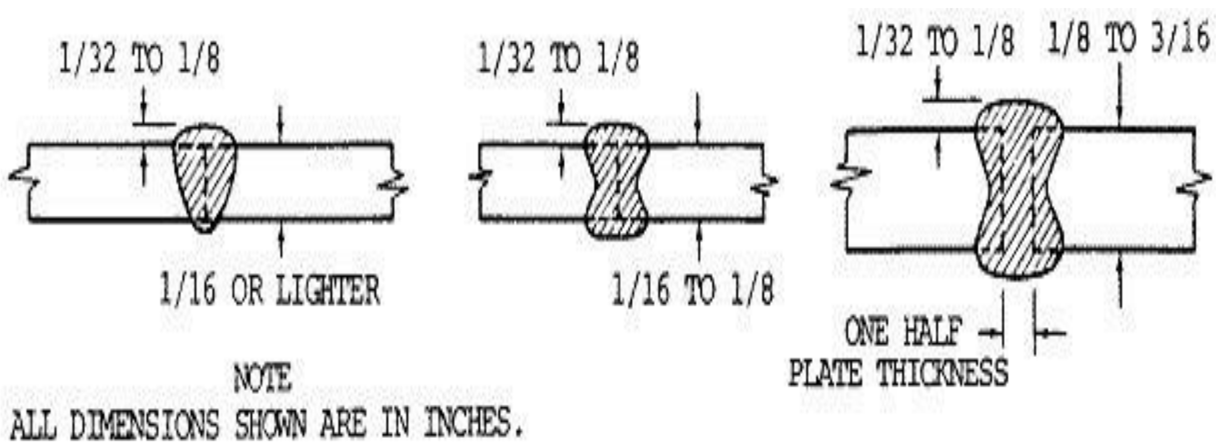


Figure 1.10 Light Section Butt Joint

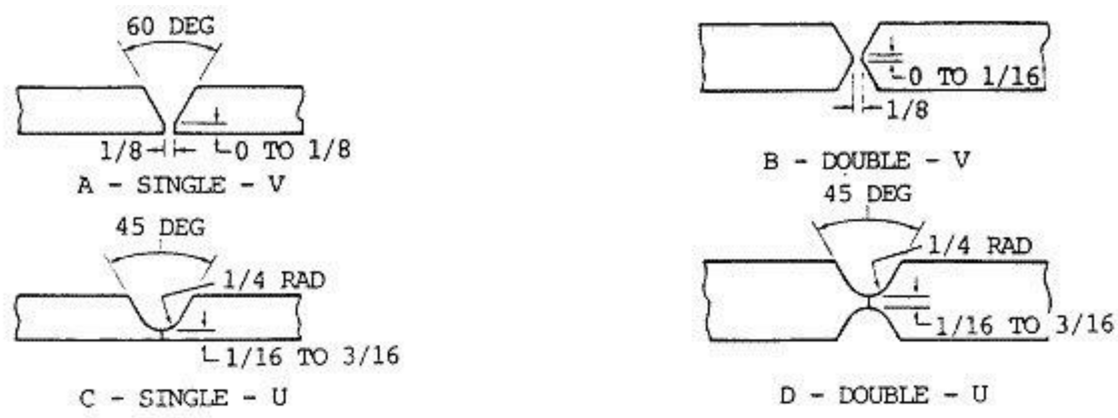


Figure 1.11 Heavy Section V and U Butt Joint Weld

In the image above, look at B (the Double V Joint, upper right corner). This should be used in plate that is 1/2 of an inch up to 2 inches thick.

If you are going to weld plate that is 3/4 of an inch and up look at the lower right hand corner of the image above (D - Double U Joint). This is the preferred method of joint preparation for this thickness of material.

The reason you want to prepare your metal on both sides (double V or double U) is because it's:

- Easier to weld.
- Less distortion (distortion is bad).
- You'll make a better weld than if you only prepared on side rather than both sides.

2. Corner Joint

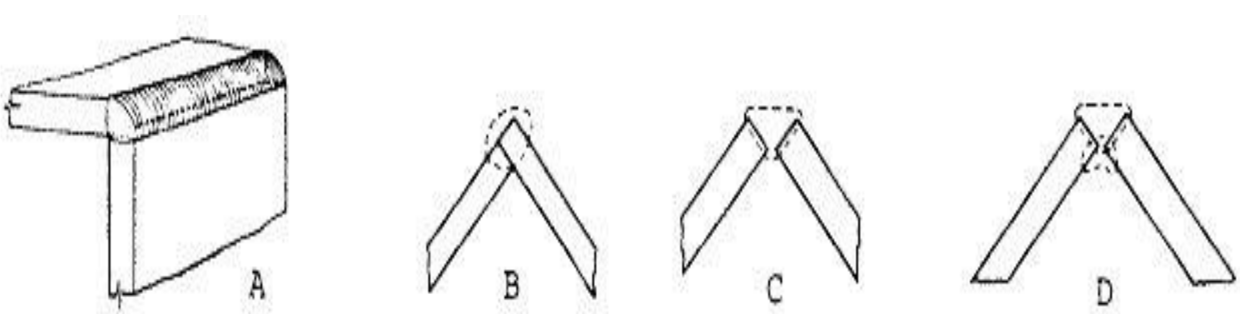


Figure 1.12 Corner Joint

Corner joints are either: Flush (and also referred to as Closed), Half open, or Full open:

- **In the image above see Corner Joint A**. These types of Corner joints are often used for fabricating boxes and tanks and the like. Image A is a fillet weld corner joint.

- **Now look at B. It's a closed corner joint**. You'll see this type of corner joint frequently with 20 gauge (or less) sheet which is considered a lighter sheet metal. When you make a closed corner joint with the oxy acetylene welding process you will use no filler, or maybe just a little bit, and the edge will melt down and overlap. If you are stick welding it just use a small bead to complete this joint. But if you are using the closed joint on thick metal or heavy metal you will bevel the plate that is lapped using the V or U groove to allow for root weld penetration.
- A half open corner weld joint is fine for metal that is 12 gauge or more. If you can only weld on one side for whatever reason, and also if strength is not real important, then you can use the half open corner joint.
- **Image C is an open corner joint and it is considered to be the strongest corner joint you can make**. And you will use this on heavier material, like thicker sheet metal or plate. The way this joint is prepared is to melt the edges and add filler material to the corner.
- **Image D shows a corner weld joint on heavier material**. So you will weld on both sides of the joint. As you can see in the image you will make a weld that is very similar to a sealer bead at the root of the outside fillet weld. The sealer bead is a reinforcing bead.

3. Edge Joint

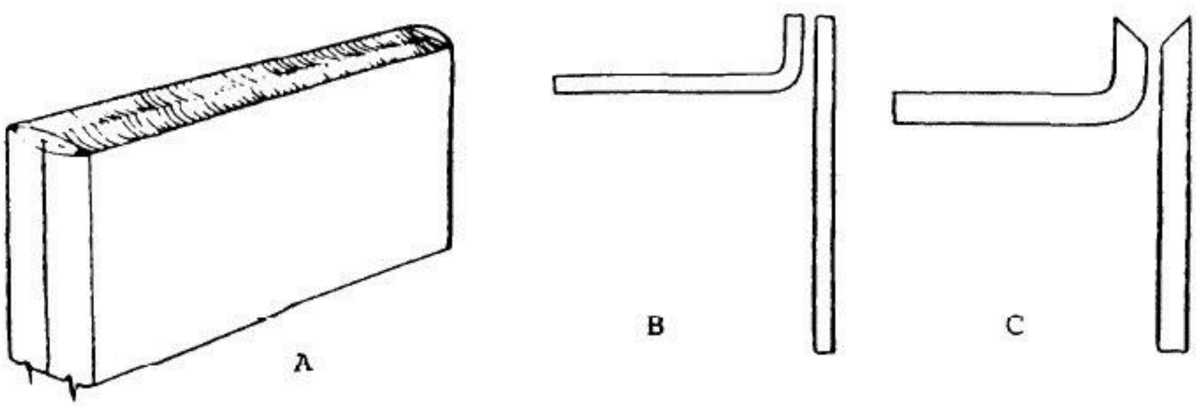


Figure 1.13 Edge Joint

An edge joint is one of the weaker welds. It is used most often on sheet, plate reinforcements, mufflers, and more.

- Look at image A above. As you can see there are two plates welded together at the top. That is one edge joint weld. These are heavier plates and filler material is used to melt and fuse the edges of the plates in order to create proper reinforcement.

- In image B, this type of edge joint requires very little joint preparation. All you will need to do is clean and tack weld them. You do not need filler material because the edges will melt together and fuse that way.
- In image C you will have to bevel the edges (notice the V at the top) because otherwise you will not get proper fusion. You will need to use filler material in order to get penetration of the weld which causes fusion on the side of the walls.

4. Lap Joint

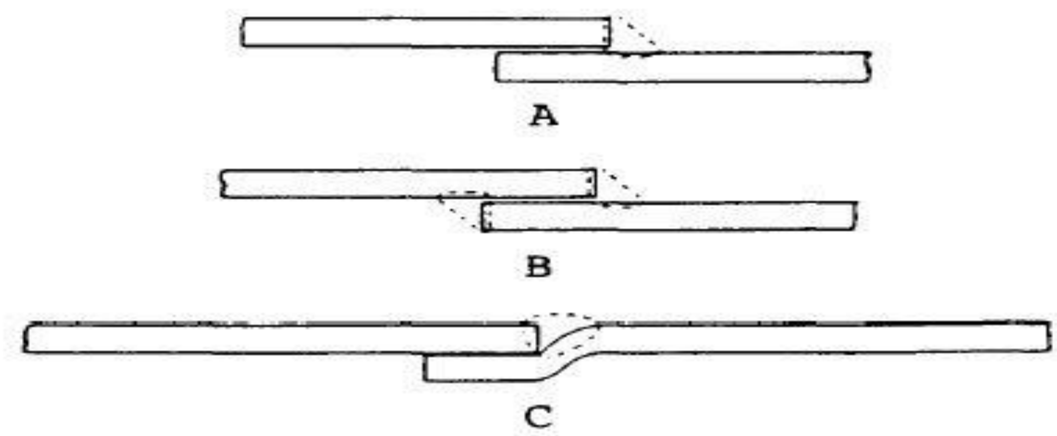


Figure 1.14 Lap Joint

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

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

5. Tee Joint

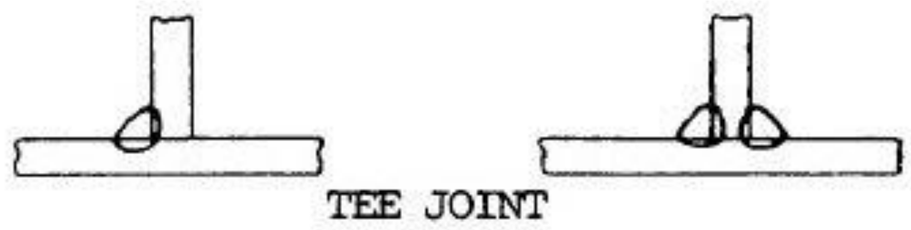


Figure 1.15 Tee Joint

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

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

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

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

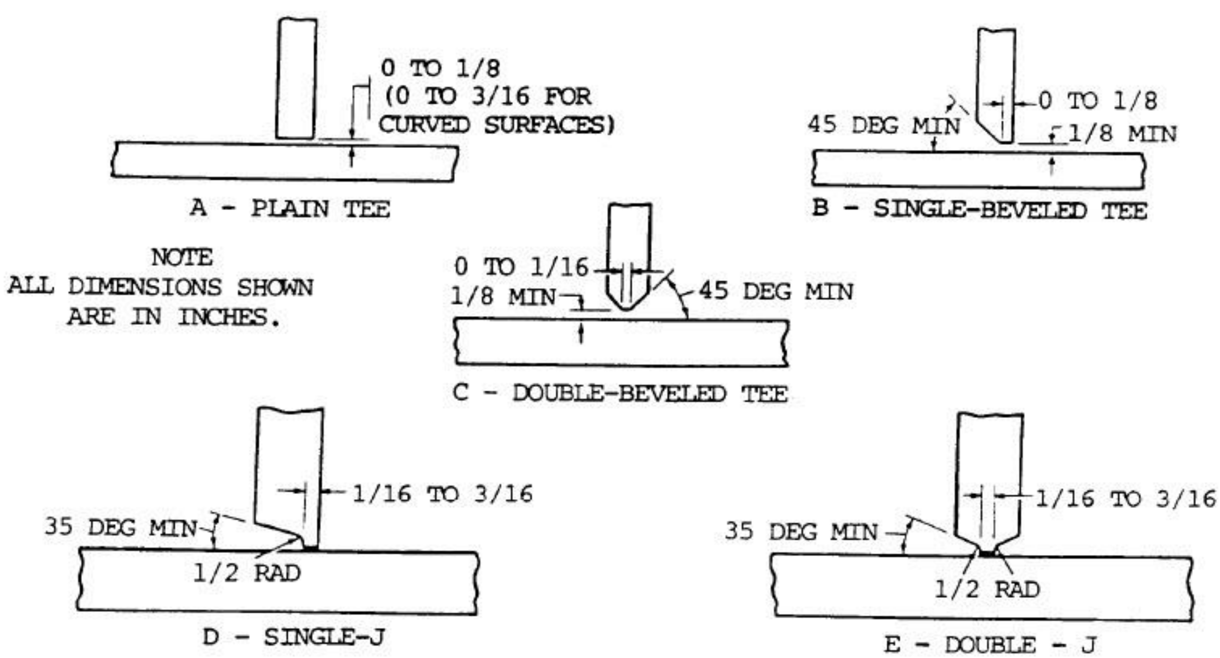


Figure 1.16 Joint Preparation for Tee Joints

- A regular Tee joint is seen in Image A above. This is a Tee joint that does not require any prep. Of course, you will clean the base metal (both pieces).
- Image B shows a single joint bevel. This will be used on heavier sections and you will be welding both sides.
- Image C is a joint that has been beveled on both sides, and both sides are welded as well. This type of preparation is for thick plates.
- Image D is what is called a sing J joint. You will weld both sides of this material but only bevel one side of the joint.
- Image E is to be used on even heavier or thicker material and it is called a double j joint.

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

1.4. Welding Consumables

When a piece of metal is heated in the atmosphere it combines with the oxygen and nitrogen to form oxides and nitrides which combine with the metal. If these were allowed to form in the weld it would result in a poor quality, weak and brittle weld. It is therefore necessary to protect the weld area from the air. This can be done either by surrounding the weld area by an inert gas or by the use of suitable fluxes. It is usual, with manual metal arc welding, to use coated electrodes. These electrodes consist of a metal core surrounded by a layer of suitable flux coating

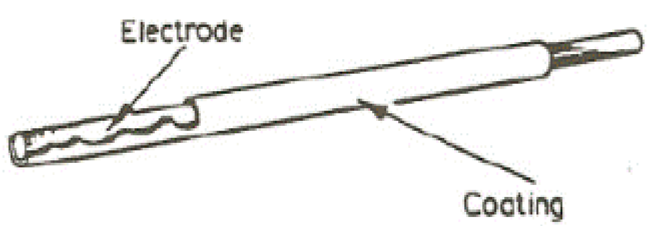


Figure 1.17 MMAW Electrode

Functions of the Electrode Coating

The six main functions of the electrode coating are as follows:

- To act as a flux and remove the impurities from the surfaces being welded.
- To form a protection layer (slag) over the weld, which prevents contact with the air as it starts to cool down. This stops the weld forming brittleness and provides a smoother surface by preventing ripples caused during the welding process.

- It forms a neutral gas atmosphere, which helps to protect the molten weld pool from oxygen and nitrogen in the surrounding air.
- It helps to stabilize the arc, allowing Alternating Current (A.C) to be used.
- It can add certain constituents to the weld by replacing any lost during the welding process.
- It can speed up the welding process by increasing the speed of melting of the metal and the electrode.

Classification electrode

The welding industry has adopted the American Welding Society's classification number series for welding rod electrodes.

The electrode identification system for steel arc welding is set up as follows:

- E – Indicates electrode for arc welding.
- The first two (or three) digits – indicate tensile strength (the resistance of the material to forces trying to pull it apart) in thousands of pounds per square inch of the deposited metal.
- The third (or fourth) digit – indicates the position of the weld. 0 indicates the classification is not used; 1 is for all positions; 2 is for flat and horizontal positions only; 3 is for flat position only.
- The fourth (or fifth) digit – indicates the type of electrode coating and the type of power supply used; alternating or direct current, straight or reverse polarity.
- The types of coating, welding current, and polarity position designated by the fourth (or fifth) identifying digit of the electrode classification are listed in Tables below.

Table 1.1. Coating, Current and Polarity Types Designated By the Fourth Digit in the Electrode Classification Number

Digit	Coating	Weld Current
0	*	*
1	Cellulose Potassium	ac, dcrp, dcsp
2	Titania sodium	ac, dcsp
3	Titania potassium	ac, dcsp, dcrp
4	Iron Powder Titania	ac, dcsp, dcrp
5	Low hydrogen sodium	dcrp
6	Low hydrogen potassium	ac, dcrp
7	Iron powder iron oxide	ac, dcsp
8	Iron powder low hydrogen	ac, dcrp, dcsp

When the fourth (or last) digit is 0, the type of coating and current to be used is determined by the third digit

<u>Example:</u>

The number E6010 – indicates an arc welding electrode with minimum stress relieved tensile strength of 60,000 psi; is used in all positions, and reverse polarity direct current is required.

Figure 1.18 Welding Electrode

The welding rod electrode identification system for **<u>stainless steel arc welding</u>** is set up as follows:

- E indicates electrode for arc welding.
- The first three digits indicated the American Iron and Steel-type of stainless steel.
- The last two digits indicate the current and position used.
- The number E-308-16 by this system indicates stainless steel Institute type 308; used in all positions; with alternating or reverse polarity direct current.

Figure 1.19 Stainless steel electrode

Care of Electrodes

Electrodes for welding mild steel should be kept dry to avoid the possibility of porosity. They should be kept in the packet in which they came to ensure correct identification and to avoid damage to the coating.

They should not be bent to avoid breaking of the coating and subsequent contamination of the weld.

Self-Check-1

Direction I: Multiple Choice

Instruction1- choose the best answer from the given alternatives.

1. Gloves used for arc welding should be __________.

A. Gauntlet gloves
B. Cotton gloves
C. Synthetic material gloves
D. Work gloves

2. The welding area should be kept free of _________.

A. Grease, fuels and solvents
B. Ultraviolet rays
C. Infrared rays
D. Electrodes

3. Arc welding produces harmful _________.

A. Noise
B. Light rays
C. Heat
D. Gas

4. One of the following isn't manual metal arc welding.

A. welding cables
B. ground clamp
C. electrode holder
D. welding torch

5. One of the following is types of welding joints.

A. T- joint
B. Edge joint
C. Corner joint
D. Lap joint
E. But joint

6. Manual metal arc welding is used _________ as a consumable.

A. Acetylene
B. Argonne
C. Electrode
D. Oxygen

Direction II: Short answer items

Instruction1- Briefly answer the following questions

1. Mention materials that can be welded by MMA welding.
2. List the two types of power sources
3. List at least 5 components of welding equipment.
4. Write the factors that can affect selection of power source for welding project?
5. Write the PPE requirements for MMAW?
6. What does an electrode numerical designation: E60123 mean?

Operation sheet 1

Operation Title: T- Joint

Instruction: Prepare materials for T- Joint

Purpose: To prepare material for MMAW

Required tools and equipment:

- Hand glove
- Clothing
- Shoes wear
- File
- Hack saw
- Angle grinder
- Wire brush
- Sand paper
- Two plates of 6 x 40 x 200mm

Precautions:

- Electrical shock
- Hand injury
- Proper utilization of angle grinder

Procedures:

Step-1: Prepare tools, equipment's and materials.

Step-2: Check the working of power source and equipment's.

Step-3: Clean the material using wire brush and sand paper.

Step-4: Prepare layout from drawing.

Step-5: Cut materials with hack saw or angle grinder.

Step-6: Prepare the edge with file or angle grinder.

Step-6: Ensure the quality of component.

Quality criteria:

- Cleaned component
- 45 degree angle of joint preparation

LAP Test	Practical Demonstration

Name: ___________________________ Date: _____________

Time started: _____3:00________ Time finished: ____9:00___

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within 6 hours.

Task 1: Prepare and clean materials for T- joint

Task 2: Prepare and clean materials for Butt joint

Task 3: Prepare and clean materials for Lap joint

Task 4: Prepare and clean materials for Edge joint

Task 5: Prepare and clean materials for Corner

Unit Two: Set-Up Welding Machine / Equipment and Accessories

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

- Manual metal arc welding equipment's, tools and accessories
- Assemble and Setting up Manual metal arc welding machine

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

- Identify Manual metal arc welding equipment's, tools and accessories
- Assemble and Setting up Manual metal arc welding machine

2.1. Manual Metal Arc Welding Equipment's, Tools and Accessories

A. Manual Metal Arc Welding Accessories

The principal equipment used in manual metal-arc welding includes:

- Welding power source
- Cables
- Electrode holder
- Earth clamp

Figure 2.1 MMAW Accessory

1. MMA Welding Power Supplies

There are two types of welding power source used to supply current for metal-arc welding.

- Alternating Current (AC) type.
- Direct current (DC) type.

a. The AC power source

This power source takes its power directly from the main electricity supply. It uses a transformer to supply the correct voltage to suit the welding conditions. A special device in the transformer allows the current in the secondary coil to be adjusted. The primary coil is connected to the electricity power supply and the secondary coil is connected to the earth clamp and the electrode holder.

b. The DC power source

There are two types of DC welding plant in use:

- DC generator
- Transformer-rectifier.

The DC generator uses a motor (electric, petrol or diesel powered) to generate electricity. The generator provides DC current for the arc.

A Transformer-rectifier is basically a transformer with an electrical device for changing the alternating current into a direct current output. This device is known as a rectifier. The transformer-rectifier has the advantage that it can be made to supply AC or DC.

c. Types of Power Supply for Arc Welding

To supply the electrical energy necessary for arc welding processes, a number of different power supplies can be used. The most common classification is constant current power supplies and constant voltage power supplies. In arc welding, the voltage is directly related to the length of the arc, and the current is related to the amount of heat input. Constant current power supplies are most often used for manual welding processes such as gas tungsten arc welding and shielded metal arc welding, because they maintain a relatively constant current even as the voltage varies. This is important because in manual welding, it can be difficult to hold the electrode perfectly steady, and as a result, the arc length and thus voltage tend to fluctuate. Constant voltage power supplies hold the voltage constant and vary the current, and as a result, are most often used for automated welding processes such as gas metal arc welding, flux cored arc welding, and submerged arc welding. In these processes, arc length is kept constant, since any fluctuation in the distance between the wire and the base material is quickly rectified by a large change in current. For example, if the wire and the base material get too close, the current will rapidly increase, which in turn causes the heat to increase and the tip of the wire to melt, returning it to its original separation distance.

d. Polarity Settings for Welding Electrodes

The type of current used in arc welding also plays an important role in welding. Consumable electrode processes such as shielded metal arc welding and gas metal arc welding generally use direct current, but the electrode can be charged either positively or negatively. In welding, the positively charged anode will have a greater heat concentration, and as a result, changing the polarity of the electrode has an impact on weld properties. If the electrode is positively charged, it will melt more quickly, increasing weld penetration and welding speed. Alternatively, a negatively charged electrode results in more shallow welds. Non-consumable electrode processes, such as gas tungsten arc welding, can use either type of direct current, as well as alternating current. However, with direct current, because the electrode only creates the arc and does not provide filler material, a positively charged electrode causes shallow welds, while a negatively charged electrode makes deeper welds. Alternating current rapidly moves between these two, resulting in medium-penetration welds. One disadvantage of AC, the fact that the arc must be re-ignited after every zero crossing, has been addressed with the invention of special power units that produce a square wave pattern instead of the normal sine wave, making rapid zero crossings possible and minimizing the effects of the problem.

The Advantages and Disadvantages MMA Welding

- **The Advantages of MMA Welding**

- Flux Shielded Manual Metal Arc Welding is the simplest of all the arc welding processes.
- The equipment can be portable and the cost is fairly low.
- This process finds innumerable applications, because of the availability of a wide variety of electrodes.
- A wide range of metals and their alloys can be welded.
- Welding can be carried out in any position with highest weld quality.
- The process can be very well employed for hard facing and metal deposition to reclaim parts or to develop other characteristics like wear resistance etc.
- Joints (e.g. between nozzles and shell in a pressure vessel) which because of their position are difficult to be welded by automatic welding machines are easily accomplished by flux shielded metal arc welding.

- **The Disadvantages of MMA Welding**

- Because of the limited length of each electrode and brittle flux coating, it is difficult to automate the process.
- In welding long joints (e.g., in pressure vessels), as one electrode finishes, the weld is to be progressed with the next electrode. Unless properly cared, a defect (like slag inclusion or insufficient penetration) may occur at the place where welding is restarted with the new electrode.

- The process uses stick electrodes and thus it is slower as compared to MIG welding.

The Advantages and Disadvantages of AC and DC Welding Plants

- **The Advantage of A. C. Welding Plants**

They are cheaper to buy than D.C. Sets. The initial cost is approx. V of that required for a D.C. set of equivalent rating.

Little or no maintenance cost, this is because there are no moving parts in an A.C. Transformer.

There is no “Arc Blow” as with D.C.

- **The Disadvantages of A. C. Welding Plants**

Nonferrous electrodes are not so well deposited.

The electric shock hazard is more pronounced with A.C. than with D.C.

- **The Advantages of D.C. Welding**

They can be used to deposit both ferrous and non-ferrous electrodes.

Smoother welding giving an advantage when welding thin sheet metal.

Safer to use in damp conditions where risk of electric shock is greater i.e. boiler work etc.

Petrol or diesel sets can be used in remote areas where there is no mains supply. Site work etc.

- **Disadvantages with D.C. Welding**

More expensive to purchase than A.C. Sets.

Periodic maintenance of the plant is necessary because of the moving parts.

Troubles from “Arc Blow”.

Arc Blow

“Arc Blow” is encountered with D.C welding equipment. The arc is forced away from the weld point notably when welding in corners. The conductors carrying the current namely the welding lead from the set, and the return lead from the work piece are carrying current in opposite direction so that a repulsive magnetic force is set up which effects the D.C. Welding Arc.

This conditions occurs most when using currents above 200 or below 40 amps. The best method of connections are:

- Weld away from the earth connection.
- Change the position of the earth wire on the work.
- Wrap the welding cable a few turns around the work, if possible on girders etc.
- Change the position of the work on the table if working at a bench.

2. MMA Welding Cables

The purpose of the cables is to carry the current required for the arc. One cable ends at the earth clamp. The other goes to the electrode holder. It is important that the cables are not too small in diameter. Small cables may have too high a resistance and may overheat during the welding operation. Most cables contain many strands of fine copper wire. This enables them to carry the electric current and it makes them very flexible.

3. The Electrode Holder

The electrode holder is an electrically insulated clamping device which holds the electrode. It is connected to one of the cables coming from the welding plant. The current passes from the cable through the electrode holder to the electrode.

4. The Earth Clamp

This is connected to the other cable coming from the power plant. It is secured to the work by means of a screw clamp or a strong spring-operated clip.

B. Hand and power tools used in MMAW

- Chipping Hammer
- Wire Brush, Power Wire Wheel
- Scriber
- Hacksaw
- Bench vice
- Flat file
- Tongs
- Chipping hammer
- Tri square
- Hammer
- C – clamp
- Portable grinder

Figure 2.2 Tools and equipment's for MMAW

C. Measuring equipment in MMAW

- Tape rule
- Steel rule
- Bevel Protractor
- Vernier Caliper
- Level

2.2. Assemble and Setting up Manual metal arc welding machine

The work is connected to the source of electrical supply (welding set). The electrode holder, held by the operator, is connected to the same source. The electric arc completes the circuit.

Set-Up for Manual Metal Arc Welding.

The arc will not start until the electrode touches the work. This completes the circuit. When the electrode is lifted away slightly, and a gap appears once more, electricity passes across the gap using the lined-up atoms of (ionized) air as a conductor. The arc is stopped, or broken, by moving the electrode further away. Intense heat is developed; temperatures in manual metal arc welding measure up to 6000°C. The heat at the upper end of the arc melts the consumable electrode, while the heat at the lower end of the arc melts the parent metal (the metal being welded).

The basic elements involved in manual arc welding process are shown in Figure: below. This process employs coatings or fluxes to prevent the weld pool from the surrounding atmosphere.

1. Switch box.
2. Secondary terminals
3. Welding machine.
4. Current reading scale.
5. Current regulating hand wheel.
6. Leather apron.
7. Asbestos hand gloves.
8. Protective glasses strap
9. Electrode holder.
10. Hand shield
11. Channel for cable protection.
12. Welding cable.
13. Chipping hammer.
14. Wire brush.
15. Earth clamp.
16. Welding table (metallic).
17. Base metal

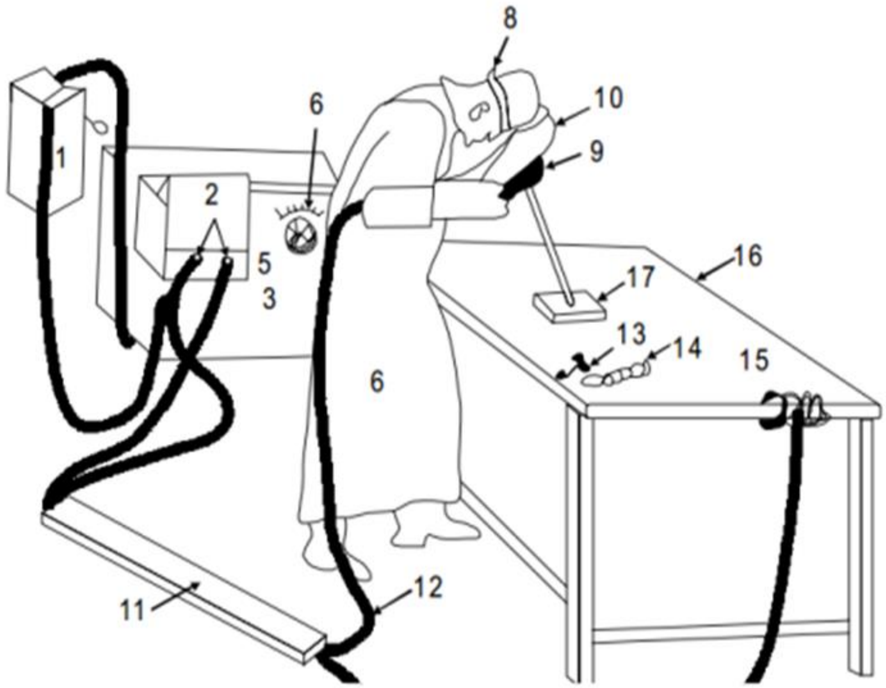


Figure 2.3 the basic elements of arc welding equipment

Self-Check -2

Directions I: Multiple choices

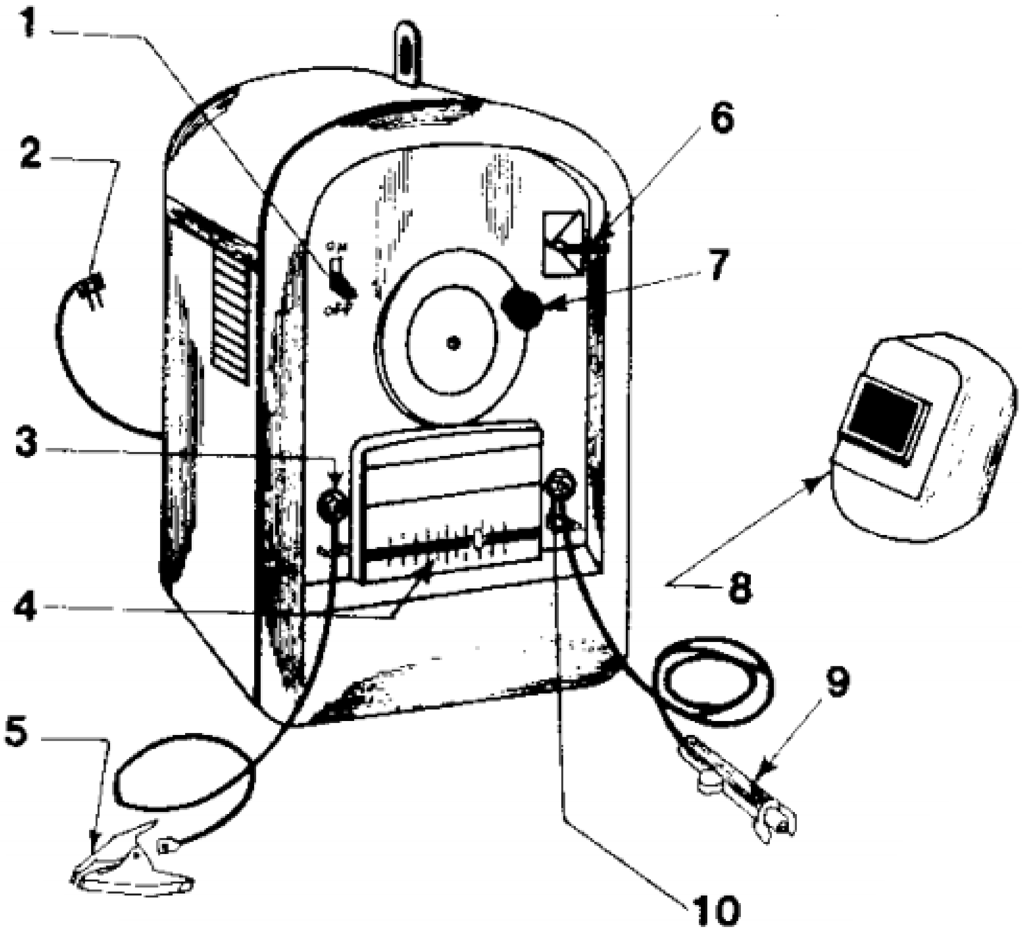
Instruction I: Choose the letter of the best answer and write on the space provided

1. Which one of the following cannot affect weld quality?
   A. Welding current
   B. Travel speed
   C. Arc length
   D. Welding electrode
   E. None of the above
2. Which type of polarity connection is better for creating good penetration
   A. DCEN
   B. DCEP
   C. Straight polarity
   D. None of the above
3. Which one of the following is not an aspect while setting welding current?
   A. Thickness of plate
   B. Welding position
   C. Length of cable required:
   D. Ease of arc initiation and maintenance needed even with low current:
   E. None of the above
4. Welding cables should be protected from ___________.
   A. sparks and flames
   B. excessive voltage
   C. excessive amperage
   D. all of these
5. If the electrode holder is placed on a grounded welding table with the welding machine on, what will happen?
   A. Nothing
   B. The welding machine will automatically shut off
   C. A deadly electrical circuit is established
   D. An arc will be struck

Directions II: Manual Metal Arc Welder Parts Identification Test

Instruction II: Match the number of each arc welder part with the correct part name.

___ A. Polarity switch	___ F. Switch
___ B. Ground clamp	___ G. Ground cable terminal
___ C. Power cord	___ H. Electrode holder
___ D. Helmet	___ I. Amperage output scale
___ E. Electrode cable terminal	___ J. Amperage adjustment hand wheel



Operation sheet 2

Operation Title: Set up manual metal arc welding equipment

Instruction: Basic procedures to set up welding equipment

Purpose: to set up the MMAW

Required tools and equipment:

- Hand glove
- Clothing
- Shoes wear

Precautions:

- Electrical shock

Procedures:

Step-1: Check the working of power source for the welding machine.

Step-2: Remember electricity is a good servant but a bad master.

Step-3: Call an electrician for solving any electrical problems.

Step-4: Connect the welding cables with the welding machines.

Step-5: Ensure that the cable connections are clean, dry, and are attached to the proper terminals of the machine.

Step-6: Attach tightly the earth cable with the welding table at the proper place.

Step-7: Keep the electrode-holder at a safe place

Step-8: If the machine is on D.C. power, connect the cables in correct polarity. Polarity means changing of +ve and -ve to the electrode is called polarity.

Quality criteria:

- Correct cable connection
- Proper clamp earth cable
- Right electrode holder
- Proper electrical installation

LAP Test	Practical Demonstration

Name: ___________________________ Date: _____________

Time started: _____3:00________ Time finished: ____6:00___

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within 3 hours.

Task 1: Setting up manual metal arc welding machine with full accessory.

Unit Three: Minimize and Rectify Distortion

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

- Prevent Distortion
- Rectifying distortion

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

- Select and applying appropriate distortion prevention measures
- Identify Rectifying mechanism of distortion

3.1. Prevent Distortion

Distortion

Distortion in a weld results from the expansion and contraction of the weld metal and adjacent base metal during the heating and cooling cycle of the welding process. Doing all welding on one side of a part will cause much more distortion than if the welds are alternated from one side to the other. During this heating and cooling cycle, many factors affect shrinkage of the metal and lead to distortion, such as physical and mechanical properties that change as heat is applied.

Expansion and Contraction in Welding and Cutting Processes

When a piece of metal is heated it expands and, on cooling down, it contracts. With welding and cutting processes the heating takes place over a localized area of the metal and expansion can only take place in that portion of the metal. The subsequent contraction that takes place on cooling can result in forces causing distortion or, even worse, cracking of the metal. When a weld bead is deposited on the joint between two plates, the molten metal passing through the arc is at a very high temperature. The arc melting the edges of the joint and the filler and base metal fuse together. As the arc moves across the joint the deposited bead starts to cool and considerable contraction forces are set up in the weld area.

As the deposited metal was at a higher temperature than the parent metal it will contract more and also, since its volume is greater, there is a large volume of metal shrinkage. The result is distortion of the joint.

3.2. Rectifying distortion

The following are several ways of controlling or rectifying the effect of distortion during welding;

A. Presetting;
B. Back stepping or step welding,
C. Jigging, and
D. Preheating.

They are described and shown below:

A. Presetting

This entails setting the joint out of alignment prior to welding so that after contraction has taken place the joint is aligned.

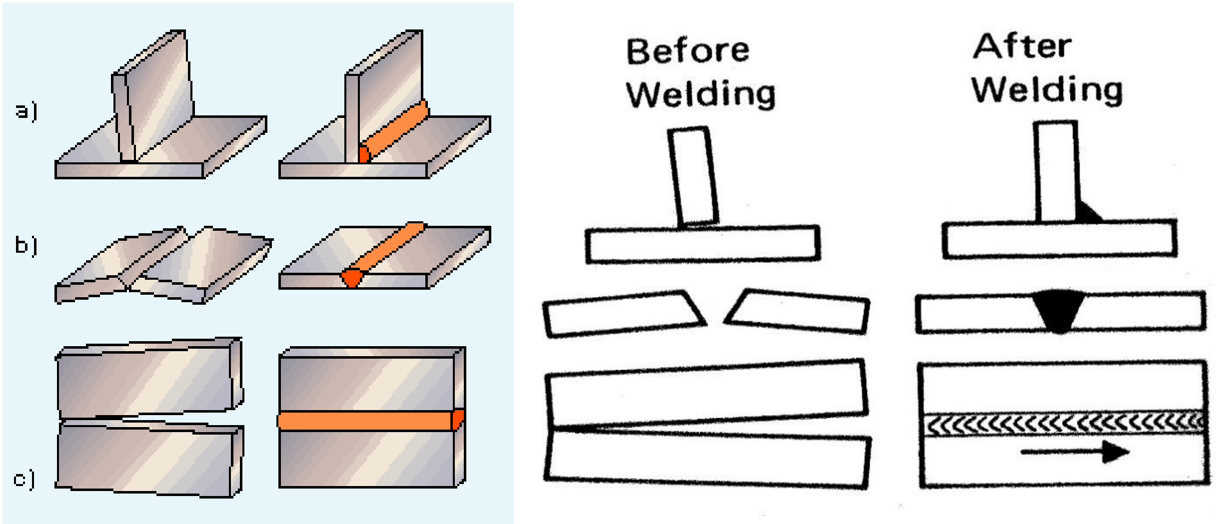


Figure 3.1 Presetting

B. Back stepping or Step welding

This entails welding the joint in short steps, ensuring that expansion and contraction zones are placed next to one another.

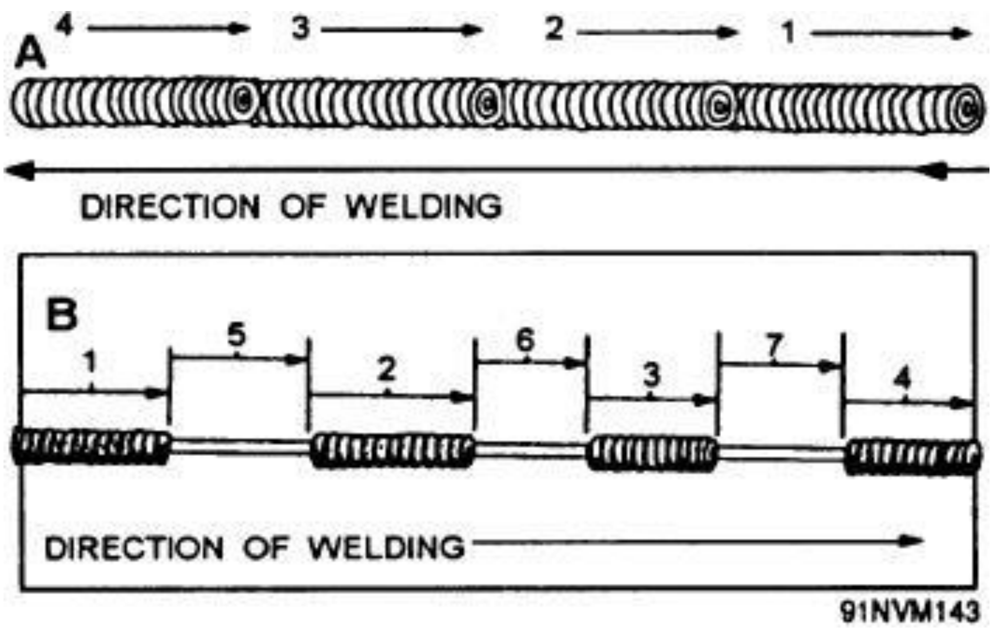


Figure 3.2 back stepping or Step welding

C. Jigging

This entails holding the metal being welded in a jig, restraining the distortion mechanically.

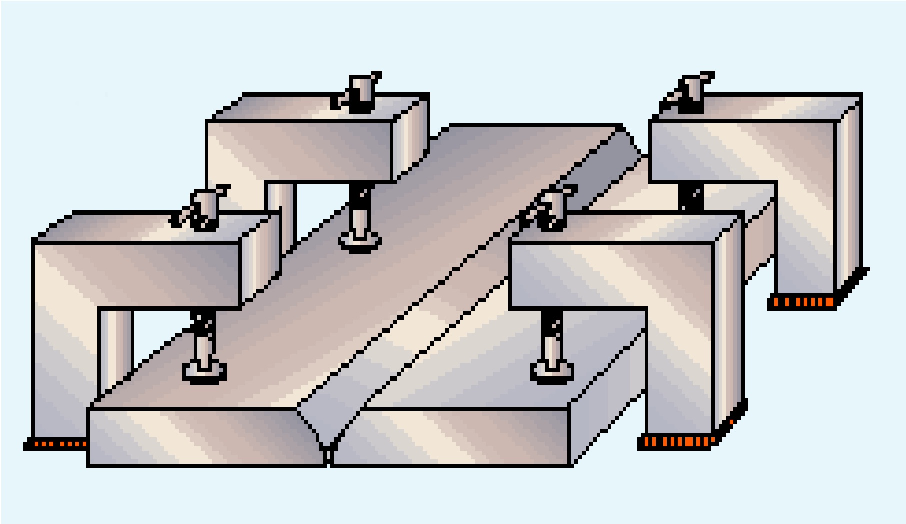


Figure 3.3 Jigging base metal

D. Preheating

The process of preheating involves heating the area around the weld joint or the entire part to a specified temperature before welding. This reduces the cooling rate of the weld and drives out moisture, which in turn helps prevent hydrogen buildup and the potential for cracking as well as preventing distortion.

Figure 3.4 Preheating Material

Summary: A Checklist to Minimize Distortion

Follow this checklist in order to minimize distortion in the design and fabrication of weldments:

- Do not over weld
- Control fit-up
- Use intermittent welds where possible and consistent with design requirements
- Use the smallest leg size permissible when fillet welding
- For groove welds, use joints that will minimize the volume of weld metal. Consider double-sided joints instead of single-sided joints
- Weld alternately on either side of the joint when possible with multiple-pass welds
- Use minimal number of weld passes
- Use low heat input procedures. This generally means high deposition rates and higher travel speeds
- Use welding positioners to achieve the maximum amount of flat-position welding. The flat position permits the use of large-diameter electrodes and high- deposition-rate welding procedures
- Balance welds about the neutral axis of the member
- Distribute the welding heat as evenly as possible through a planned welding sequence and weldment positioning
- Weld toward the unrestrained part of the member
- Use clamps, fixtures, and strong backs to maintain fit-up and alignment
- Prepend the members or preset the joints to let shrinkage pull them back into alignment
- Sequence subassemblies and final assemblies so that the welds being made continually balance each other around the neutral axis of the section

Self-Check -3

Directions I: Short answer items

Instruction I: Briefly answer the following question

1. What is manual metal arc welding distortion?
2. How to prevent and minimize welding distortion?
3. What are the rectifying mechanism of distortion?
4. Explain the distortion rectifying mechanism in detail?

Unit Four: Manual Metal Arc Welding (MMAW)

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

- Set up welding current
- Weld materials
- Clean Welding beads

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

- Set up welding current for welding preparation.
- Weld materials in deferent welding technics and welding positions.
- Clean Welding beads with appropriate cleaning tools.

4.1. Set Up Welding Current

A. Welding Current

Welding current is the term used to describe the electricity that jumps across the arc gap between the end of the electrode and the metal being welded. An electric current is the flow of electrons. The resistance to the flow of electrons (electricity) produces heat.

The greater the electrical resistance, the greater the heat and temperature that the arc will produce. Air has a high resistance to current flow, so there is a lot of heat and temperature produced by the SMA welding arc. Electrons flow from negative (–) to positive (+).

- **Voltage, or volts (V)**, is the measurement of electrical pressure in the same way that pounds per square inch is a measurement of water pressure. Voltage controls the maximum gap that the electrons can jump to form the arc. A higher voltage can jump a larger gap. Welding voltage is associated with the welding temperature.
- **Amperage, or amps (A),** is the measurement of the total number of electrons flowing, in the same way that gallons are a measurement of the amount of water flowing. Amperage controls the size of the arc. Amperage is associated with the welding heat.
- **Wattage, or watts (W),** is a measurement of the amount of electrical energy or power in the arc. Watts are calculated by multiplying voltage (V) times amperes (A), Watts are associated with welding power or how much heat and temperature an arc produces.

B. Setting Current

It is important to consider various aspects while selecting suitable type of welding current for developing weld joints in a given situation. Some of the points need careful considerations for selection of welding current are given below.

1. Thickness of plate/sheet to be welded: DC for thin sheet to exploit better control over heat.
2. Length of cable required: AC for situations where long cables are required during welding as they cause less voltage drop i.e. loading on power source
3. Ease of arc initiation and maintenance needed even with low current: DC preferred over AC
4. Arc blow: AC helps to overcome the arc blow as it is primarily observed with DC only.
5. Odd position welding: DC is preferred over AC for odd position welding (vertical and overhead) due to better control over heat input.
6. Polarity selection for controlling the melting rate, penetration and welding deposition rate: DC preferred over AC

7. AC gives the penetration and electrode melting rate somewhat in between that is offered by DCEN&DCEP.

Figure 4.1 Set up Welding Current

Look at the numbers around the amperage dial and find the recommended amperage for the thickness and type of metal that you're going to weld. Turn the dial on the stick welder right to increase the amps or left to decrease the amps until the arrow on the knob points at the correct number of amps.

Table 4.1 Manual metal arc welding amperage chart

Electrode	Diameter (Inches)	Diameter (mm)	Amperage Range
6010/6011	3/32"	2.4	40-85
6010/6011	1/8"	3.2	75-125
6010/6011	5/32"	4.0	110-165
6010/6011	3/16"	4.8	140-210
6010/6011	7/32"	5.6	160-250
6010/6011	1/4"	6.4	210-315
6013	1/16"	1.6	20-45
6013	5/64"	2.0	35-60
6013	332"	2.4	40-90
6013	1/8"	3.2	80-130
6013	5/32"	4.0	105-180
6013	3/16"	4.8	150-230
6013	7/32"	5.6	210-300
6013	1/4"	6.4	250-350
7014	3/32"	2.7	80-125
7014	1/8"	3.2	110-165
7014	5/32"	4.0	150-210
7014	3/16"	4.8	200-275
7014	7/32"	5.6	255-340
7014	1/4"	6.4	330-415

4.2. Weld Materials

4.2.1. Procedures for arc welding

To weld materials by manual arc welding, the following common procedures should be followed. Safety and other issues should be considered as described in the previous information sheets of this learning guide.

- Set the arc welding plant by one cable connection to electrode with electrode holder another connection for work piece with earthling clamp.
- Set the current range & electrode according to plate thickness.
  Ex: 6mm plate, i) Current range 120Amps
  ii) Electrode size 3.2mm Dia
- Set the work piece for tack weld by fixing with C Clamp using suitable tack welding fixture.
- Tack the pieces at both ends by scratching or tapping method.
- Place the tack weld unit to full bead welding fixture as provided in working table.
- Deposits full bead weld with correct
  i) Arc lengths 3 to 5mm
  ii) Electrode angle 700 to 80o
  iii) Travel speed 150mm/min
  iv). Uniform Movement
  v) Direction towards your end, usually from left to right for right handed welders.
- Reverse the joint to perform full bead on other end.
- Chip off all slag, remove spatters with using white spectacles
- Clean the bead by wire brush with using white spectacles.
- Inspect the weld bead

4.2.2. Welding positions

Understanding the four basic welding positions can help you chose the right filler metal and welding process for whatever project or job you're tackling. Each welding position may require different techniques, parameters and preparation to achieve the best results.

To help operators understand the type of weld joint (fillet or groove) and the weld position, each weld is given a number and a letter — 1G, 2G, 3G, 4G or 1F, 2F, 3F, 4F — to indicate the position and the type of weld required. Welds with a 1 are flat position, 2 is horizontal, 3 is vertical and 4 is overhead. F stands for fillet weld, while G is a groove weld. A fillet weld joins together two pieces of metal that are perpendicular or at an angle. A groove weld is made in a groove between workpieces or between workpiece edges. Using this system, a 2G weld is a groove weld in the horizontal position.

Fillet and groove welds are performed in these basic positions:

1. Flat (1)
2. Horizontal (2)
3. Vertical (3)
4. Overhead (4)

1. Flat welding position

Generally, flat is an easier position to weld in since you're not fighting gravity. The weld puddle stays fluid and wets into the joint evenly. As a result, operators can typically run hotter with higher deposition rates in the flat position because there is no worry about the puddle becoming too fluid and gravity pulling it out of the joint.

Any welding process can be used to weld in the flat position. Just be sure to use the recommended techniques for whichever process you're using. For example, the stick process produces a slag during welding so you may want to use a drag technique rather than a push technique.

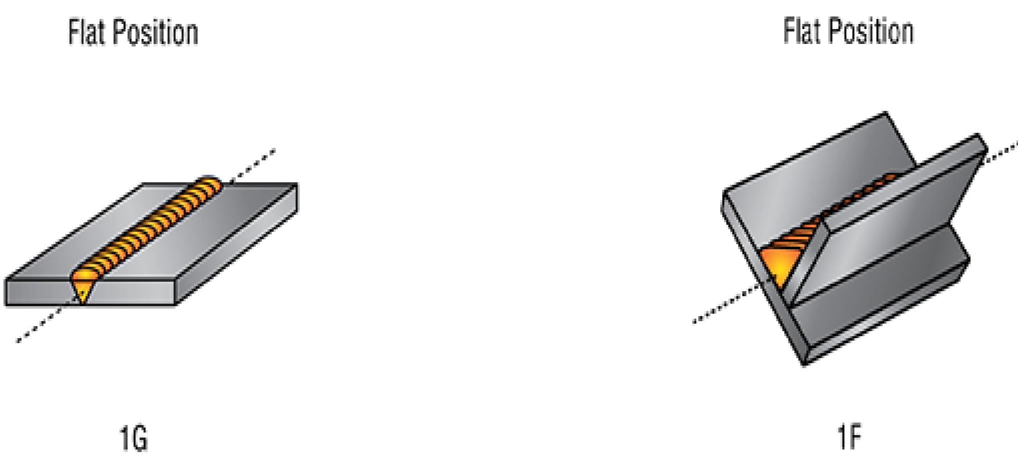


Figure 4.2 Scheme of placement of components to be welded for flat welding

2. Horizontal welding position

In a horizontal weld, the weld axis is roughly horizontal. Welds in the horizontal position share many similarities with flat position welds.

A 2G weld is slightly more difficult than a 2F weld because the 2F provides a bottom shelf to ensure the weld puddle doesn't get out of control or sag too much. To combat the effect of gravity on the weld puddle in a horizontal groove weld, favor the top edge of the joint slightly with the work angle, knowing the puddle may sag a bit. In a horizontal fillet weld, keep a 45-degree angle to the joint to make sure the heat is focused where the two pieces come together.

Be careful not to run too hot in horizontal welds since a puddle that's too fluid can be the victim of gravity. Tweak your weld parameters to make sure the puddle doesn't get too hot or too fluid.

Figure 4.3 Scheme of placement of components to be welded for horizontal welding

3. Vertical welding position

Vertical welds can be done in either vertical up (moving bottom to top in the weld joint) or vertical down (moving top to bottom in the weld joint). Vertical up is typically more common, especially on thicker materials. This welding position may be required when you're working on a large weldment that cannot be easily moved into the flat or horizontal position.

Moving up the plate for a vertical weld, the weld puddle will naturally want to sag out of the joint. If you use the same techniques and parameters that are ideal for flat and horizontal welds on a vertical weld, it likely won't produce a very good weld.

A 90-degree travel angle is typically recommended for a 3G weld, while a 45-degree angle is recommended for a 3F weld.

Figure 4.4 Scheme of placement of components to be welded for vertical welding

4. Overhead welding position

Overhead welds may be required when you're working on a fixed piece of equipment or metal that cannot be moved. Operators may find themselves lying on the ground or floor or their shop for overhead welding, so it's important to find the most comfortable position with a range of motion. The same techniques used for vertical welding often apply to overhead welding. A 4G weld will require a slight weave or manipulation of the weld puddle to wash in at the toes better, just as with a vertical weld. The parameters should also be dialed back to run cooler with overhead welds, since you don't want a weld puddle that is too fluid that will fall out of the weld joint and onto you.

One of the biggest factors to think about when welding in the overhead position is that the sparks will drop down. You may want extra protection on the top of your head, such as a bandana under your welding helmet. Use a fully leather welding jacket, especially with a process like stick welding, which produces more sparks and spatter.

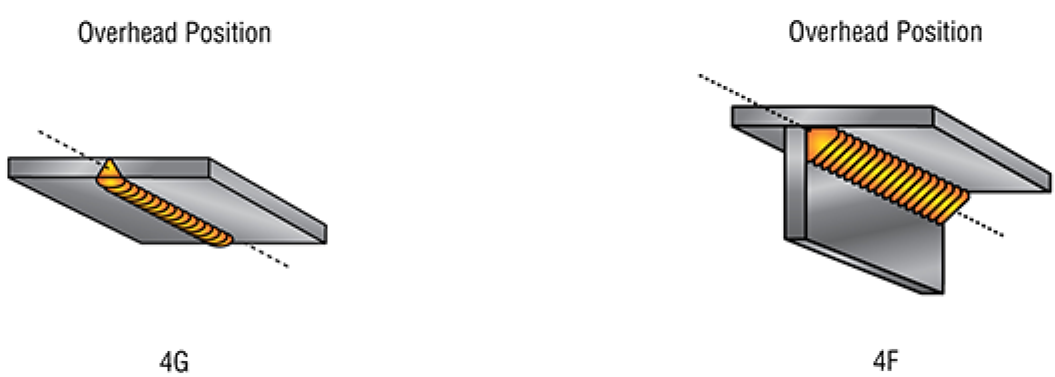


Figure 4.5 Scheme of placement of components to be welded for vertical welding

4.2.3. Welding Techniques

1. Current Too Low

If the current value is too low the resulting weld has poor penetration, due to the lack of heating to create complete fusion. The weld filler metal tends to heap up on the surface of the plate without fusing to it and the arc has an unsteady sputtering sound.

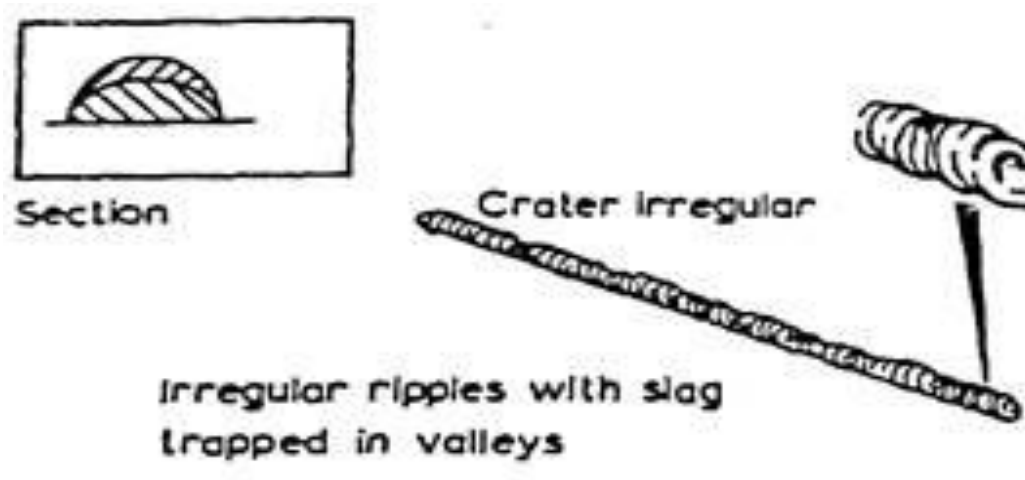


Figure 4.6 Current Too Low

2. Current Too High

When the current value used is too high the electrode becomes red hot and a large amount of spatter takes place. This can result in blowholes being formed in the plate, excessive penetration resulting in weld metal beads on the underside of the plate, undercut along the edge of the weld and excessive oxidation and slag which is hard to remove. The arc has a fierce crackling sound.

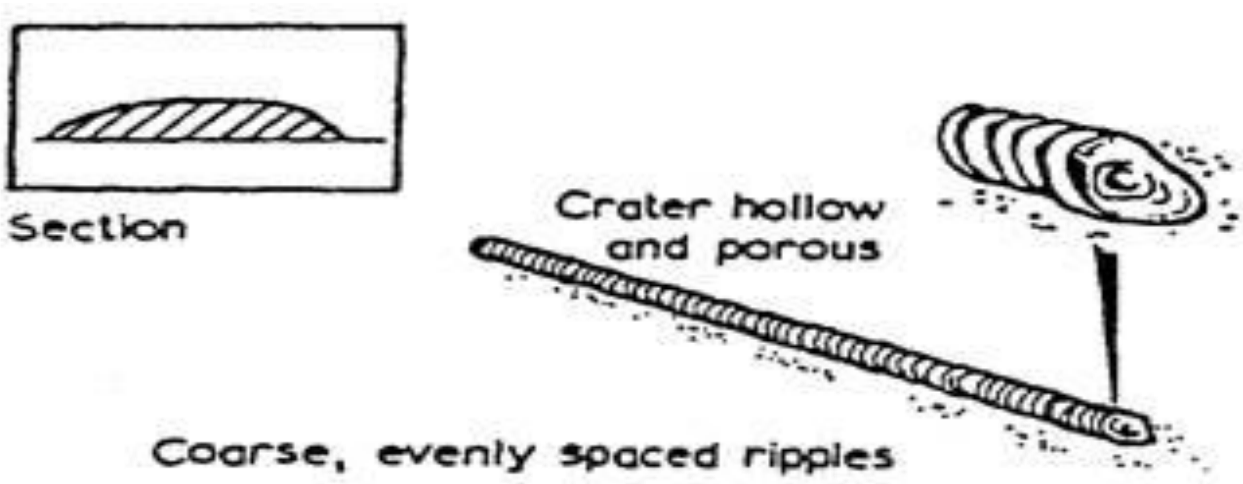


Figure 4.7 Current Too High

3. Correct Current

With the correct current the arc has a steady crackling sound. The weld formed has good **penetration** and is easily controlled.

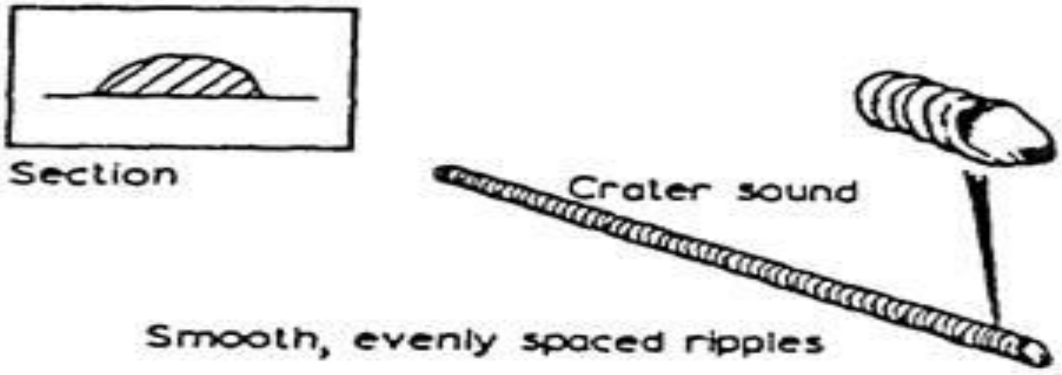


Figure 4.8 Correct Current

4. Arc Length

The arc length is the distance between the tip of the electrode and the surface of the weld pool. It should be approximately equal to the diameter of the wire core of the electrode being used. When this distance is correct the electrode metal is deposited in a steady stream of metal particles into the weld pool. If the arc length is reduced it becomes difficult to maintain the arc, due to the increase in welding current that takes place, and it can result in the electrode becoming welded to the weld pool. Also, if the arc length is increased the welding current is reduced, resulting in a poor weld being produced, and the protective gas shield produced from the electrode surrounding the weld pool cannot efficiently prohibit the formation of oxides, etc., in the weld.

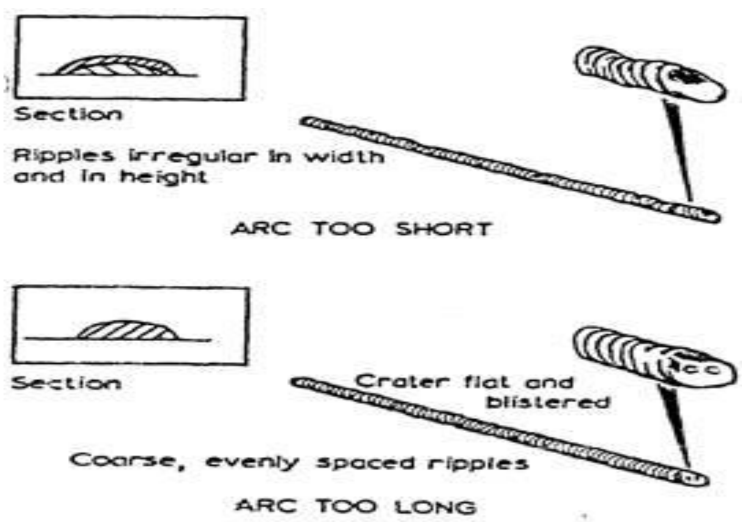


Figure 4.9 the effect of Arc Length

5. Speed of Travel

a. Too Fast

A fast rate of travel results in a thin deposit of the filler metal and can result in insufficient fusion of the filler metal with the base metal. The surface of the weld has elongated ripples and a porous crater.

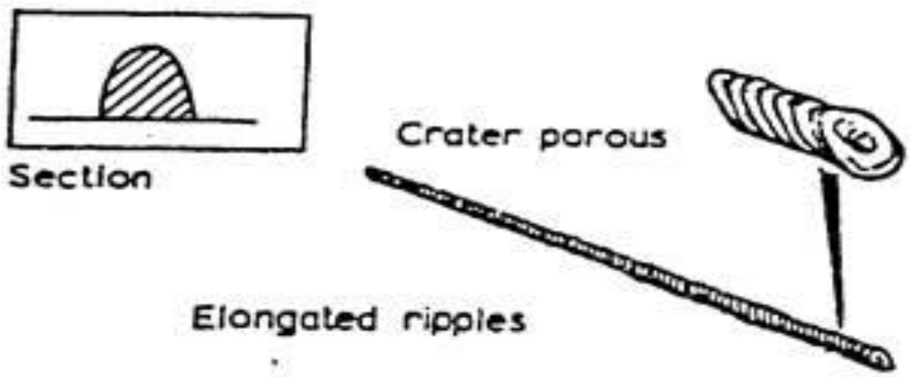


Figure 4.10 Speed of travel – too fast

b. Too Slow

Too slow a rate of travel gives a wide thick deposit of the filler and it can allow the slag to flood the weld pool making it difficult to deposit the filler metal. The surface of the weld appears as coarse ripples and has a flat crater.

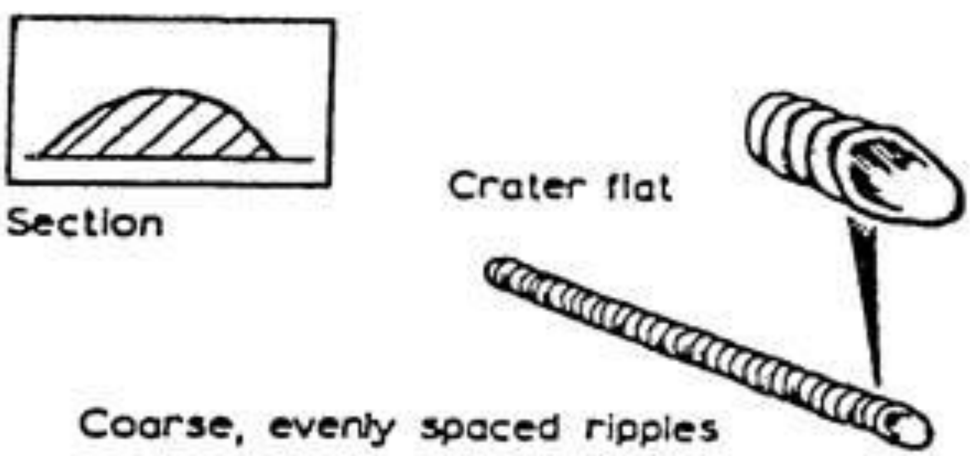


Figure 4.11 Speed of travel – too slow

Bead comparison

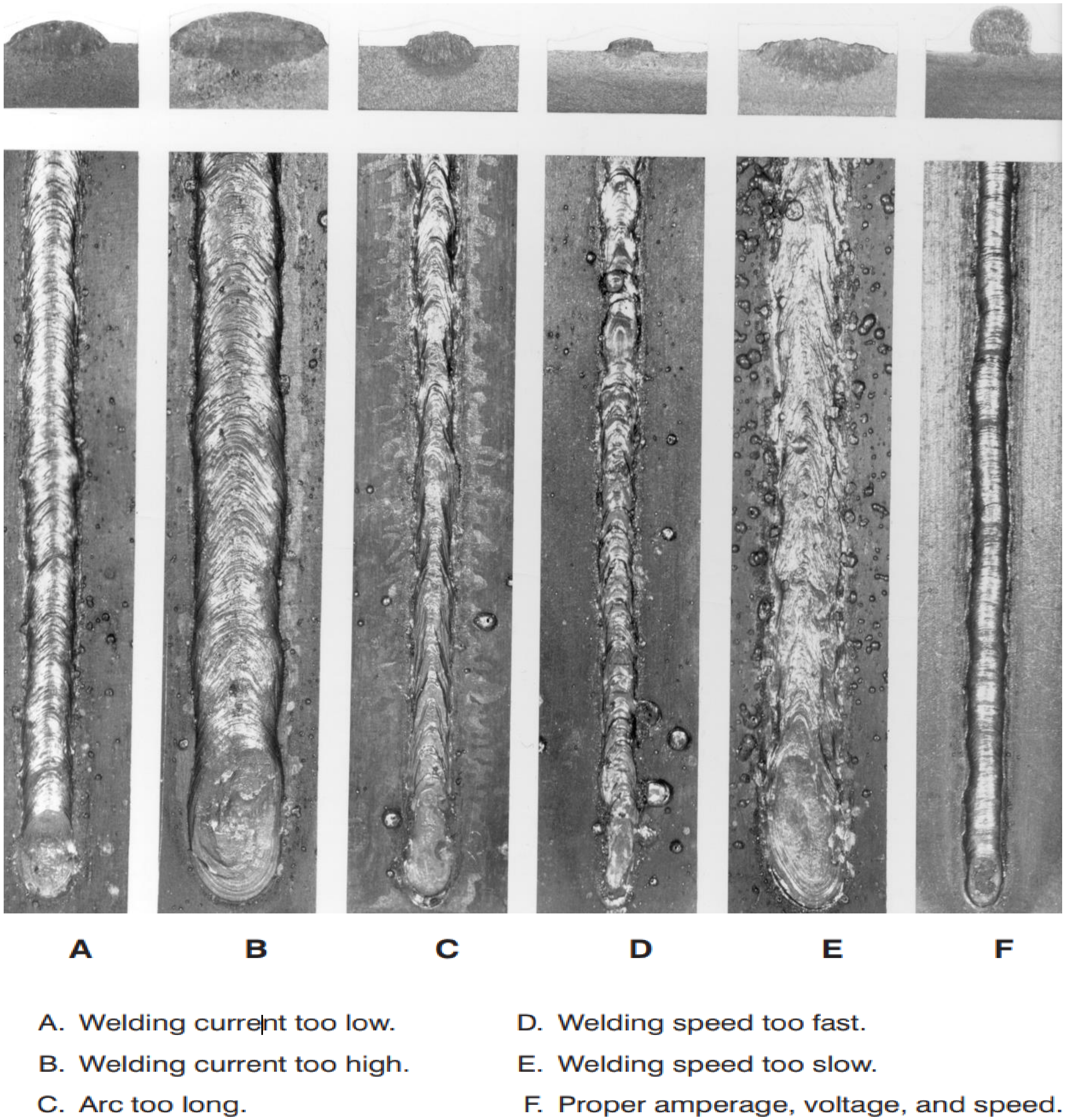


Figure 4.12 Bead comparison stick welding

4.2.4. Strike and Establish an Arc

A welding arc is maintained when the welding current is forced across a gap between the electrode tip and the base metal. A welder must be able to strike and establish the correct arc easily and quickly.

There are two general methods of striking the arc:

1. Scratching
2. Tapping

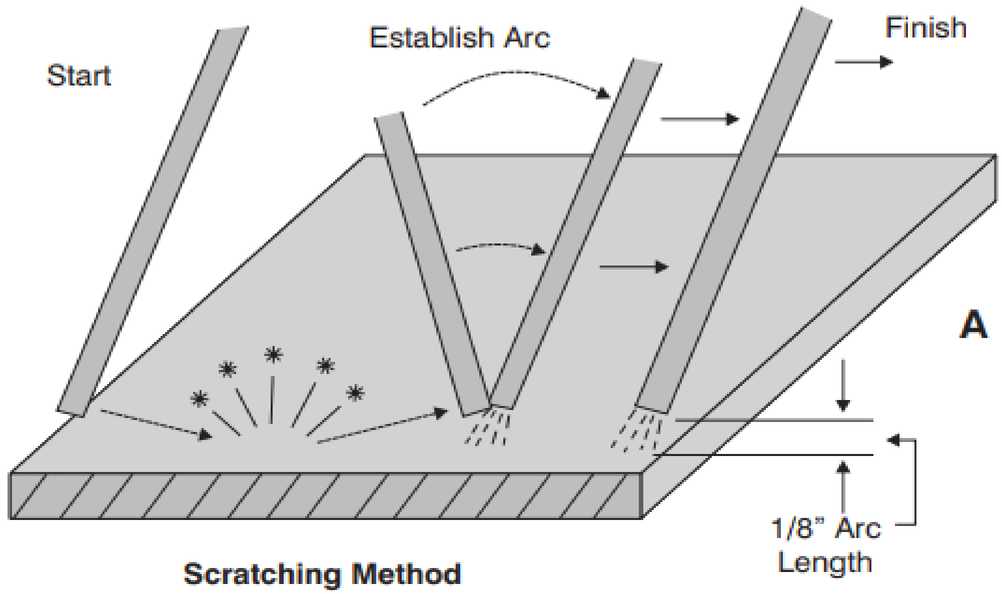


Figure 4.13 Scratching method

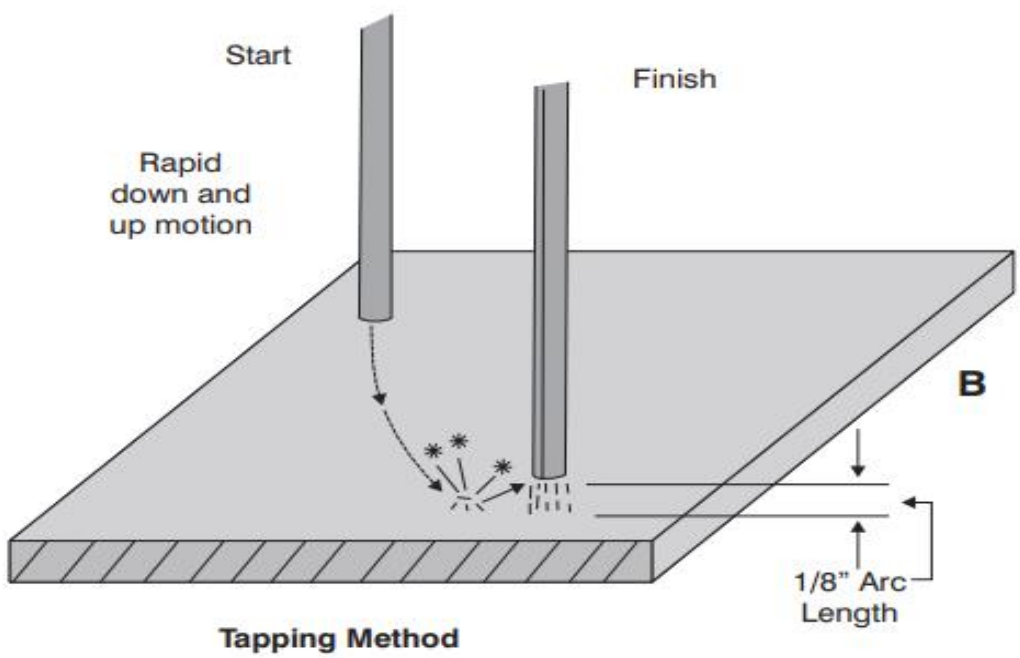


Figure 4.14 Tapping method

Electrode movement

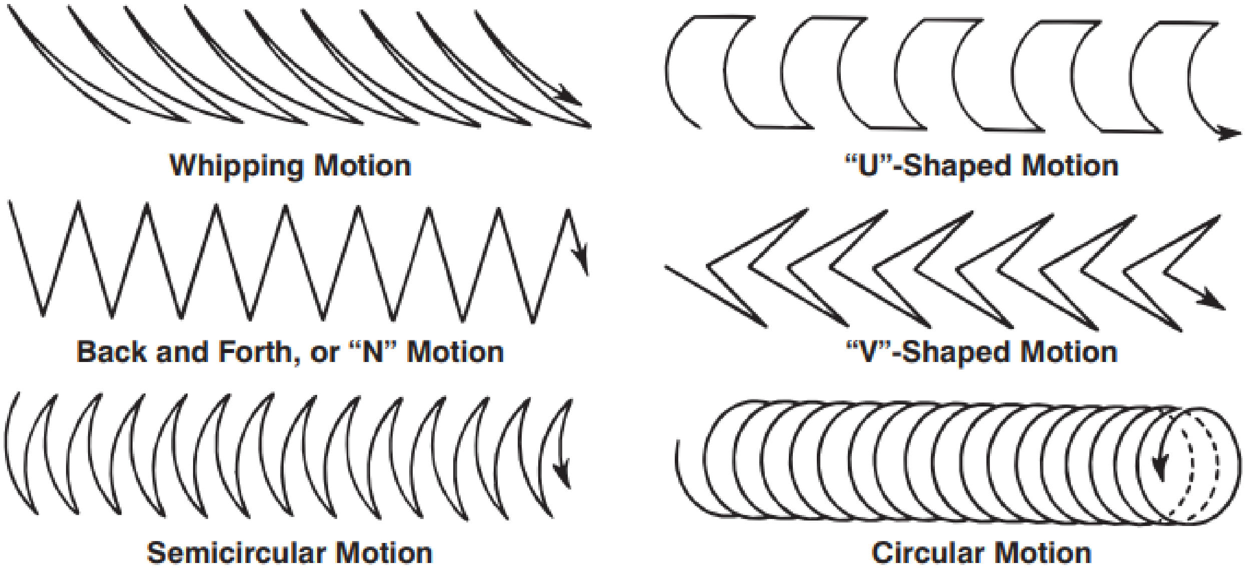


Figure 4.15 Electrode movement method

Manual metal arc welding

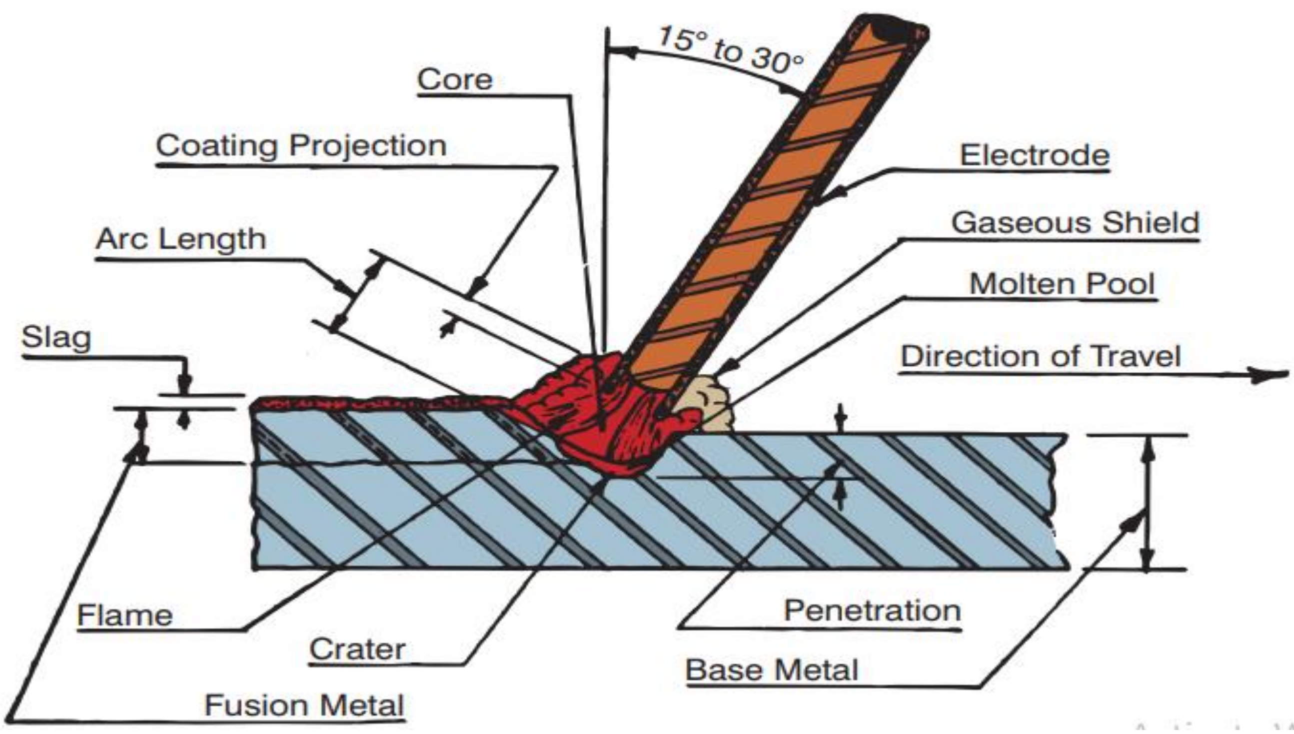


Figure 4.16 Manual metal arc welding

4.3. Clean Welding Beads

Cleaning is necessary before welding, during welding (interphase) and is usually essential after welding in order to ensure maximum corrosion resistance. Each welding run must be thoroughly cleaned to remove **slag and spatter** before proceeding with the next run. The cleaning method used (chipping, brushing, grinding) will depend on the welding process, bead shape, etc. but care should be taken to see that the weld area is not contaminated in the process. Any cleaning equipment should be suitable for stainless steel and kept for that purpose. During welding, a gas purge on the reverse side may be advantageous. After welding, weld spatter, flux, scale, arc strikes and the overall heat discoloration should be removed. This can involve grinding and polishing, blasting and brushing with a stainless steel wire brush, or use of a descaling solution or paste. The preferred procedure is usually dictated by end use. Grinding and dressing is to be carried out with iron-free brushes, abrasives, etc. and should not be so heavy as to discolor and overheat the metal. Rubber and resin bonded wheels are satisfactory. Wheels should be dressed regularly to prevent those becoming loaded thereby producing objectionable scratches. In any blasting process steel shot shall not be used.

Steps to clean welding beam

1. Cooled the weld material at room temperature or using water
2. Dray the material using dry cloth
3. Remove the sludge with cheeping hammer
4. Brushed the seam with wire brush
5. Clean the weld seam with angle grinder have rotating brush

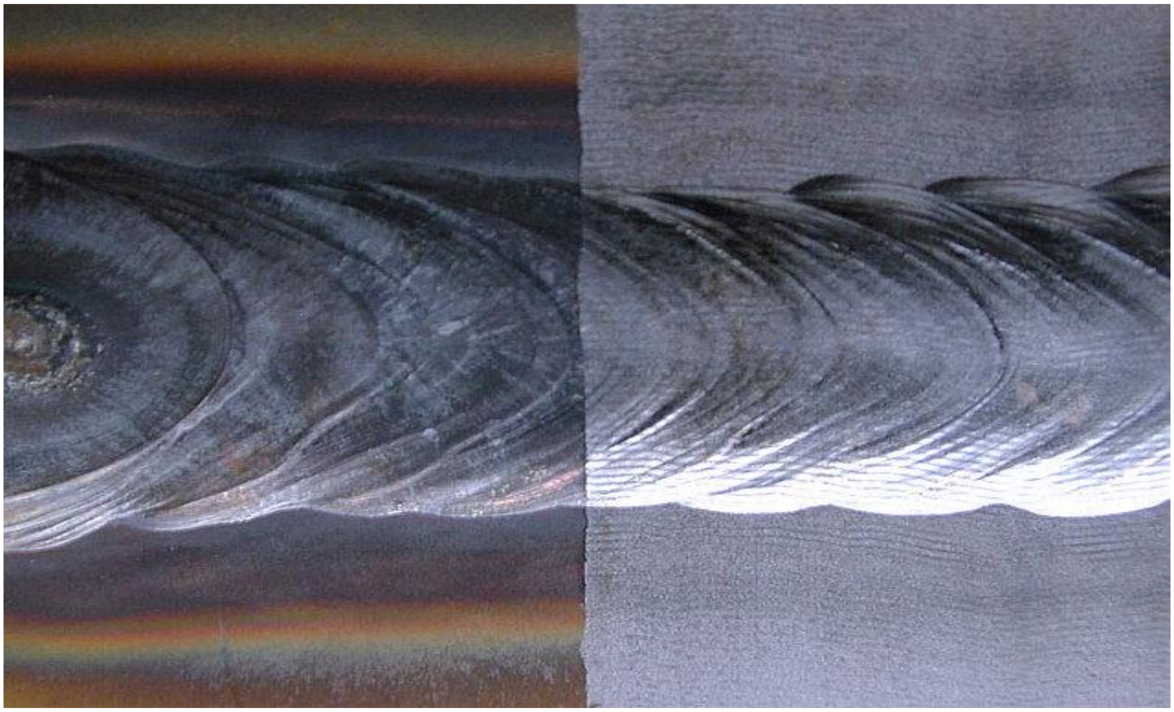


Figure 4.17 Cleaning welding seam

Summery to perform manual metal arc welding

Safety rules

- Always wear leather shoes, not sandals.
- Don't wear loose clothes.
- Know the correct posture before welding the job piece.
- Hold the electrode in proper way.

Name of the Tools

- Chipping hammer
- Tong
- Step down welding transformer
- Welding table and fixtures
- Wire brush
- Gloves and apron
- Face shield
- Electrode holder

Procedure

- Cleaning the raw material
- Clean the workpieces first.

- Then clean the welding table.
- Keep the workpieces on the table side by side.

Holding

- Take the electrode holder.
- Then insert an electrode within the electrode holder.
- Hold the electrode holder properly.

Welding

- Turn on the power switch.
- Then start welding.
- Draw a weld bead.

Chipping

- Take the chipping hammer.
- With the help of it, remove the slag from the workpiece.

Cleaning

- Take the wire brush.
- After that, clean the workpiece.
- Finishing & checking
- Check the finishing of the work pieces.
- Thus, you will get a welded joint.

Self-Check -4

Directions I: Multiple choices

Instruction I: Choose the letter of the best answer and write on the space provided

1. The full form of MMAW is –
   A. Mechanical material's arc welding
   B. Mechanical manual arc welding
   C. Manual metal arc welding
   D. None of these
2. The full form of S.M.A.W is _____.
   A. Steel metal's arc welding
   B. Submerged material arc welding
   C. Shielded metal arc welding
   D. None of these
3. By welding, we can ________________.
   A. Join two materials
   B. Cut the slots
   C. Reduce the diameter/length of the job piece
   D. None of these
4. Electrode is coated to _____.
   A. Protect the weld
   B. To remove rusting
   C. Both 1 and 2
   D. None of these
5. Is electrode consumable in M.M.A.W?
   A. Yes
   B. No
6. The chipping hammer is used to
   A. To remove the slag
   B. To hold the electrode
   C. To clean the work zone
7. The current set for 3.15 mm medium coated mild steel electrode is
   A. 50 to 80 amps
   B. 90 to 120 amps
   C. 120 to 150 amps
   D. 150 to 170 amps
8. Which type of arc length is used for welding in horizontal position?
   A. Short arc
   B. Long arc
   C. Correct arc
   D. None
9. Lack of penetration in a butt welded joint is due to
   A. too low welding speed
   B. short arc length
   C. high current
   D. low current
10. How to specify the size of an electrode holder?

A. By its weight
B. By its shape
C. By its current carrying capacity
D. By the metal used for making it

Directions II: Short answer items

Instruction II: Briefly answer the following questions

1. List the five types of welding joints.
2. Write the methods of striking the arc.
3. What are the major types of welding positions? Explain with drawing
4. What is the difference between bead weld and groove weld?
5. With what type of welding joint is high penetration impossible?
6. While fillet welding the T-joint, how much should be the angle of the electrode from the plate face?
7. Mention the three methods of cleaning welding bead?
8. What is the importance of cleaning weld piece?
9. What are to be cleaned from welding seams?

Operation Sheet 4.1:

Operation Title: welding practice

Instruction: practice welding with machine set up and material preparation.

Purpose: To practice straight beads on the given mild steel flat piece in down hand position by arc welding.

Required tools and equipment:

- Clothing
- Shoes wear
- Chipping hammer
- Tong
- Step down welding transformer
- Welding table and fixtures
- Wire brush
- Gloves and apron
- Face shield
- Electrode holder
- Ground clamp

Materials

- Two piece of mild steel

Precautions:

- Electrical shock
- Burn
- Flayers
- Arc ray
- Hand damage

Procedures:

Step-1: Copy the given working drawing in the work record.

Step-2: Cut the work piece as per the drawing.

Step-3: File the work piece to the dimensional accuracy**.**

Step-4: Kept the work piece on the welding table in the down hand position.

Step-5: Set the ampere of the machine and use protective cloth, select suitable electrode and proper shield.

Step-6: weld the two work piece down hand positon.

Step-7: Remove the slag and spatters using the chipping hammer and wire brush.

Step-8: The inspected weld bead.

Quality criteria:

- The work pieces are joined
- The work piece are joined parallel
- Cleaned and neat weld bead

Operation Sheet 4.2:

Operation Title: T- joint welding

Instruction: Weld the two materials using T- joint method.

Purpose: To make a T-joint using the given two mild steel pieces by arc welding.

Required tools and equipment:

- Clothing
- Shoes wear
- Chipping hammer
- Tong
- Step down welding transformer
- Welding table and fixtures
- Wire brush
- Gloves and apron
- Face shield
- Electrode holder
- Ground clamp

Materials

- Two piece of mild steel (8 x 40 x 200 mm)

Precautions:

- Electrical shock
- Burn
- Flayers
- Arc ray
- Hand damage

Procedures:

Step-1: wear appropriate safety equipment.

Step-1: Copy the given working drawing in the work record.

Step-2: Cut the work piece as per the drawing.

Step-3: File the work piece to the dimensional accuracy.

Step-4: Kept the work piece on the welding table in the down hand position.

Step-5: Set the ampere of the machine and select suitable electrode

Step-6: Tack welds the two ends of the work piece and checks the alignment.

Step-1: weld the two metal pieces.

Step-7: Remove the slag and spatters using the chipping hammer and wire brush.

Step-8: The inspected weld bead.

Quality criteria:

- The work pieces are joined
- Cleaned and neat weld bead
- The joined pieces are perpendicular each other

LAP Test: 4.1

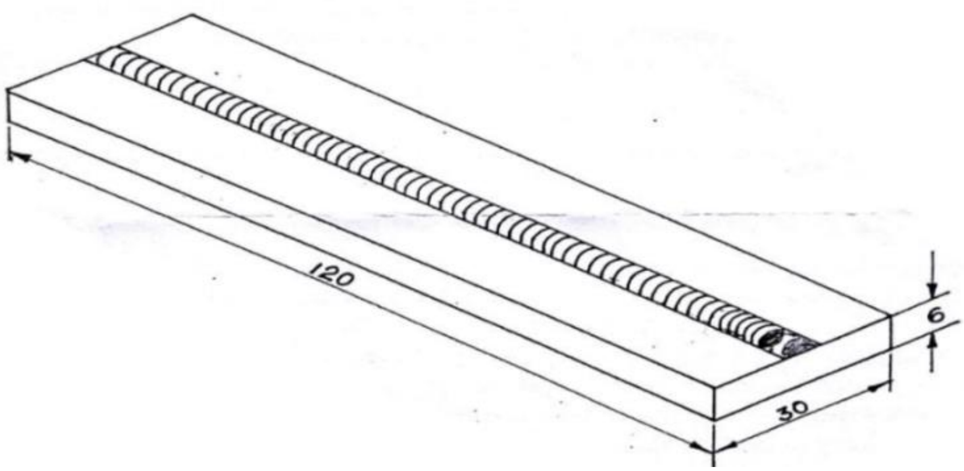
Name: _______________________________ Date: _________________

Time started: ______3:00______ Time finished: ___10:00____

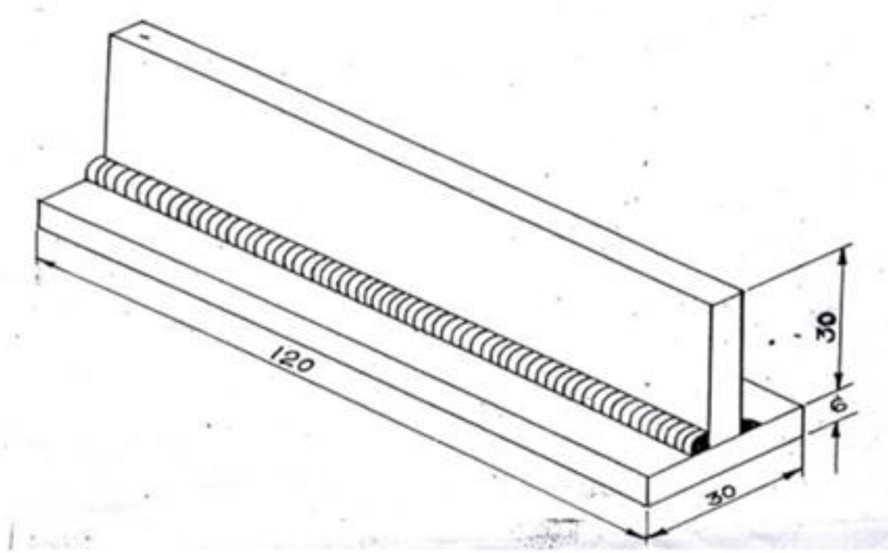
Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 8 hours

Task 1: Set up the arc welding equipment

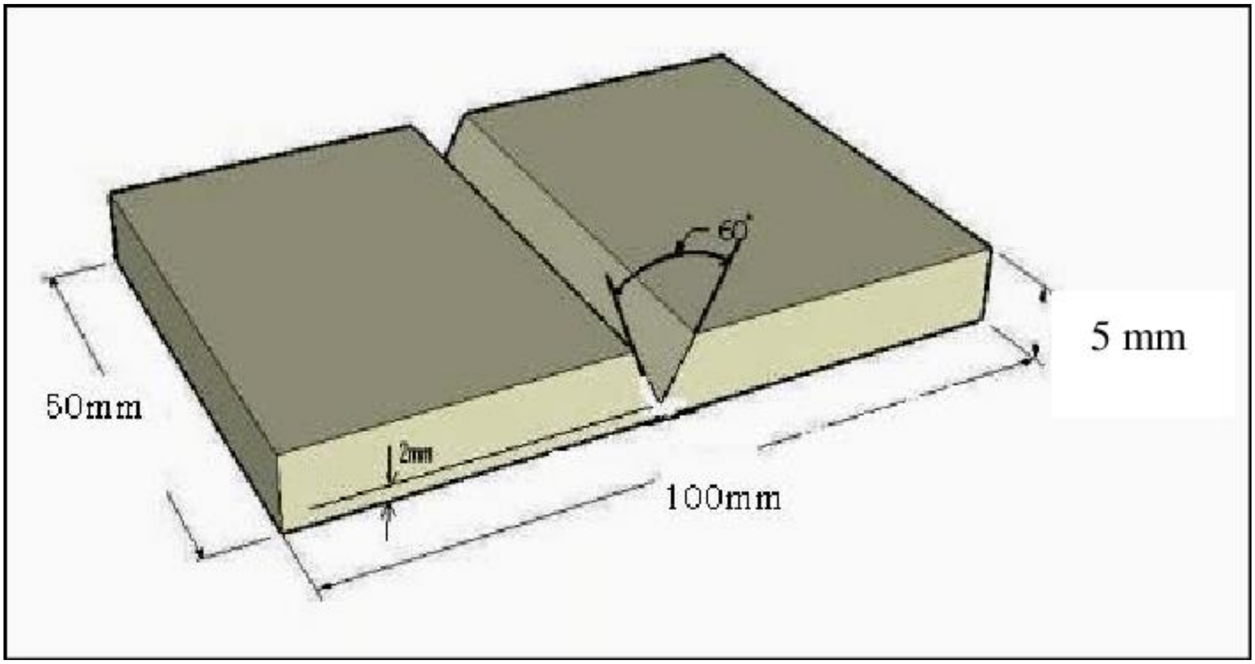
Task 2: Produce a straight bead on the mild steel as described on the working drawing below.



Task 3: Make a T-joint using mild steel pieces dimension as indicated on working drawing below.



Task 4: Make a Butt joint using mild steel pieces dimension as indicated on working drawing below.



Unit Five: Ensure Welding Conformance

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

- Visually inspect welding joints
- Welding defects and Rectify them

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

- Visually inspecting welding joints
- Rectify welding defects
- Identifying welding defects

5.1. Visually Inspect Welding Joints

Visual inspection can be done at three stages

1. Before welding,
2. During welding and
3. After welding

1. **Before Welding:** The inspector shall be familiarized with the applicable codes and standards/drawings/welding procedures (WPS and PQR). Welder qualification shall be carried out before production welding. The inspector shall confirm the material and review the MTC. Welding consumables shall also be inspected before welding. Joint preparation and alignment shall also to be checked prior to welding. After confirmation of all the parameters (as mentioned above), the welding inspector can permit the welder to start the production welding. If preheat is applicable, then the preheat temperature shall be confirmed before starting the weld.
2. **During Welding:** The inspector shall check the welding process and welding parameters with respect to the welding procedure specification (WPS) at any time during welding. Root run and root run dressing, inter pass temperature shall be witnessed by the inspector. The welding consumables shall also be checked during welding.
3. **After welding:** After complete welding, identification number is punched near joint. Complete visual inspection is done and any surface breaking or defect shall be repaired as per approved procedure. Following defects (or discontinuity) can be revealed by visual inspection:

- Crack
- Under fill
- Undercut
- Surface porosity
- Overlap
- Lack of side wall fusion
- Arc strike
- Spatters
- Excessive Penetration
- Unacceptable weld profile

5.2. Welding Defects and Rectifying Them

In short, a weld defect is any flaw or imperfection that compromises the intended use of a weldment. This also implies a flaw or imperfection may not compromise the weld, and a weld is said to have a discontinuity when this occurs. So, a weld can have a discontinuity and not be considered defective.

There are many types of welding defects, but in general, the most common weld defects are:

A. 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.

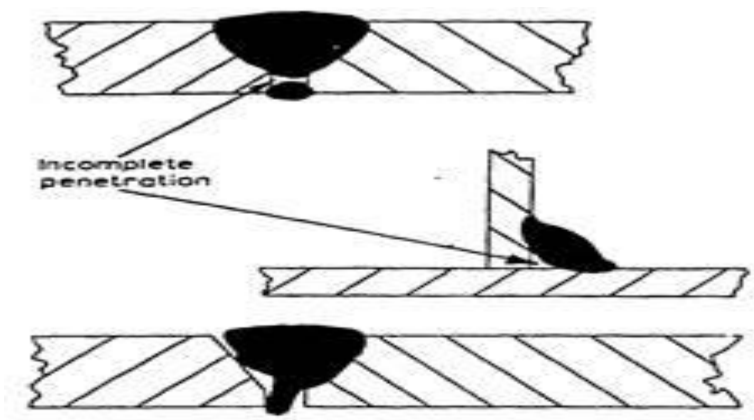


Figure 5.1 Lack of Penetration

How to get good penetration

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

B. 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

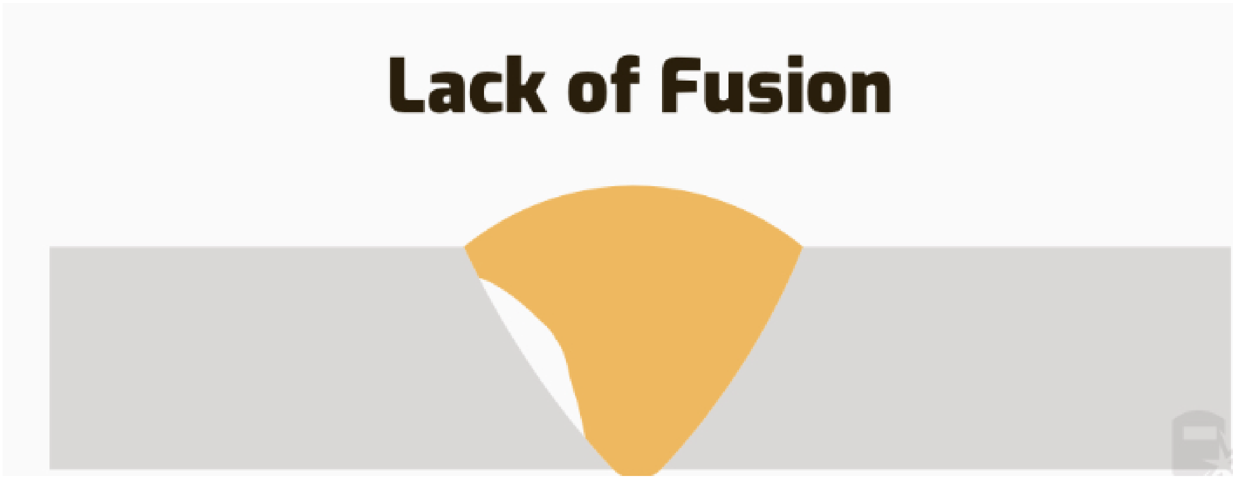


Figure 5.2 Figure 38 Lack of Fusion

How to prevent a lack of fusion

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

C. 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.

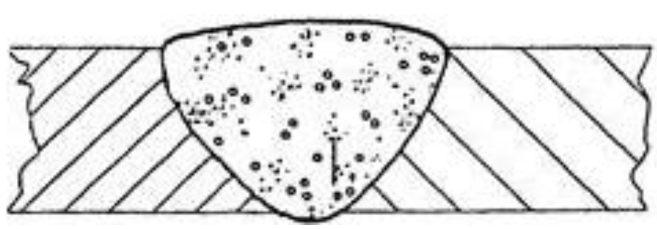


Figure 5.3 Porosity

How to avoid porous welds

- Properly clean and prepare the base metal.
- Make sure the joint is dry.
- If used, set your shielding gas flow correctly (too low or high can create issues).
- Keep the amperage from getting too high (i.e., too “hot”).

- Use the correct electrode alloy for the job.
- Ensure the electrode coating is not damaged if it has one.
- Move your torch slow enough to keep a molten puddle, allowing the gas to bubble out.
- Avoid a long arc.
- Use low hydrogen electrodes.

D. 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.

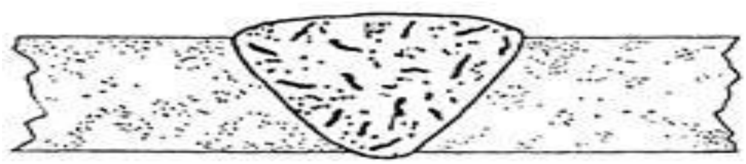


Figure 5.4 Slag Inclusion

How to prevent inclusions in your welds

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

E. 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.

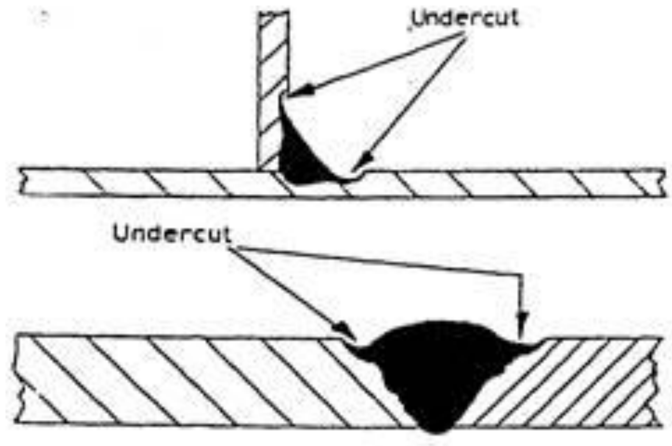


Figure 5.5 Undercut

How to prevent undercutting

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

F. 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.

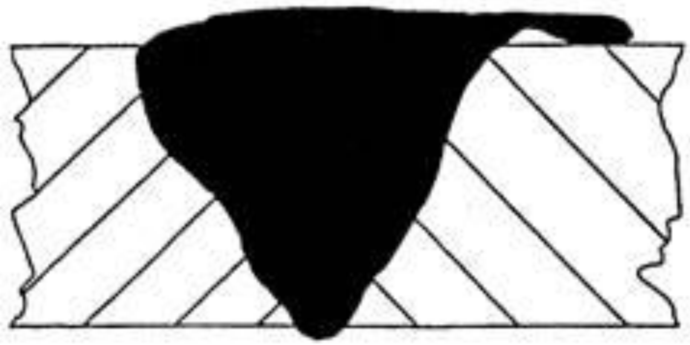


Figure 5.6 Overlays

How to Prevent Overlap

If you want to avoid this condition:

- Avoid letting your travel speed get too slow.
- Keep the correct torch angle.
- Do not use oversized electrodes.
- Set the correct amperage, avoid a high setting

G. 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 5.7 Crackling

How to prevent cracks

- Use the correct alloy filler material for the metal being welded.
- Avoid welding high sulfur and carbon steel.
- Preheat your joint.
- Ensure the joint is filled and avoid a convex-shaped bead.

- Use sound, defect-free base metal.
- Avoid low currents coupled with high travel speeds.
- Do not use hydrogen shielding gas with ferrous metals.
- Keep a good depth to width ratio for your joint.
- Avoid craters at weld termination by placing adequate filler material when ending a bead.
- Allow for expansion and contraction of a weld joint during the weld and cool down.

H. Blowholes

Blowholes are large holes in the weld caused by:

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

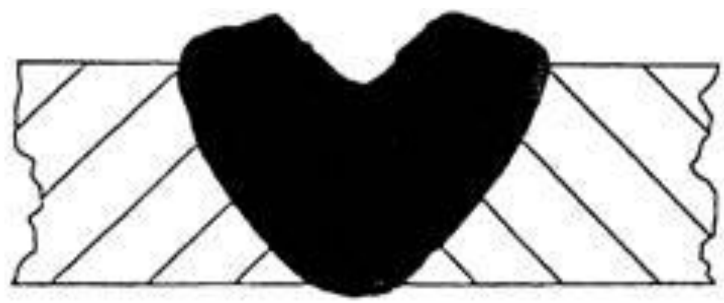


Figure 5.8 Blowholes

I. Burn Through

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

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

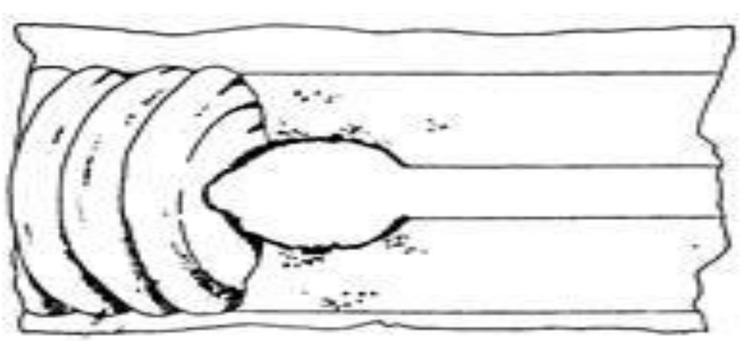


Figure 5.9 Burn Through

How to prevent Burn Through

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

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

J. 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.

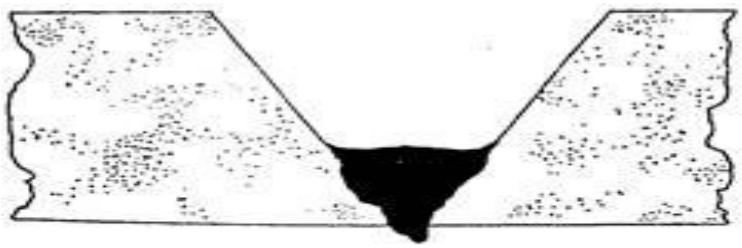


Figure 5.10 Excessive Penetration

K. Spatter

While usually not a threat to structural integrity, spatter can be considered a defect. The aesthetics of a weld are sometimes as important as the weld's strength. But nothing makes welded pieces look sloppy, like spatter stuck all over the surrounding metal.

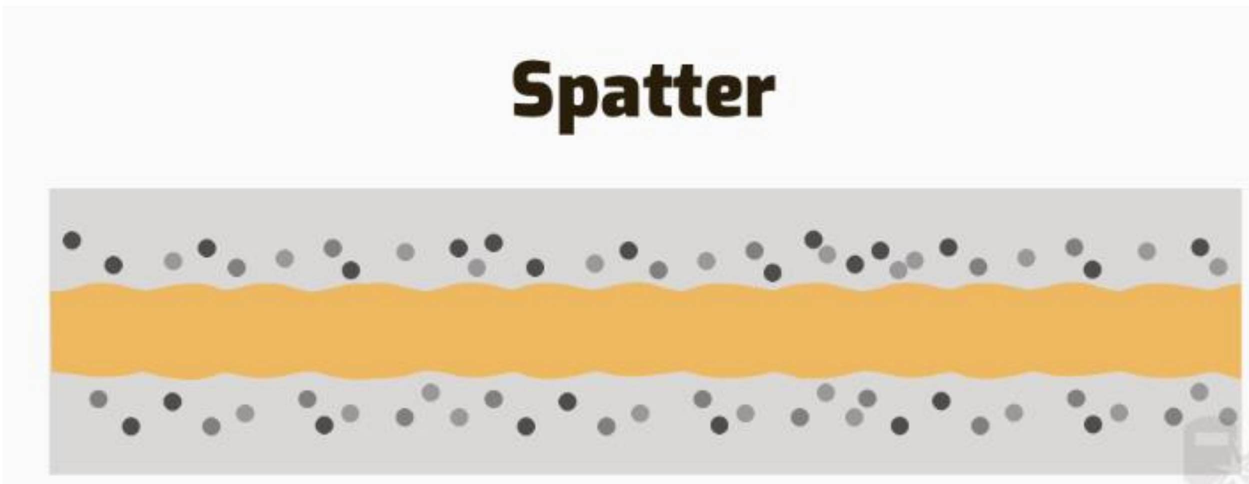


Figure 5.11 spatter

How to reduce spatter

While you can never eliminate all spatter, there a few things you can do to minimize it:

- Clean the base metal well.
- Use the correct amperage, and avoid “hot” settings.
- Use the correct voltage, and avoid low settings.
- Ensure the polarity is set correctly.
- Keep a short arc.
- Increase the electrode angle.
- Check the feed wire to ensure it is unimpeded.

Self-Check -5

Directions I: Multiple choices

Instruction I: Choose the letter of the best answer and write on the space provided

1. Welding inspection should be taken at:
   A. Before welding,
   B. During welding and
   C. After welding
   D. None of the above
   E. All except D
2. Which of the following is the defects of welding
   A. Undercut
   B. Porosity
   C. Both 1 and 2
3. Which increases the porosity on the weld?
   A. Contaminated surface
   B. Improper gas shield
   C. Presence of moisture
   D. All of the above ✓
4. Name the defect, in which the weld metal is following on the surface on the base metal without fusing.
   A. Crater
   B. Overlap
   C. Lack of fusion
   D. Excessive convexity
5. If the travel speed of electrode is high, which type of weld defect you will get on T fillet joint?
   A. Over lap
   B. Slag inclusion
   C. Excessive reinforcement
   D. Lack of root penetration
6. Which internal defect is occurs to use of wet electrodes?
   A. Undercut
   B. Porosity
   C. Crater
   D. None of these
7. A keyhole is to be maintained throughout the welding of the first run in a butt joint to ensure
   A. Crack free weld
   B. Proper bead width
   C. Good reinforcement
   D. Proper root penetration
8. Excessive Penetration is occurred due to_____________________.
   A. Too big a heat concentration.
   B. Too slow a travel.
   C. A and B
   D. None of the above

Directions II: Short answer items

Instruction II: Briefly answer the following questions

1. What are visually inspected after manual metal arc welding?
2. Discus about the following welding defects and how to prevent them.
   A. Lack of Penetration
   B. Lack of Fusion
   C. Slag Inclusion
   D. Undercut
   E. Overlays
   F. Crackling
   G. Burn Through
   H. Spatter

Unit Six: Oxy acetylene cutting requirements

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

- Oxy acetylene safety (OHS) precaution
- Consumables and equipment
- Preparing materials
- Planning and sequencing tasks
- Tools and equipment
- Preparing work area

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

- Identify Oxy acetylene safety (OHS) precaution
- Prepare consumables and equipment
- Prepare materials for oxy acetylene cutting
- Plane and sequencing tasks
- Select and checking tools and equipment
- Prepare work area for cutting with oxy acetylene.

6.1. Oxy Acetylene Safety (OHS) Precaution

General safety rules for oxy-acetylene welding

- Always use goggles when welding or cutting
- Use aprons and gloves.
- Do not point the flame towards the regulators and another person.
- When finished welding shut off the main valves, bleed the lines and loosen the regulator adjusting screws.
- Wind up the hoses when finished shutting everything off.
- Do not turn acetylene valve more than 1 ½ turns.
- Never use oil near oxygen equipment
- Threads used for acetylene are LEFT-HANDED.
- Threads used for oxygen are RIGHT HANDED.
- There will be no horseplay.

Key points for safely utilization of oxy fuel cutting

1. **Wear personal protective equipment.**

Wear welding gloves, helmet, leather apron, welding chaps, leather shoes, welding goggles, and other personal protective equipment to help prevent weld burns and injury. Make sure the welding goggles or face shield have a filter lens. Do not wear clothing made of synthetic fibers while welding.

Figure 6.1 Wear personal protective equipment

2. **Fasten cylinders securely.**

Do not handle cylinders roughly. Chain the cylinders in an upright position to a wall or cart. When regulators are not on cylinders, keep safety caps in place. Caps will prevent damage to cylinder valves.

3. **Never use oil on welding equipment**.

Oil and grease may ignite spontaneously, when in contact with oxygen.

4. **Open cylinder valves correctly**.

Open the valve on the acetylene cylinder no more than three-fourths of a turn so it can be closed quickly in case of emergency. Open the valve on the oxygen tank fully. While welding or cutting, leave the valve wrench in position.

5. **Keep the tip pointed away from your body**.

Do not saturate your clothing with oxygen or acetylene. Before and while lighting the flame, keep the tip pointed away from your body.

6. **Light the flame with an approved lighter.**

Using matches to light the torch brings fingers too close to the tip and May born it.

7. **Set the operating pressure carefully.**

Never use acetylene at a pressure over 15 psi. Follow the manufacturer's recommendations for the correct operating pressures for the metal being welded and for the tip size being used.

8. **Do not smoke or allow anyone else to smoke near the oxy-fuel gas welder.**

If fuel gas were to leak from the unit, smoking could provide ignition and cause a fire or an explosion.

9. **Treat the flame with respect.**

Keep the flame and heat away from the cylinder, hoses, and people. Never lay down a lighted torch. Be sure the flame is out before laying down the torch. Never walk around with a lighted torch.

10. **Control flashbacks and backfires.**

Make certain that reverse flow-check valves and flash arrestors are installed on the oxygen and acetylene lines.

11. **Do not leave the work area until the cylinder valves are closed.**

Be sure the cylinder valves are closed and pressure is relieved from the hoses before you leave the work area.

12. **Never stand in front of a regulator while you are opening a tank valve.**
13. **Do not weld or cut on containers that have held flammable materials**.
14. **Remove regulators and replace protective caps before transporting cylinders.**
15. **Store oxygen cylinders away from acetylene cylinders.**

A non-combustible wall at least 5 feet high should be used to separate cylinders.

16. **Handle hot metal with pliers or tongs**.

Do not leave hot metal on the welding table because unsuspecting persons may touch it and be burned.

17. **Check connections for leaking gases**.

To prevent fires or explosions, use soapy water to check connections for leaks.

6.2. Preparing Consumables and Equipment

A. Consumable for oxy acetylene cutting

1. Oxygen gas
2. Acetylene gas

1. Purity of oxygen

The cutting speed and cut edge quality are primarily determined by the purity of the oxygen stream. Thus, nozzle design plays a significant role in protecting the oxygen stream from air entrainment. The purity of oxygen should be at least 99.5%. A decrease in purity of 1% will typically reduce the cutting speed by 25% and increase the gas consumption by 25%.

Choice of fuel gas

Fuel gas combustion occurs in two distinct zones. In the inner cone or primary flame, the fuel gas combines with oxygen to form carbon monoxide and hydrogen which for acetylene, the reaction is given by

$$2C_2H_2 + 2O_2 \rightarrow 4CO + 2H_2$$

Combustion also continues in the secondary or outer zone of the flame with oxygen being supplied from the air.

$4CO + 2H_2 + 3O_2 \rightarrow 4CO_2 + 2H_2O$

Thus, fuel gases are characterized by their flame temperature - the hottest part of the flame is at the tip of the primary flame (inner cone) fuel gas to oxygen ratio - the amount of fuel gas required for combustion but this will vary according to whether the flame is neutral, oxidizing or reducing heat of combustion - heat of combustion is greater in the outer part of the flame

The five most commonly used fuel gases are acetylene, propane, MAPP (methyl acetylene-prop diene), propylene and natural gas. The properties of the gases are given in the Table. The relative performance of the fuel gases in terms of pierce time, cutting speed and cut edge quality, is determined by the flame temperature and heat distribution within the inner and out flame cones.

2. Acetylene

Acetylene produces the highest flame temperature of all the fuel gases. The maximum flame temperature for acetylene (in oxygen) is approximately 3,160°C compared with a maximum temperature of 2,828°C with propane. The hotter flame produces more rapid piercing of the materials with the pierce time being typically one third that produced with propane.

The higher flame speed (7.4m/s compared with 3.3m/s for propane) and the higher calorific value of the primary flame (inner cone) (18,890kJ/m3 compared with 10,433 kJ/m3 for propane) produce a more intense flame at the surface of the metal reducing the width of the Heat Affected Zone (HAZ) and the degree of distortion.

B. Preparing equipment

1. Oxygen cylinder,
2. Acetylene cylinder,
3. Two hose
4. Cutting Nozzle or tip
5. Regulator,
6. Valves,
7. Torch,
8. Friction lighter,
9. Tip cleaner,
10. Personal safety equipment
    a) Google
    b) Safety cloth
    c) Safety shoes
    d) Glove

Figure 6.2 oxy acetylene cutting equipment

Oxygen Cylinders – are tanks made of steel and come in many sizes. Usually paints blue color. This is done in order to avoid confusion. Oxygen cylinder is drawn from a piece of high strength steel plate and is available in common sizes.

- Cylinders are under a lot of pressure. Be careful when handling them.
- They have a high pressure valve on them with a safety nut that will burst and let the oxygen out safely if the pressure in the cylinder becomes too great.
- Never move cylinders around without the safety cap on, unless attached to an approved oxyacetylene mobile cart. Oxygen from these cylinders is not a substitute for compressed air.
- This oxygen can be 99% pure and makes things burn really fast.

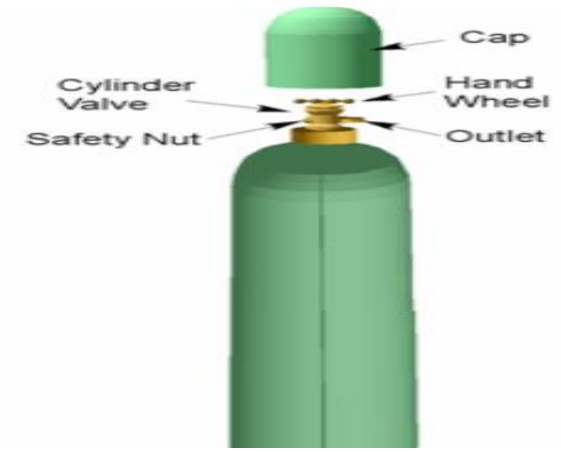


Figure 6.3 Oxygen cylinder

Acetylene Cylinders – These cylinders have lower amounts of pressure in them, but can be quite dangerous because acetylene is a fuel and can easily ignite. 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).

- As a safety measure, acetylene should never be released or used at a rate above 15 pounds per square inch (p.s.i.).
- If the acetylene in the cylinder gets too hot, there are plugs on them which will melt and release the acetylene.
- Raw acetylene gas has a very strong odor (worse than propane) when released. It is a bad smell, but if it is leaking you know it right away.

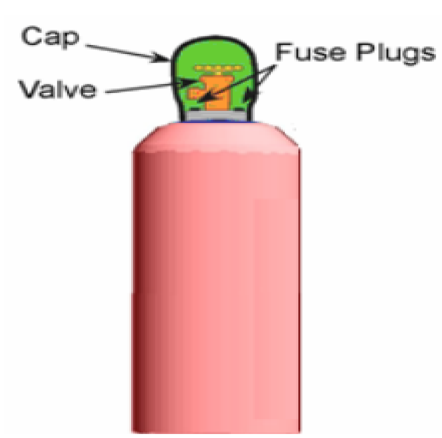


Figure 6.4 Acetylene Cylinder

Regulators – A regulator is a device used to control pressure from the tanks by reducing pressure and regulating flow rate.

- Regulators for oxygen and acetylene are different.
- Acetylene regulators have a male fitting with a left hand thread and oxygen regulators have a female fitting with a right hand thread.
- Normally, both types will have two gauges on them. One will indicate the amount of pressure left in the cylinder and the other will indicate the amount of pressure that has been set by the operator to go to the torch.
- There is an adjusting screw in the center of the regulator that is used to adjust the flow of gas.

Figure 6.5 Regulators

Hoses – As, the fitting with the regulators on oxyacetylene hoses are different than the oxygen ones. The acetylene (fuel) hose has left hand threads and the oxygen hoses have standard threads. The acetylene hoses are usually red and the oxygen hoses are green. You must be careful to keep the hoses protected from damage as they are made of a flexible rubber

Figure 6.6 oxy acetylene Hoses

Flashback 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 6.7 Flashback Arrestors

Cutting torch

A cutting torch head is used to cut materials. It is similar to a welding torch, but can be identified by the oxygen blast trigger or lever.

When cutting, 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, producing more heat and forming an oxide which is then blasted out of the cut. It is the 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 being cut. 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 workpiece, forming a hard "slag" which can be removed by gentle tapping and/or grinding. Flashbacks arrester: Flashbacks are commonly caused by a reverse flow of oxygen into the fuel gas hose (or fuel into the oxygen hose), producing an explosive mixture within the hose. The flame can then burn back through the torch, into the hose and may even reach the regulator and the cylinder. Flashbacks can result in damage or destruction of equipment, and could even cause the cylinder to explode.

Figure 6.8 oxy acetylene Cutting torch

Cutting nozzle

Acetylene tips are manufactured with four or six preheat holes and are produced to allow light, medium, and heavy preheats for use with clean, dirty, or rusted plate. Rivet-washing tips use a low-velocity cutting oxygen stream to blow rivets through a plate without damaging it. Tips also are available for gouging out welds, cutting sheet metal, and other specialized uses.

Figure 6.9 Cutting nozzle

Cylinder opener and Spanner

Are an oxy acetylene equipment used to open and close cylinders, and also to assemble and disassemble hoses and fittings.

Figure 6.10 Cylinder opener and Spanner

Oxy acetylene spark igniter

Figure 6.11 Oxy acetylene spark igniter

6.3. Preparing materials

Oxy-flame cutting is an efficient method of cutting steel products. It can only be successfully employed on materials that have a lower ignition temperature than their melting point, e.g. carbon steels or low alloy steels.

Materials such as aluminum and stainless steel cannot be successfully cut because their oxide layer melts at a higher temperature than their melting point.

Oxy-acetylene can cut only **low- to medium-carbon steels** and **wrought iron**. High-carbon steels are difficult to cut because the melting point of the slag is closer to the melting point of the parent metal, so that the slag from the cutting action does not eject as sparks but rather mixes with the clean melt near the cut.

Oxyacetylene Cutting can cut steel thickness from 1 mm to 1200 mm. And in most cases it used to cut steel plate thickness more than 20 mm.

There are four basic requirements for oxy-fuel cutting:

- The ignition temperature of the material must be lower than its melting point otherwise the material would melt and flow away before cutting could take place
- The oxide melting point must be lower than that of the surrounding material so that it can be mechanically blown away by the oxygen jet
- The oxidation reaction between the oxygen jet and the metal must be sufficient to maintain the ignition temperature
- A minimum of gaseous reaction products should be produced so as not to dilute the cutting oxygen

6.4. Planning and sequencing tasks

Oxy fuel cutting also referred to as oxy fuel flame cutting and oxy fuel gas cutting, is the most economical process for cutting mild and low-alloy steel, even with weld preparations involved. Oxy fuel cutting is regarded as one of the most important production processes in the entire metal industry.

Advantages:

- Straight-edge quality and high accuracy.
- Bevel strip cutting.
- Pierce mild steel up to 4 inches thick (101 millimeters) to 5 inches (127 millimeters) thick.
- Edge start and cut steel 10 inches (254 millimeters) to 12 inches (304 millimeters) thick.
- With multiple torches, produce multiple parts, reducing time and labor.

Disadvantages:

- Cannot cut stainless steel under normal circumstances.
- Slower cut speeds compared with plasma cutting.
- Thin material cutting might warp.

- Difficult to produce holes smaller than two times the steel's thickness.

The followings are Oxy acetylene cutting tasks sequences

- Step 1- Identify cutting tips.
- Step 2- Select the required raw material for cutting purpose.
- Step 3- clean the selected materials.
- Step 4- put the selected material at cutting station properly.
- Step 5- Making lay out on the selected materials.
- Step 6- assemble oxy-acetylene cutting accessories.
- Step 7- check the leakage of fitting.

6.5. Tools and equipment

In oxy acetylene cutting deferent tools and equipment are used. These are:

Tools, equipment and measuring tools

- Tongs
- Pliers
- Fume extractor
- Sand paper
- Angle grinder
- Scriber or any lay outing tools
- C- clamps
- Hammer
- Steel rule
- Tape rule
- Verner caliper
- Steel protractor

6.6. Preparing work area

Pure oxygen and acetylene are both gases used for a wide range of industrial welding and cutting applications. They are frequently stored at the same worksite, and both are extremely volatile and dangerously reactive.

Acetylene cylinders

Acetylene cylinders require special precautions and must be stored and handled with extreme care. The main risk associated with acetylene cylinders is a dangerous chemical reaction known as decomposition. Decomposition gives out a great deal of heat and can cause spontaneous fires and explosions. Some risks and hazards and include:

- Flashbacks from welding and cutting equipment causing decomposition and an explosion.

- Decomposition and explosions caused by cylinders exposed to heat from sunlight, hot works, industrial plant and machinery.
- Cylinders handled roughly or stored lying down causing the acetone and acetylene within the cylinders to separate and decompose.
- Acetylene will react with incompatible substances like copper, brass, silver and mercury.
- Dropped or roughly handled cylinders can heat from shock and friction resulting in a delayed explosion.
- Cylinder valves opened too quickly can create static electricity and solvent loss. Ultimately causing decomposition and an explosion

Oxygen cylinders

Though pure oxygen on its own does not burn, it causes any combustible material it comes in contact with to burn much hotter and much faster. The main risk of oxygen cylinders is gas leaks creating an oxygen enriched atmosphere (oxygen levels are higher than 21%) where fires are easily ignited. Some of the risks and hazards associated with oxygen cylinders include:

- Leaking oxygen creating an oxygen enriched environment. Leaks can be caused by damaged hoses, worn and damaged valves, loose connections, leaving valves open when the cylinder isn't being used.
- Oxygen cylinders contacting combustible substances like oil, grease, certain plastics and metals can create fires and explosions
- Workers incorrectly substituting oxygen for compressed air and others gases causing fires and fatal explosions
- Damaged or ruptured cylinders creating a fire or explosion. Cylinders damage can be caused by incorrect handling/storage (dropped or falling; impact from vehicles or falling objects)
- Cylinders exposed to heat can explode.

Work area for cutting with oxy acetylene

- At ground level
- Upright with valves closed and cylinder caps in place
- Securely restrained by individual safety straps or chains
- Protected from impact
- Preferably outside in a well ventilated area

- Inside a secure area that has been fenced off and unable to be accessed by unauthorized persons
- Away from any potential ignition sources including static electricity
- With mandatory placards and warning signage
- Near first aid equipment, and emergency instructions

Self-Check -6.1

Directions I: Multiple choices

Instruction I: Choose the letter of the best answer and write on the space provided

1. The cutting helmets protects from?
   A. A.radiation
   B. Intense light
   C. A and B
   D. None
2. The fire/burns resulting from misuse of ______
   A. Nitrogen
   B. Oxygen.
   C. Helium
   D. All
3. Oxy/fuel gas equipment has many uses which are?
   A. Cutting
   B. Heating.
   C. Straightening
   D. All
4. The color coded for oxygen hose is ___________.
   A. yellow
   B. white
   C. green
   D. red
5. Which one of the following is the fastest ways of cutting ferrous metals?
   A. by hack saw
   B. by oxyacetylene torch
   C. by arc welding
   D. a and b
6. An acetylene cylinder is painted _______color.
   A. maroon
   B. black
   C. Green
   D. Yellow
7. The gases used in gas welding are
   A. Acetylene and Oxygen
   B. Nitrogen and oxygen
   C. Both (a) and (b)
   D. None
8. Reason for using acetylene is
   A. Produces high temperature and high pressure
   B. High temperature
   C. High pressure
   D. None

Directions II: Short answer items

Instruction II: Briefly answer the following questions

1. Wright the general safety requirements for oxy acetylene?
2. Wright the personal protective equipment for oxy acetylene cutting?
3. Wright and explain oxy acetylene cutting apparatus accessory's.
4. What are the material cut using oxy acetylene cutting process?
5. What are the tools and equipment's used during oxy acetylene cutting process?
6. Discuss how to prepare oxy acetylene cutting station?

Unit Seven: Oxy Acetylene Cutting and Inspection

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

- Set up oxy acetylene apparatus.
- Principles of oxy acetylene equipment.
- cutting tip size
- Adjust cutting pressures
- Clean and Prepare materials
- Mark out materials and clamp.
- Set up cutting flame and cut materials.
- Visual inspection and repair defects.

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

- Set up oxy acetylene cutting equipment.
- Operating principle of oxy acetylene equipment.
- Select tip size as appropriate for the material to be cut.
- Adjust cutting pressures for the cutting material to be cut.
- Prepare materials for cut using oxy acetylene cutting process.
- Mark out materials and clamping.
- Perform flame setting and cutting.
- Visually inspecting completed cuts and repairing defects.

7.1. Set up oxy acetylene cutting equipment and test

An oxy acetylene torch is an affordable and versatile tool used by many people to heat, weld, solder, and cut metal. It uses extreme heat to function, and setting it up properly is one of the most important steps in using it safely. Using pressure-reducing regulators, connecting gas supplies, and safely lighting the torch flame are all essential parts of learning how to use an oxy acetylene torch.

Method of Assembly

1. Stand both cylinders vertically, acetylene on left, and ensure they are properly supported and secured. Preferably use a cylinder trolley for this purpose. Oxygen cylinders are painted **black** and Acetylene cylinders are painted **maroon**.
2. Check that the cylinder valves and all joints are free from oil and grease. Never use oil or grease on any gas equipment.
3. For safety and to prevent incorrect connecting of components, oxygen fittings have right hand threads and acetylene have left hand threads.
4. Before attaching regulators to cylinders, the cylinder valves should be wiped with an oil-free cloth, then rapidly open and close each cylinder valve to blow out any dust or dirt. This also ensures that empty cylinders are not being connected.
5. Direct valve outlet away from people in the vicinity and keep well clear of the gas being vented.
6. Ensure that regulator adjusting screws are set to zero outlet pressure i.e. turn knob anti-clockwise as far as it will go but do not force beyond stop point.
7. Screw oxygen regulator into oxygen cylinder valve (right hand thread) but first note whether regulator stem/ bullnose has an "O" ring fitted. If so, the connection will seat under hand tightening of the regulator nut. If "O" ring is not fitted, then the regulator must be secured with the correct spanner.
8. Do not use excessive force but make certain the joint is gas tight.
9. Attach oxygen flashback arrestor to oxygen regulator (right hand thread) and tighten with appropriate spanner. Screw acetylene regulator into acetylene cylinder valve (left hand thread) and proceed as with oxygen cylinder described above.
10. Attach acetylene flashback arrestor to acetylene regulator (left hand thread) and tighten with appropriate spanner.
11. Connect hoses (acetylene - Red; oxygen - Blue) fitted with approved connections to outlets of flashback arrestors.

12. Before connecting torch to hoses, open oxygen cylinder valve very slowly and screw in pressure adjusting screw on oxygen regulator for a short period to blow out foreign matter from hose. Close cylinder valve.
13. Repeat procedure for acetylene.
14. Connect torch mount arrestors to end of hoses and fit to welding torch. Ensure that torch valves are closed. Check that all connections are spanner tight - or hand tight where applicable.
15. Select correct nozzle for the job and fit to torch.

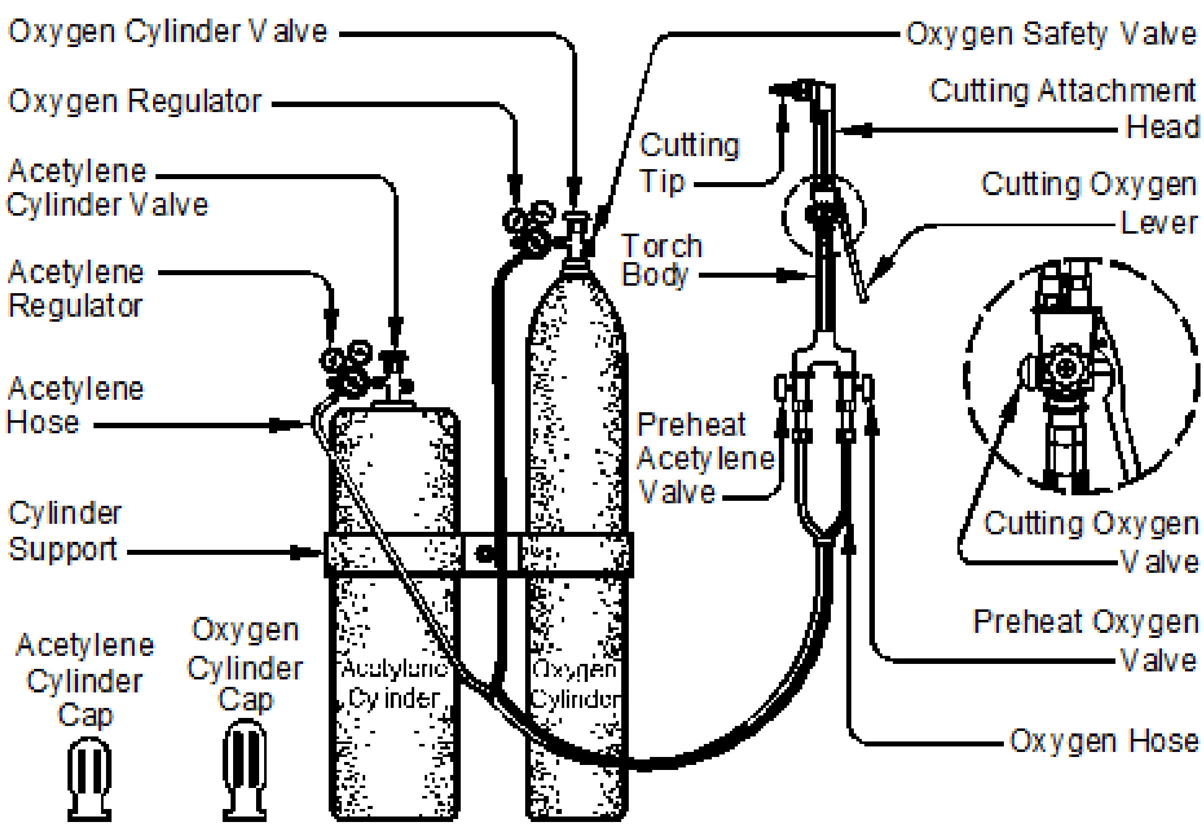


Figure 7.1 Oxy acetylene cutting equipment/accessory

Procedure of testing for linkage

- Test for acetylene leaks first.
- Use the Safe test Leak Detection Spray
- Spray directly onto the joints and connections
- Check that torch valves are closed and that regulators are set to zero outlet pressure

- Open acetylene cylinder valve very slowly (sudden opening may cause damage to the regulator)
- Adjust regulator to an outlet pressure of 50 to 60 kPa.
- Open torch acetylene valve for a short period (4 to 5 seconds) to purge air from hoses
- Close torch valve
- Apply Safe test Leak Detection Spray to all acetylene connections starting at cylinder valve spindle, regulator stem and work through all connections up to the torch inlet
- Leaks will be clearly indicated by foaming bubbles at point of leak
- Leaks must be corrected immediately by further tightening the leaking joint
- If leak persists the connection is faulty and must be replaced
- A leaking cylinder valve spindle may be corrected by tightening the spindle nut - the regulator spanner is the same size hexagon
- After testing shut on the acetylene valve, open the torch valve to release pressure
- Adjust regulator to zero outlet pressure
- Close torch valve.

7.2. Operating principles

The oxy fuel process is the most widely applied industrial thermal cutting process because it can cut thicknesses from 0.5mm to 250mm, the equipment is low cost and can be used manually or mechanized. There are several fuel gas and nozzle design options that can significantly enhance performance in terms of cut quality and cutting speed.

Process fundamentals

The cutting process is illustrated in Fig. 56. Basically, a mixture of oxygen and the fuel gas is used to preheat the metal to its 'ignition' temperature which, for steel, is 700°C - 900°C (bright red heat) but well below its melting point. A jet of pure oxygen is then directed into the preheated area instigating a vigorous exothermic chemical reaction between the oxygen and the metal to form iron oxide or slag. The oxygen jet blows away the slag enabling the jet to pierce through the the material and continue to cut through the material.

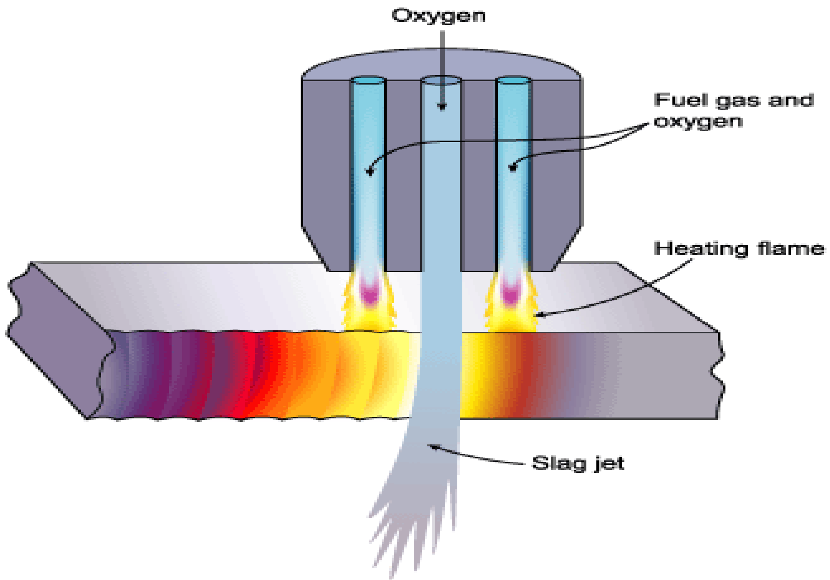


Figure 7.2 Diagram of oxyacetylene cutting process

Properly Light, Adjust and Shut Down an Oxy–Acetylene Torch

Lighting, adjusting and shutting down an oxygen-acetylene torch is easy – especially when following the proper procedures. In addition to these easy to follow instructions, you must always be sure to follow the torch manufacturer's operating procedures.

First - before you attempt to light the torch follow these checks:

1. Make sure regulator pressure adjustment screws are backed out!
2. Make sure torch valves are closed!
3. Stand away from front of regulator
4. Separately and slowly open the oxygen and acetylene cylinder valves
5. Adjust regulator p/a screws to tip pressure settings
6. Open/close torch valves separately and fine tune pressure settings on regulators
7. Depress cutting lever and adjust pressure if necessary

Shutting down the torch (with a positive/equal pressure mixer):

1. Close fuel gas torch valve
2. Close oxygen torch valve

If the torch/regulators and gases are done being used for a while, follow these procedures:

1. Close oxygen and fuel gas cylinder valves
2. Separately purge oxygen and fuel gas lines
3. Make sure all regulator gauges read 0
4. Back out regulator pressure adjustment screws!
5. If you are using in a commercial environment, report any damage, etc. to your supervisor

7.3. Appropriate cutting tip size

Choosing the correct cutting tip for the job is critical to performance and safety. It's easy when you use the 4-Step Method, but you need to understand these four things about your project and equipment:

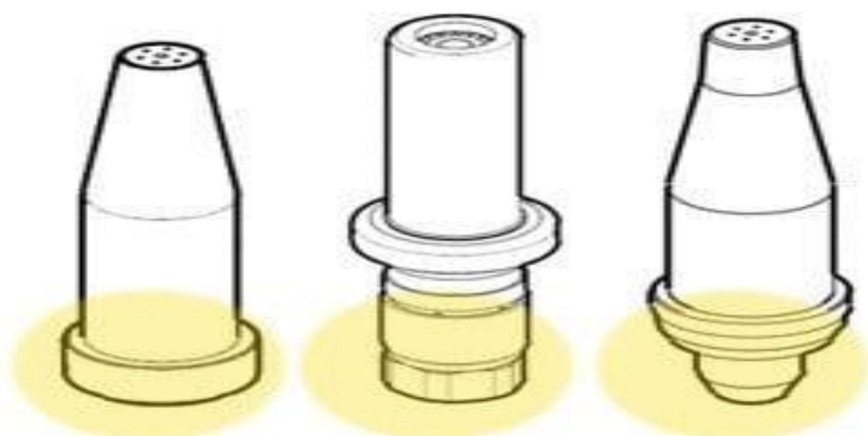


Figure 7.3 Select appropriate cutting tip size

1. Seat type

This is determined by brand. You must know the manufacturer or model of your torch and/or the part number of the cutting tips you want to replace as this determines the seat type.
If this important step is skipped, damage to the equipment or dangerous flammable gas leakage can result. Tip seats vary greatly with torch model (shown here in yellow).

2. Metal thickness

The thickness of the metal being cut is very important because the center hole of the cutting and gouging tip is sized to deliver the proper amount of oxygen at the proper pressure for a specific thickness. The pre-heat orifice is also sized to handle the proper amounts of mixed gas to heat a given thickness of metal adequately. Oxy-fuel equipment is capable of cutting mild steel from 3 mm (1/8") to 300 mm (12").

3. Application

Tips are designed specifically for the applications in which they are to be used. There are different tips used for cutting, gouging, and heating. They may be one piece of solid copper, or a two-piece hybrid with a brass inner peace and a copper outer piece. Some cutting tips are specially designed to use with automated cutting machinery for high-pressure cutting that permits quicker, cleaner, more accurate cuts.

4. Fuel gas

There are many types of gases used in oxy-fuel cutting operations. Cutting tips, designed differently for each fuel gas, optimize how the oxygen and gas are delivered.

7.4. Adjust cutting pressures

When a cutting attachment is fitted to a multi-purpose blowpipe, the blowpipe oxygen valve should be kept fully open at all times. Oxygen flow is then controlled via the preheat oxygen valve, and the cutting lever of the cutting attachment.

Acetylene should be set to a 100 kPa maximum with the acetylene blowpipe valve open approximately one quarter of a turn.

Oxygen should be set to the appropriate pressure (Table 4.1) with the cutting lever fully depressed. Use your pressure chart as a guide. Incorrect pressures are wasteful, they prevent you doing your best work, and they cause flashbacks, and can be very dangerous.

The following table shows pressures for hand cutting of various thicknesses.

Table 3 – Pressures for cutting

Thickness of plate	Size of nozzle	Oxygen pressure	Acetylene pressure
3 mm	8	100 kPa	100 kPa
6 mm	8	180 kPa	100 kPa
12 mm	12	200 kPa	100 kPa
20 mm	12	235 kPa	100 kPa
25 mm	15	180 kPa	100 kPa
40 mm	15	300 kPa	100 kPa
50 mm	15	350 kPa	100 kPa

7.5. Prepare materials

Oxy acetylene will only cut ferrous metals, so its only application is steel. The metal needs to be preheated before you can begin cutting, especially on thick sections. The preheating is done with the same torch, but its extra time standing and waiting to be ready.

Steps to prepare materials

1. Wear the appropriate PPE for the work
2. Select the required steel materials
3. Oils and dusts should be clean up

Cleaning

The base metals before cutting them to size will have impurities like dirt, oil, paint, water and surface oxides, due to long storage. These impurities will affect the welding and will create some defects in the welded joint. So in order to get a strong welded joint, it is necessary to clean the surfaces to be joined and remove the dirt, oil, paint, water, surface oxide etc. from the joining surfaces before welding.

Importance of cleaning

The basic requirement of any welding process is to clean the joining edges before welding. The joining edges or surfaces may have oil, paint, grease, rust, moisture, scale or any other foreign matter. If these contaminants are not removed the weld will become porous, brittle and weak. The success of welding depends largely on the conditions of the surface to be joined before welding.

Methods of cleaning

Chemical cleaning includes washing the joining surface with solvents of diluted hydrochloric acid to remove oil, grease, paint etc.

Mechanical cleaning includes wire brushing, grinding, and filing, sand blasting, scraping, machining or rubbing with emery paper. For cleaning ferrous metals a carbon steel wire brush is used. For cleaning stainless and non-ferrous metals, a stainless steel wire brush is used

7.6. Mark out materials and clamp.

Laying out a line to be cut can be done with a piece of soapstone or a chalk line. To obtain an accurate line, a scribe or a punch can be used. If a piece of soapstone is used, it should be sharpened properly to increase accuracy. A chalk line will make a long, straight line on metal and is best used on large jobs. The scribe and punch can both be used to lay out an accurate line, but the punched line is easier to see when cutting.

Marking out refers to the process of measuring and marking lines on the surface of materials that will be used for fabrication purposes. The marking out is used to indicate:

- Cutting lines
- Folding lines
- Hole positions

Steps to layout materials

1. Preparing lay outing materials, like Tre-square, scriber, steel rule, hammer, center punch, soapstone and chalk.
2. Understand the drawing to be lay outed
3. Prepare lay out on material
4. Clamp the material for cut

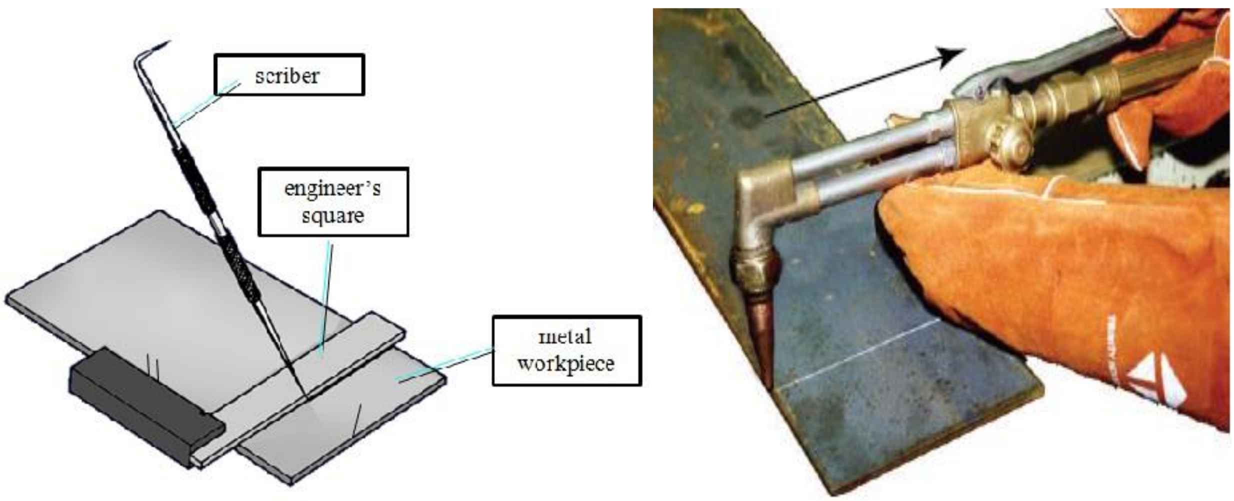


Figure 7.4 Mark out materials and clamp.

7.7. Set up cutting flame and cut materials.

7.7.1. Set up cutting flame

1. Separately purge both oxygen and fuel gas lines
2. Open fuel gas valve 1/2 turn
3. Ignite flame with striker
4. Increase fuel gas flow until flame leaves end of tip and no smoke is present

5. Decrease until flame goes back to tip
6. Open oxygen valve and adjust to neutral flame
7. Depress oxygen lever and make necessary adjustments

7.7.2. Cut materials

With all oxy-flame cutting, a preheating flame is necessary. This usually surrounds the orifice through which the oxygen jet passes and its purpose is to bring the surface of the metal to ignition temperature and to maintain it at that temperature. The flame is adjusted to neutral with the oxygen cutting stream ON.

There are three types of gas flames commonly used for all oxy-gas processes. They are

1. Carburizing,
2. Neutral, and
3. Oxidizing.

To ensure proper flame adjustment, you should know the characteristics of each of these three types of flame.

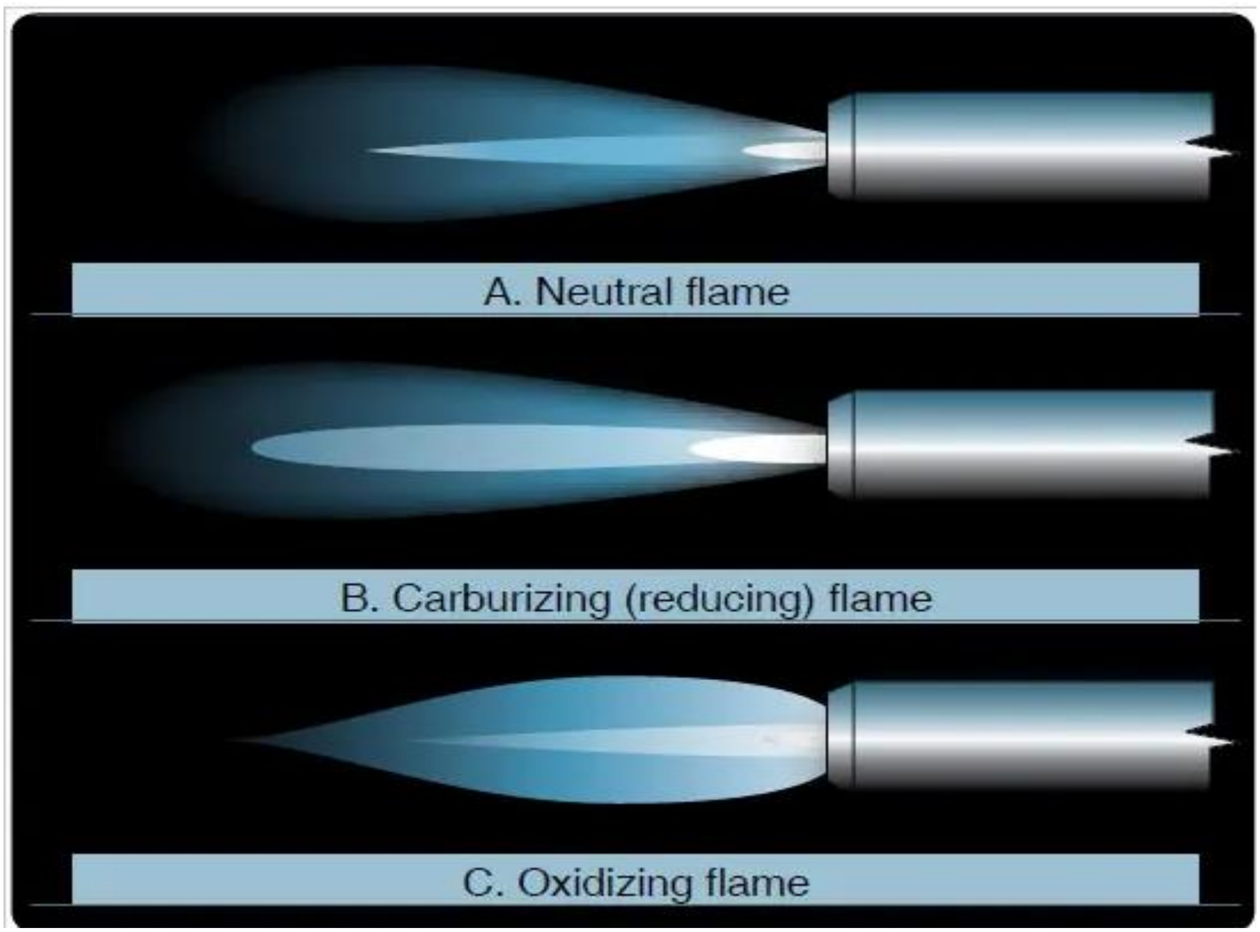


Figure7.5 Oxy-acetylene flames

A pure fuel-gas flame is long and bushy and has a yellowish color. It takes the oxygen it needs for combustion from the surrounding air. The oxygen available is not sufficient enough to burn the fuel gas completely; therefore, the flame is Smokey and consists of soot.

This flame is not suitable for use. You need to increase the amount of oxygen by opening the oxygen needle valve until the flame takes on a bluish white color, with a bright inner cone surrounded by a flame envelope of a darker hue. It is the inner cone that develops the required operating temperature.

1. **Carburizing flame.**

The carburizing flame always shows distinct colors;

- The inner cone is bluish white, the intermediate cone is white,
- The outer envelope flame is light blue, and the feather at the tip of the inner cone is greenish. The length of the feather can be used as a basis for judging the degree of carburization.
- The highly carburizing flame is longer with yellow or white feathers on the inner cone,
- While the slightly carburizing flame has a shorter feather on the inner cone and becomes whiter.
- The temperature of carburizing flames is about 5400°F.
- Strongly carburizing flames are not used in cutting low-carbon steels because the additional carbon they add causes embrittlement and hardness.
- These flames are ideal for cutting cast iron because the additional carbon poses no problems and the flame adds more heat to the metal because of its size.
- Slightly carburizing flames are ideal for cutting steels and other ferrous metals that produce a large amount of slag.
- Although a neutral flame is best for most cutting, a slightly carburizing flame is ideal for producing a lot of heat down inside the kerf.
- It makes fairly smooth cuts and reduces the amount of slag clinging to the bottom of the cut.

2. **Neutral flame.**

- The most common preheat flame for oxy-gas cutting is the neutral flame.
- When you increase the oxygen, the carburizing flame becomes neutral. The feather will disappear from the inner flame cone and all that will be left is the dark blue inner flame and the lighter blue outer cone.
- The temperature is about 5600°F.

- The neutral flame will not oxidize or add carbon to the metal you are cutting.

3. **Oxidizing flame.**

- When you add a little more oxygen to the preheat flame, it will quickly be-come shorter.
- The flame will start to neck down at the base, next to the flame ports.
- The inner flame cone changes from dark blue to light blue.
- Oxidizing flames are much easier to look at because they are less radiant than neutral flames. The temperature is about 6000°F.
- The oxidizing flame is rarely used for conventional cutting because it produces excessive slag and does not leave square-cut edges.
- Oxidizing flames are used in conjunction with cutting machines that have a high-low oxygen valve.
- The machine starts the cut with an oxidizing flame then automatically reverts to a neutral flame. The oxidizing flame gives you fast starts when using high-speed cutting machines and is ideal for piercing holes in plate.
- Highly oxidizing flames are only used in cutting metal underwater where the only source of oxygen for the torch is supplied from the surface.

A. Oxy-flame-cutting techniques

The following segments outline the recommended techniques (methods to be used when oxy-fuel cutting).

1. Straight line cutting – by hand

1. It is usual to start the cut from the edge of the plate (other starting positions will be covered later).
2. Heat the metal until it reaches red heat ignition temperature. The tip of the preheating cone should be held 2–3 mm from the surface of the plate for this operation.
3. Depress the cutting oxygen lever slowly and let the oxygen to come into contact with the heated steel. This allows the resultant reaction oxide stream to track down the face of the plate edge.
4. The cutting action is continued by a smooth movement of the cutting blowpipe. The cutting oxygen stream produces a fine spray of sparks under the cut, together with

droplets of molten metal. The correct cutting speed is accompanied by a spluttering sound.

Straight line oxy-flame cutting by hand demands a high degree of skill to maintain a smooth travel and to keep the cut to a given line. To assist the operator when cutting straight lines, a set of roller guides can be attached to the cutting blowpipe.

Roller guides can also be adopted for cutting bevels and for assisting with the cutting of circular shapes.

2. Straight line cutting – using aides

a. Roller guides

1. Fit the roller guides to the cutting blowpipe making sure the cutting nozzle fits snugly into the recess provided in the roller guide body.
2. Partially tighten clamp nut. Ensure that the roller guides are at 90° to the cutting blowpipe. Fully tighten clamp nut.
3. Check the nozzle distance off the plate. Adjust by raising or lowering wheels
4. Finally, by having both wheels placed on the metal surface, make sure the cutting nozzle is at 90° to the horizontal. This ensures that a square cut will be made.

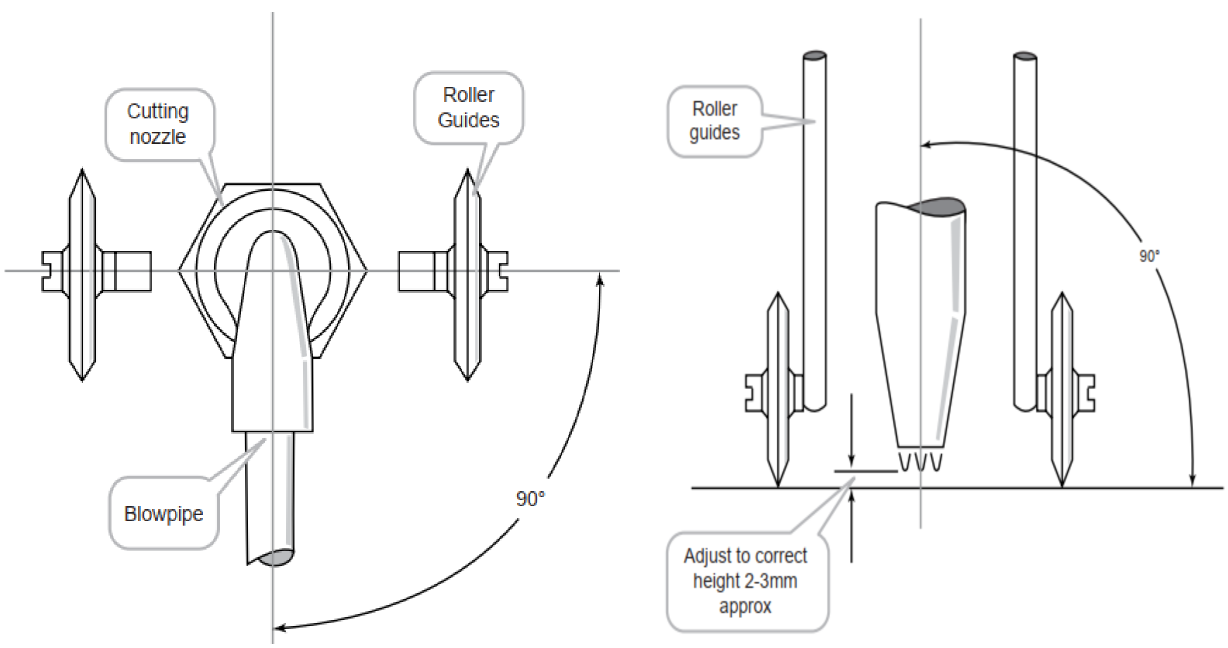


Figure 7.6 Straight line cutting – using Roller guides

b. Angle irons or heavy steel sections

1. An angle iron can be used in conjunction with the cutting blowpipe.
2. Any steel section that will not distort easily due to local heat can be used. The section is set away and parallel to the line of cut.

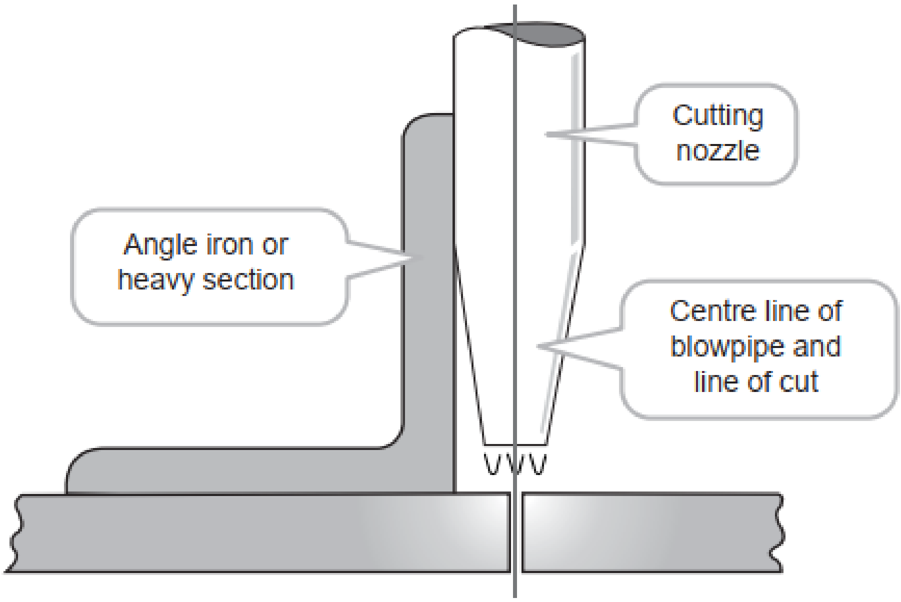


Figure 7.7 Straight line cutting – using Angle irons or heavy steel sections

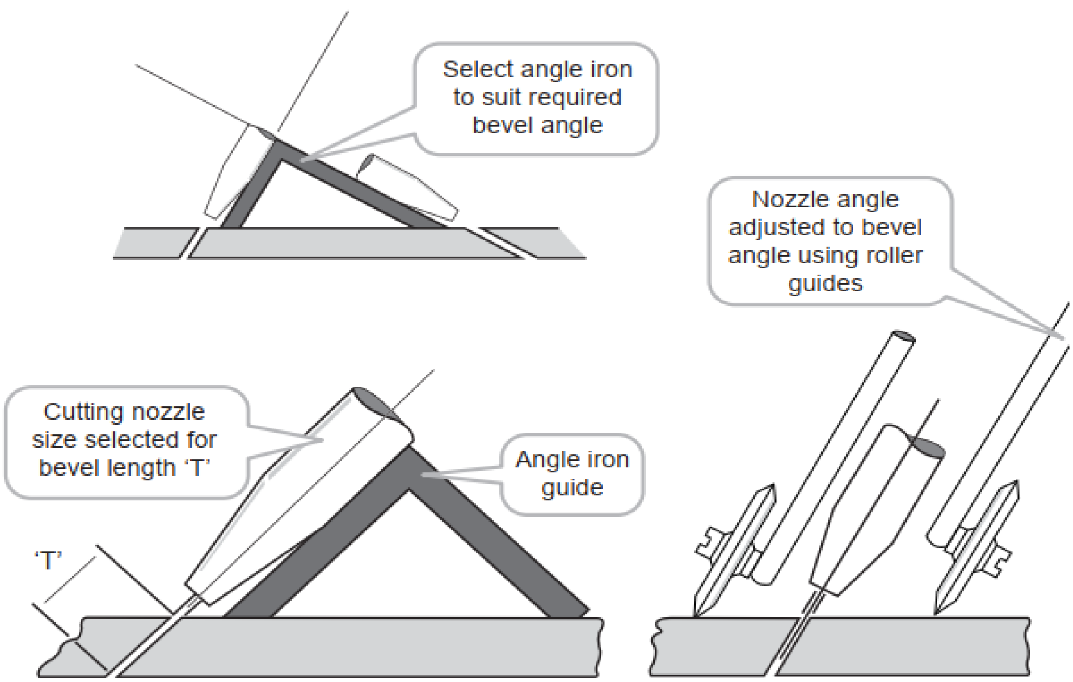


Figure 7.8 Straight line cutting – using deferent technics

c. Circle cutting

Manual oxy-flame cutting of a round hole or disc can be made easier using a radius bar or radius rod.

1. **Radius rod** is fitted into the roller guide stock. It can be made in a variety of sizes to suit mainly small radii. The wheel shown fitted is optional as it may hinder the operator in small work but can be a steadying influence with slightly larger radii.

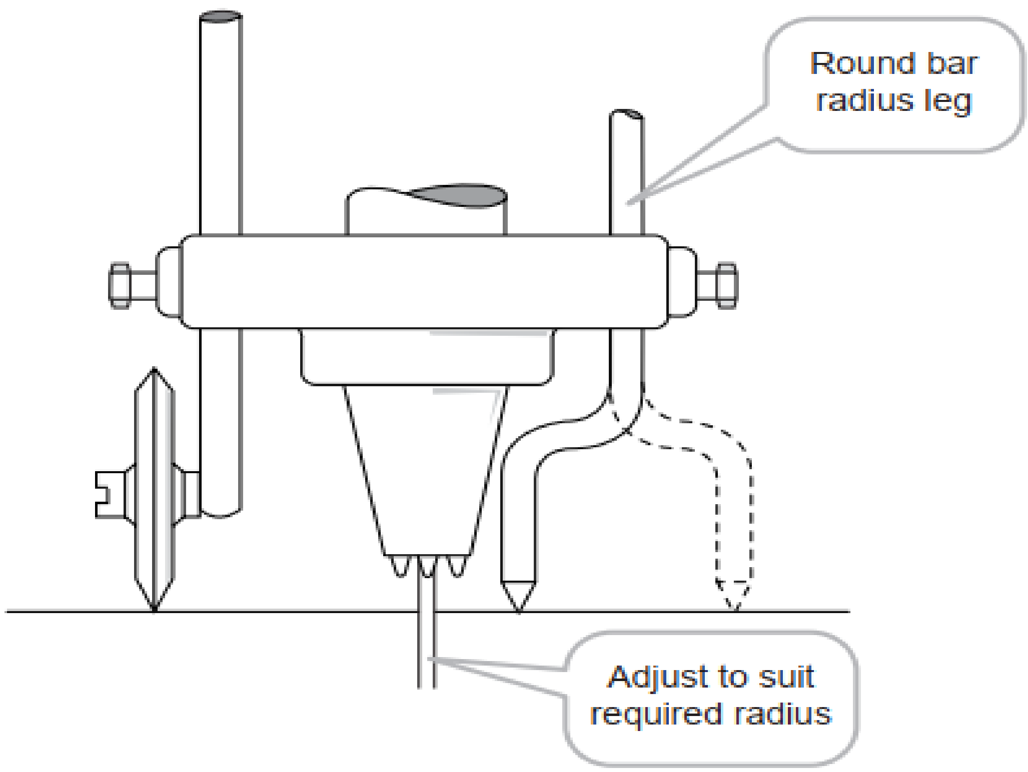


Figure 7.9 Radius rod fitted to roller guide

2. **Radius plate** (Fig below) has a larger range than the radius rod and can be used for both small and medium sized radii. The design of the fixing device must be made to suit the particular model of cutting blowpipe used.

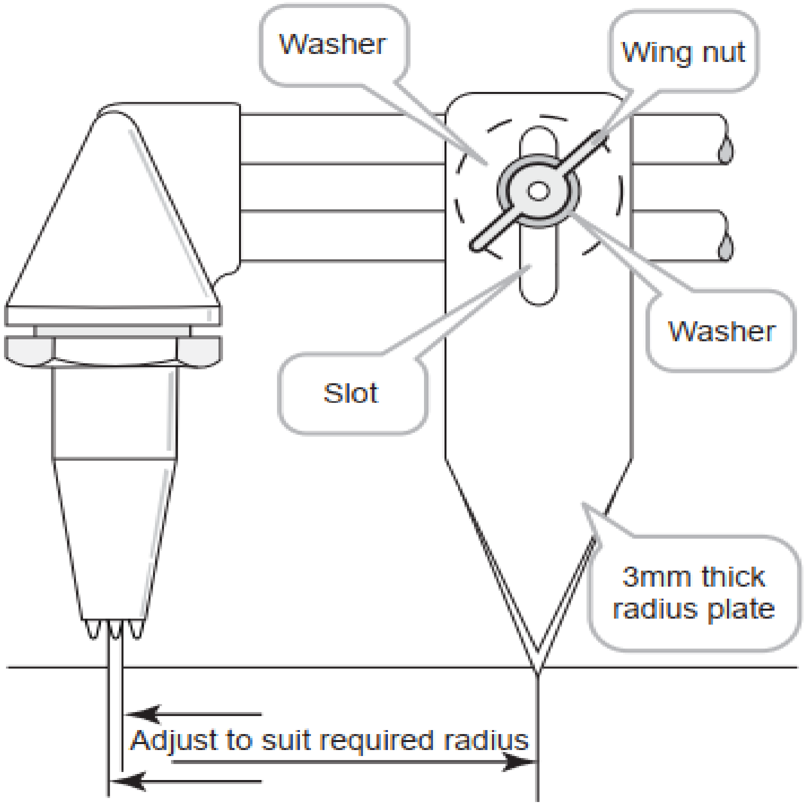


Figure 7.10 Radius plate

3. **Radius bar** (Fig below) is used in conjunction with roller guides and is suitable for medium to large circle cutting.

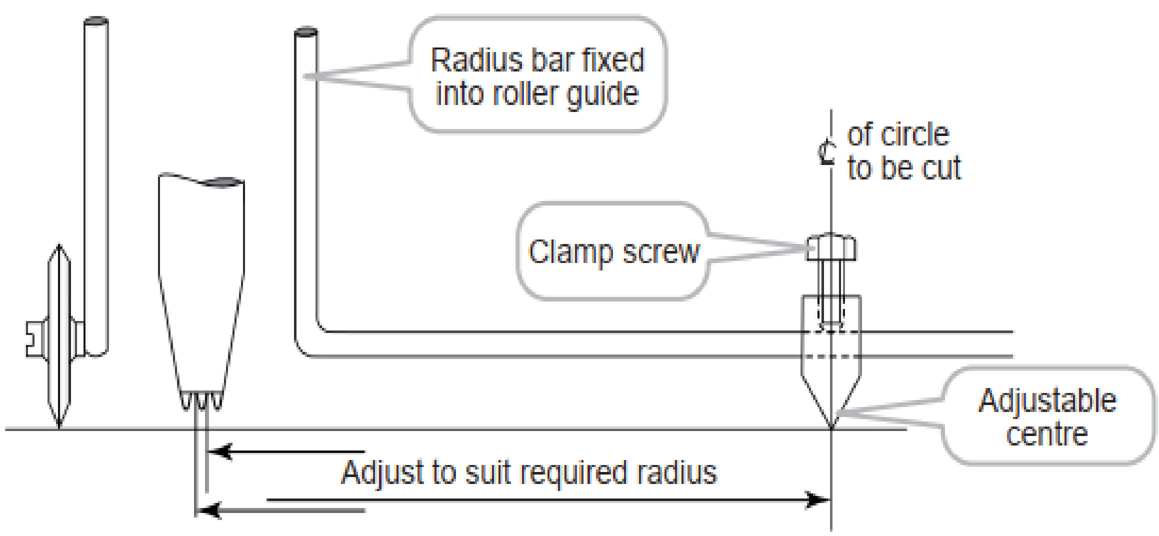


Figure 7.11 Radius bar

d. Pipe cutting

1. The tubular section should be supported on rollers or in such a way that it can be easily turned (see Fig below).
2. Half-way round one side, pierce a hole and carry the cut along the required line to the top of the pipe. The operator should maintain the nozzle at 90° to the pipe face by using a rolling action of the wrists.
3. Give the pipe a quarter turn and repeat the operation. Continue this procedure until the pipe is severed.

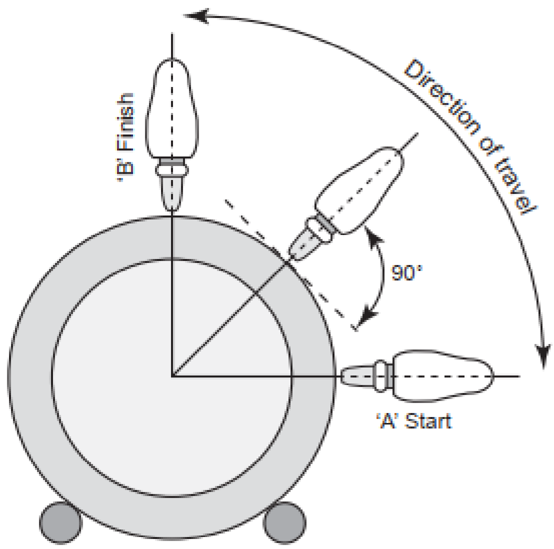


Figure 7.12 Tubular section supported on rollers

7.8. Visually inspect and repair defects.

Quality of the cut

A satisfactory cut may be defined as one fulfilling the following requirements:

- Accurate shape and size of finished object
- Reasonably smooth surface of cut face (drag lines not too pronounced)
- Sharp upper and lower edges of cut
- Slag adhesion light or non-existent.

To produce high quality cuts the following factors should be observed.

1. Make sure that the cutting equipment is in good condition.
2. Select a nozzle size appropriate to the thickness of metal to be cut.

3. Ensure that the nozzle face and the cutting and heating orifices are clean
4. Adjust gas pressures to suit nozzle size and plate thickness.
5. Correct heating flame adjustment (i.e. neutral flame of suitable size).
6. Clean surface of work along the line of the cut (i.e. free of rust, scale).
7. The nozzle must be a correct distance from plate, i.e. tip of preheating cone about 2 mm above the work.
8. Cutting blowpipe held at correct angle.
9. Suitable and uniform speed of cutting.
10. Suitably trained operator.

Other factors which may affect the quality of the cut are:

- Quality of the material, e.g. presence of laminations, slag pockets and heavy surface scaling
- Purity of the oxygen
- Angle of nozzle to plate surface, e.g. bevel cutting more difficult than a 90° cut
- Training and experience of operator.

By observing all the above factors oxy-flame cutting will be of very high standard. The positive results of good quality oxy-flame cutting are:

- Less time and effort spent in cleaning up the job by grinding and filing
- Greater accuracy means final finishing or machining is kept to a minimum
- Less material wastage
- Overall quality and finish is attained which promotes a general feeling of pride in those associated with the work or product.

Common faults in oxy-flame cutting

When all the conditions are correct, a good quality cut should have the following features:

- A sharp top edge
- A smooth surface, with draglines barely visible
- Very light scale or oxide film on the cut face which is easily removed
- A square face
- A sharp bottom edge

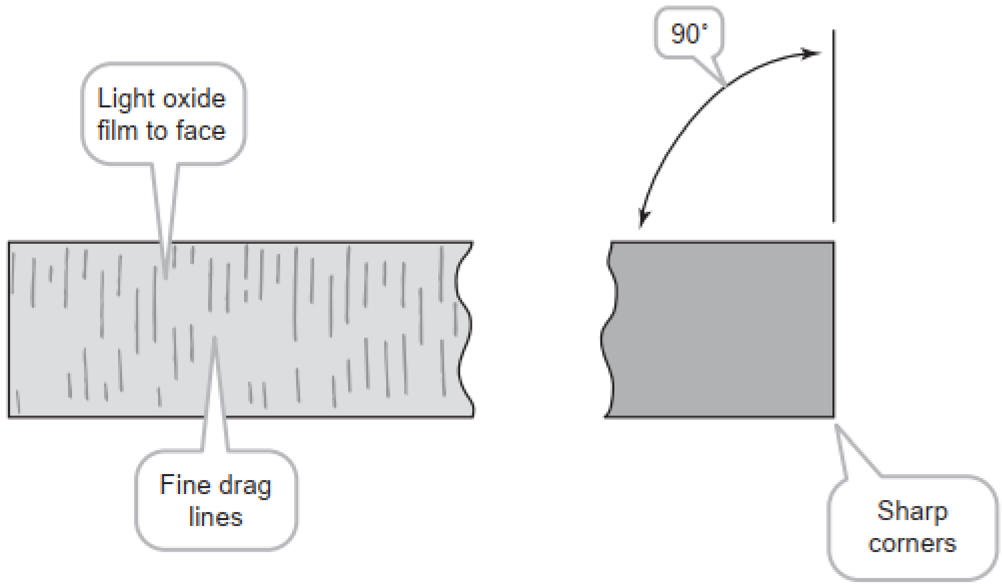


Figure 7.12 Features of a good quality oxy-cut

A good operator will endeavor to maintain a high standard of workmanship when it comes to oxy-flame cutting. Before starting, the operator should check the equipment and settings and prove the procedure by a trial cut, preferably on scrap steel.

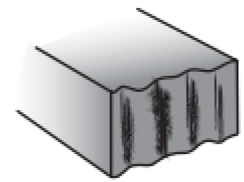
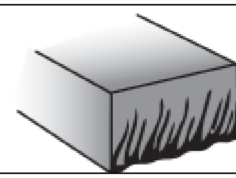
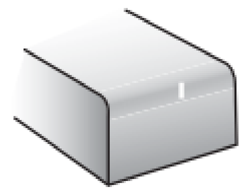
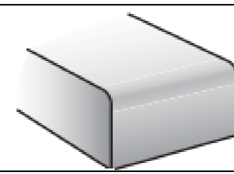
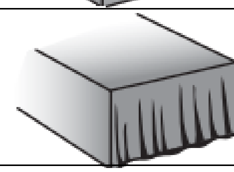
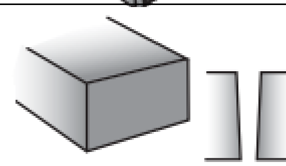
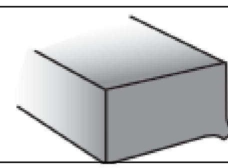
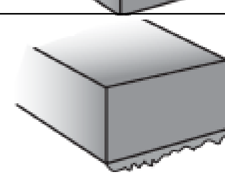
The operator should make periodic checks to see that the quality is maintained and if not, determine reasons for the low quality. The necessary adjustments should then be made immediately before carrying on with the work. Table below outlines the common faults and possible causes when oxy-flame cutting.

Example: Rounded top edge – condition 3 in Table below.

Possible causes:

- Too much preheat
- Cutting oxygen pressure too low
- Cutting speed too slow
- Preheat flame too high above work
- Preheat flame too close to work
- Dirty nozzle
- Dirty or rusty plate

Table 4 - Outlines the common faults and possible causes when oxy-flame cutting

Common faults in cutting	**Condition of cut**								**Diagram 1 to 8**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Possible cause	Ne of cut wavy or irregular	Gouging on the cut face	Top edge melted or rounded	Undercut just below	Bottom edge rounded, rough or irregular	Cut tapered	Pronounced lag or drag	Excessive or tenacious slag	**1.** 
Not enough preheat		■				■	■		**2.** 
Too much preheat		■	■					■	
Cutting oxygen pressure too low			■			■	■		**3.** 
Cutting oxygen pressure too high		■		■		■			
Cutting speed too slow		■	■		■	■		■	**4.** 
Cutting speed too fast					■	■	■		
Bent magnet spindle or unsteady blowpipe	■								**5.** 
Preheat flame too high above work		■	■						**6.** 
Preheat flame too close to work		■	■						
Dirty nozzle	■	■	■	■	■	■	■	■	**7.** 
Dirty or rusty plate		■	■		■		■	■	
Nozzle too large		■							**8.** 
Nozzle too small					■	■	■		

Self-Check -7

Directions I: Multiple choices

Instruction I: Choose the letter of the best answer and write on the space provided

1. Mixed oxygen and acetylene pass through holes surrounding the center holes for __________
   - A. Preheating flame
   - B. Neutral
   - C. Flame
   - D. All
2. ______ includes washing the joining surface with solvents of diluted hydrochloric acid to remove oil, grease,
   - A. Chemical cleaning
   - B. Mechanical
   - C. Cleaning
   - D. All
3. __________Close the fuel gas valve first, then the oxygen valve whether you are using a welding head or cutting attachment.
   - A. Cutting off
   - B. Shutting off
   - C. Neutral
   - D. None
4. __________ with oxygen valve closed; open the fuel gas valve on the torch handle about one turn.
   - A. Fuel gas
   - B. Oxy-acetylene gas
   - C. Propane
   - D. All
5. A neutral flame is produced when Acetylene and Oxygen are in the ratio of
   - A. 3:1
   - B. 2:1
   - C. 1:1
   - D. None
6. A carburizing flame is produced when acetylene is
   - A. Less than oxygen
   - B. More than oxygen
   - C. Equal to oxygen
   - D. None
7. An oxidizing flame is produced when acetylene is
   - A. More than Oxygen
   - B. Less than oxygen
   - C. Equal to oxygen
   - D. None
8. The chemical formula of acetylene is?
   - A. C_2H_4
   - B. C_2H_6
   - C. C_2H_5OH
   - D. C_2H_2

9. The inner cone is bluish white, the intermediate cone is white?
    A. Cutting cast iron
    B. Oxidizing flame.
    C. Carburizing flame.
    D. All
10. ___________flame is long and bushy and has a yellowish color.
    A. Pure fuel-gas
    B. Oxygen
    C. Carbon
    D. None
11. Which of the following Elements of Oxy-fuel cutting?
    A. Free heat flame
    B. Oxygen stream
    C. A and b
    D. None
12. What is top Quality in Oxy-fuel cutting?
    A. Square top corner
    B. Connect
    C. Cut face
    D. A and C

Directions II: Matching

Instruction II: Match the Correct Latter on the Provided Space

1. Cutting Torch ___________
2. Welding Torch ___________
3. Butt Joint Welding ___________
4. Overhead Welding ___________
5. Carburizing Flame ___________
6. Oxidizing Flame ___________
7. Neutral Flame ___________
8. Red Cylinder ___________
9. Left Hand Tread ___________
10. Right Hand Tread ___________

A. More Oxygen less Fuel
B. Welding Joining Method
C. Filled With Acetylene Gas
D. More Acetylene less Oxygen
E. Acetylene Treads
F. Equal Ratio of Oxygen and Acetylene
G. Oxygen Accessory Treads
H. Welding Position
I. Used For Cutting Purpose
J. Used For Welding Purpose
K. Horizontal Welding
L. T Joint Welding

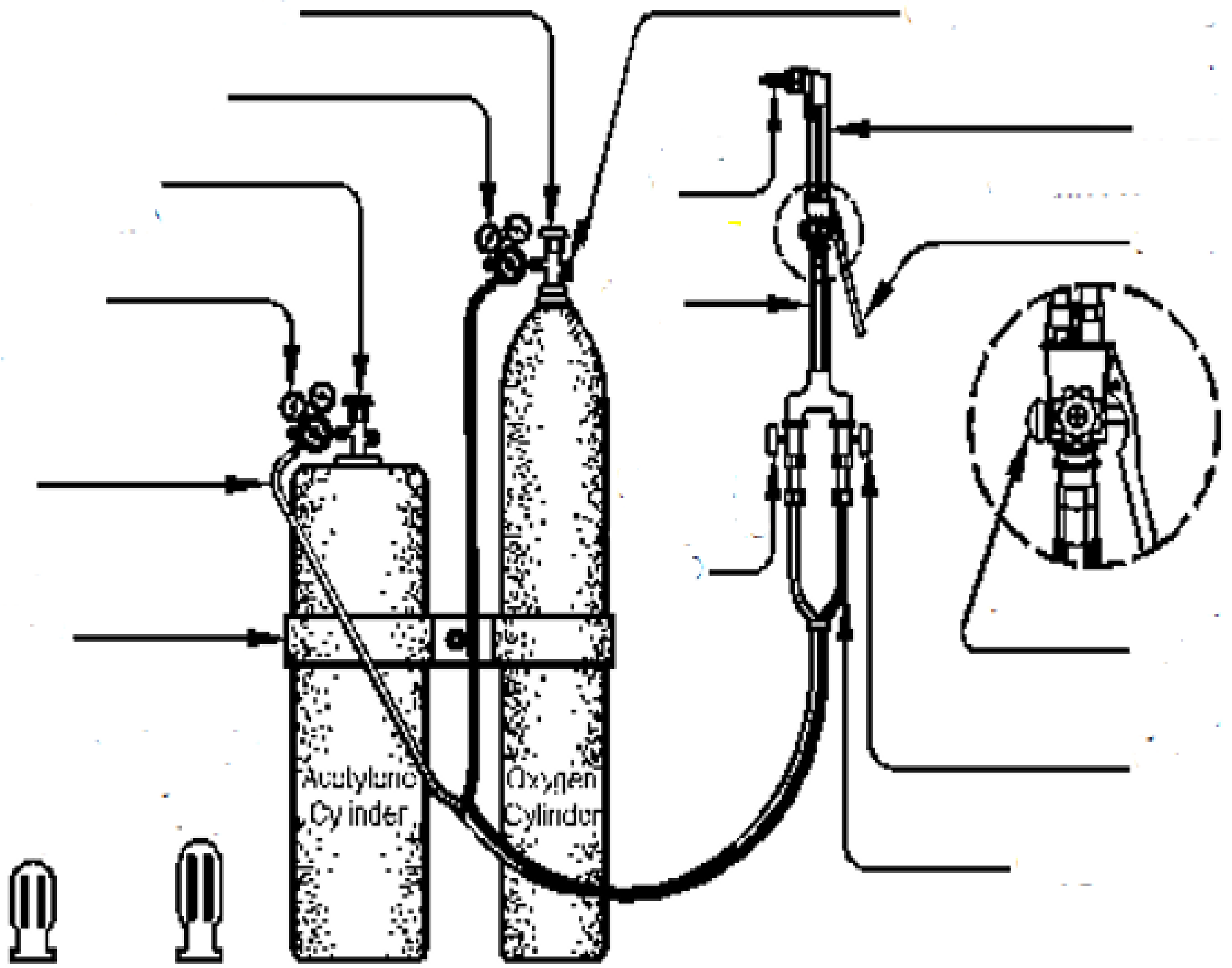
Directions III: Short answer items

Instruction III: Briefly answer the following questions

1. What are the possible defects of oxy acetylene cutting and how to prevent them?
2. How to prepare the quality component using oxy fuel cutting?
3. Define the following terms.
    A. Carburizing flame
    B. Oxidizing flame
    C. Neutral flame
4. How to adjust oxy acetylene cutting pressure?
5. How to prepare and clean materials for oxy acetylene cutting operation?
6. What are the cutting principles /Technics of oxy acetylene cutting?

Directions IV: Labeling

Instruction IV: Label the following oxyacetylene cutting apparatus



Operation sheet 7.1

Operation title: Cutting

Instruction: prepare equipment for Cutting

Purpose: To ready cutting equipment and accessories for Flame Cutting

Equipment, tools and

- Flame Cutting machine,
- Welding cable,
- Installed torch,

Materials:

- Cutting table,
- Chipping hammer,
- Steel brush and
- Tong,
- Metal piece

Precaution:

- Keep yourself from electrical shock
- Keep your working area clean and tidy
- The inserted electrode in the electrode holder should not be connected with working table

Procedure:

Step 1: Prepare the material for Cutting

Step 2: Prepare and set up the Flame Cutting equipment

Step 3: Open the regulator valve of the cylinder

Step 4: Adjust the cutting flame.

Step 5: Cut a continuous on a given material according to the drawing

Step 6: Close the regulator valve of the cylinder

Criteria:

- The Flame should be adjusted according to the material thickness and the diameter of the torch.
- All accessories should be assembled properly
- All safety equipment's should be placed at the right place.

Operation sheet 7.2

Operation Title: Assembling oxy acetylene cutting apparatus

Instruction: set up and assembling oxy acetylene cutting apparatus.

Purpose: To set up and assemble oxy acetylene cutting apparatus.

Required tools and equipment:

1. Oxygen cylinder,
2. Acetylene cylinder,
3. Two hose
4. Cutting Nozzle or tip
5. Regulator,
6. Valves,
7. Torch,
8. Friction lighter,
9. Tip cleaner,
10. Personal safety equipment
    a. Google
    b. Safety cloth
    c. Safety shoes
    d. Glove

Materials

Precautions:

- Explosion
- Burn

Procedures:

Step 1: Stand both cylinders vertically, acetylene on left, and ensure they are properly supported and secured. Preferably use a cylinder trolley for this purpose. Oxygen cylinders are painted **black** and Acetylene cylinders are painted **maroon**.

Step 2: Check that the cylinder valves and all joints are free from oil and grease. Never use oil or grease on any gas equipment.

For safety and to prevent incorrect connecting of components, oxygen fittings have right hand threads and acetylene have left hand threads.

Step 3: Before attaching regulators to cylinders, the cylinder valves should be wiped with an oil-free cloth, then rapidly open and close each cylinder valve to blow out any dust or dirt. This also ensures that empty cylinders are not being connected.

Step 4: Direct valve outlet away from people in the vicinity and keep well clear of the gas being vented.

Step 5: Ensure that regulator adjusting screws are set to zero outlet pressure i.e. turn knob anti-clockwise as far as it will go but do not force beyond stop point.

Step 6: Screw oxygen regulator into oxygen cylinder valve (right hand thread) but first note whether regulator stem/ bullnose has an "O" ring fitted. If so, the connection will seat under hand tightening of the regulator nut. If "O" ring is not fitted, then the regulator must be secured with the correct spanner.

Step 7: Do not use excessive force but make certain the joint is gas tight.

Step 8: Attach oxygen flashback arrestor to oxygen regulator (right hand thread) and tighten with appropriate spanner. Screw acetylene regulator into acetylene cylinder valve (left hand thread) and proceed as with oxygen cylinder described above.

Step 9: Attach acetylene flashback arrestor to acetylene regulator (left hand thread) and tighten with appropriate spanner.

Step 10: Connect hoses (acetylene - Red; oxygen - Blue) fitted with approved connections to outlets of flashback arrestors.

Step 11: Before connecting torch to hoses, open oxygen cylinder valve very slowly and screw in pressure adjusting screw on oxygen regulator for a short period to blow out foreign matter from hose. Close cylinder valve.

Step 12: Repeat procedure for acetylene.

Step13: Connect torch mount arrestors to end of hoses and fit to welding torch. Ensure that torch valves are closed. Check that all connections are spanner tight - or hand tight where applicable.

Step 14: Select correct nozzle for the job and fit to torch.

Quality criteria:

- No gas linkage

Operation sheet 7.3

Operation Title: Light and Shutting down the torch

Instruction: Light and Shutting down the torch.

Purpose: To light and shutting down the torch.

Required tools and equipment:

1. Oxy Acetylene Apparatus
2. Friction lighter,
3. Tip cleaner,
4. Personal safety equipment

a. Google
b. Safety cloth
c. Safety shoes
d. Glove

Materials

Precautions:

- Explosion
- Burn

Procedures:

Step 1: Make sure regulator pressure adjustment screws are backed out!

Step 2: Make sure torch valves are closed!

Step 3: Stand away from front of regulator

Step 4: Separately and slowly open the oxygen and acetylene cylinder valves

Step 5: Adjust regulator P/A screws to tip pressure settings

Step 6: Open/close torch valves separately and fine tune pressure settings on regulators

Step 7: Depress cutting lever and adjust pressure if necessary

Step 8: Close fuel gas torch valve

Step 9: Close oxygen torch valve

Quality criteria:

- No gas linkage

LAP Test: 7.

Name: ______________________________ Date: ________________

Time started: ______3:00______ Time finished: ___10:00____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 8 hours

Task 1: Set up oxy acetylene cutting equipment.

Task 2: Light and Shutting down the torch.

Task 3: Cut materials using oxy acetylene cutting and inspect the quality of cut.

Unit Eight: Clean Up

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

- Clean work areas
- Clean tools and equipment's
- Inspect tools, equipment's and work area
- Maintain tools and equipment's
- Store tools and equipment

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

- Clearing and material disposing work area
- Cleaning, checking, maintaining and storing tools and equipment's

8.1. Inspect tools, equipment's and work area

Heavy equipment inspections combine data collection and analysis with hands-on testing and examination for a thorough look at the equipment's condition. A complete inspection is an important preventive way to make sure equipment is safe for use and that all systems are working properly.

Importance of Inspect tools, equipment's and work area

Proper care and routine maintenance of your hand tools and power tools makes any home improvement or repair project easier, safer and more successful. Proper tool care also saves you money because the better they're cared for, the longer they'll last.

The need to inspect tools and equipment

The purpose of an inspection is to identify whether work equipment can be operated, adjusted and maintained safely, with any deterioration detected and remedied before it results in a health and safety risk.

The Benefits of Equipment Inspections

- Lower Risk of Workplace Injuries
- Increase Productivity
- Lower Repair Costs

8.2. Clean work areas

After completing welding and cutting work aria should be clean and maintained for any damage. The following are Tools and equipment for cleaning the work area:

List of Basic Cleaning Supplies

- Sponges and scourers.
- Yellow dusters/microfiber cloths.
- Glass polishing cloths.
- Cleaning brushes.
- Broom and dustpan
- A mop and bucket.
- A dustpan and brush.
- Protective gloves.
- A plastic caddy to carry the essentials

What should be cleaned after work?

1. Metal scraps
2. Slags
3. Electrode scraps
4. Dusts

8.3. Clean tools and equipment’s

Make it a habit to clean tools after each use before you return them to storage. Wipe them down with a rag or old towel and be sure they are free of dust, grease and debris before you put them into their proper places. This is also an opportunity to look for any damage or defects. Check your tools' handles for splinters, breaks and cracks. Also, make sure that metal parts show no signs of corrosion or rust. Repair or replace any tools that show signs of damage.

Workshops tend to be covered with grease and oil and whilst this is to be expected, it’s important to know how to properly clean your workshop in order to keep your equipment in top notch condition. Tools like hammers, screwdrivers, chisels, blades and wrenches and equipment’s like welding machine, angle grinder, oxy acetylene apparatuses etc. can quickly accumulate dirt over time, which can affect their performance and worsen their condition over time. Instead of spending extra money replacing your tools, it’s better to keep them well maintained so you can always rely on your workshop equipment when you need it most.

8.4. Maintain tools and equipment’s

If you don't maintain your tools, they will accumulate dust, dirt, and grease. Also, they won't be as effective when you need to use them the next time. Ensure that your tools are free of grease and oil before storing them. It helps maintain their condition and prolong their lifespan.

- Read the User Guide
- Use the Correct Equipment for the Job
- Know Your Machinery
- Inspect Regularly
- Carry Out Regular Maintenance, Using a Schedule
- Replace Parts When Needed
- Clean After Use
- Repair and Refurbish, Rather Than Replace
- Store Correctly

8.5. Store tools and equipment

You invest a lot in your tools, so you want them to last as long as possible. Proper storage protects your tools and equipment from breaking, rusting, or having other damage that makes them stop working prematurely. Adequate tool storage also helps keep everything organized so it's easier to find the things you need when you're mid-project.

Tools should stay in a dry, clean area to make them last as long as possible. Humidity can cause rust to develop, which can make tools stop working properly. Dirt can also get inside tools and cause them to malfunction prematurely. Avoid areas with extreme temperature swings, which can be hard on your equipment.

Store tools and equipment

- Choose Correct conditions to store tools
- Store in an appropriate safe location in accordance to the correct conditions
- Store safely when transporting

Proper storing of manual metal arc welding machine

Oxy acetylene apparatus should be stored and placed correctly at the right place after the work is completed.

Proper storing of oxy acetylene

Oxy acetylene apparatus should be stored and placed correctly at the right place after the work is completed.

Figure 8.1 proper storing of oxy acetylene apparatus

Self-Check -8

Directions III: Short answer items

Instruction III: Briefly answer the following questions

1. What is inspecting work area and what should be inspected?
2. What is the importance of inspecting tools, equipment's and work aria?
3. What are the cleaning tools and equipment's?
4. What are the benefits of cleaning tools and equipment's as well as work area?
5. What should be clean after work?
6. How to clean work area, tools and equipment's?
7. How to maintain any damage in work area, tool and equipment's?
8. How to store tool and equipment's?
9. Discusses the storing mechanism for manual metal arc welding and oxy acetylene cutting apparatus after the completion of the work.

Reference

1. J F Lancaster, Metallurgy of Welding, Abington Publishing, 1999, 6th edition, England.
2. Metals Handbook-Welding, Brazing and Soldering, American Society for Metals, 1993, 10th edition, Volume 6, USA.
3. R S Parmar, Welding engineering & technology, Khanna Publisher, 2002, 2nd edition, New Delhi.
4. Summaryplanet.com/engineering/MMA-Welding-Manual-Metal-Arc.html

Reference links

1. https://www.linde-gas.com/en/processes/cutting_joining_and_heating/welding/manual_metal_arc_welding/index.html#:~:text=Manual%20Metal%20Arc%20(MMA)%20welding%20is%20the%20most%20flexible%20and,cooling%2C%20a%20continuous%20solid%20mass.
2. **https://weldguru.com/welding-electrode/**
3. http://www.arcraftplasma.com/welding/weldingdata/ferrous.htm
4. https://www.kobelco.co.jp/english/welding/events/files/2015_KOBELCO_Nonferrous.pdf
5. https://bakersgas.com/blogs/weld-my-world/8-ways-to-prep-metal-for-welding
6. https://www.3-bwelding.com/3-important-steps-for-weld-joint-preparation-in-the-field
7. https://www.wcwelding.com/joint-preparation.html
8. https://www.millerwelds.com/resources/article-library/what-are-the-4-basic-welding-positions-and-when-should-you-use-them
9. https://amarineblog.com/2019/09/01/what-is-welding-current/#:~:text=Welding%20current%20is%20the%20term,electrons%20(electricity)%20produces%20heat.
10. https://www.weldingandndt.com/visual-inspection-of-weld-joints/
11. https://weldguru.com/common-welding-defects/
12. https://www.twi-global.com/technical-knowledge/job-knowledge/oxyfuel-cutting-process-and-fuel-gases-049
13. https://blog.storemasta.com.au/oxygen-acetylene-cylinder-storage-requirements
14. https://americantorchtip.com/blog/how-to-select-the-correct-cutting-tips-oxy-fuel/

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