

Introduction

Welding is a process of joining two or more similar or dissimilar metals by means of heat or pressure with or without using filler metal. It is a crucial in a field of building construction, which plays role in joining metal components to create strong and durable structures. Whether you're working on residential, commercial, or industrial projects, understanding the basics of welding is essential for a successful construction career because learner will be able to prepare the work by selecting suitable materials, tools and equipment; perform arc welding; and perform oxy-acetylene gas welding as required in order to fabricate windows, doors, roofs and building structures. There are several types of welding processes, each with its own characteristics, applications, and advantages.

Here are some of the most common types of welding such as Arc Welding and Gas Welding:

Arc welding is a welding process that utilizes an electric arc to melt and join metals. It is one of the most common and versatile welding techniques, widely used in various industries for its ability to create strong and durable welds. The process involves the use of electrical power to generate an intense heat source, known as an arc, between an electrode and the workpiece. The heat produced by the arc melts the materials, and when they cool and solidify, a welded joint is formed.

Gas welding is a welding process that uses the heat generated by the combustion of a fuel gas mixed with oxygen to melt and join metals. This versatile welding method has been widely used for decades, although it has become less common in some applications with the advent of other welding processes. Gas welding can be applied to a variety of metals, and it is particularly well-suited for tasks involving thin sections of metal. There are different types of gas welding processes, and one of the most common is oxy-acetylene welding.

According to the important of welding in a field of building construction, it provides the skills, knowledge and attitude to perform the basics welding on construction sites.

LEARNING OUTCOME 1: PREPARE THE WORK

Indicative content 1.1: Selection and wearing of PPE

✓ **Identification of PPE used in welding process**

Personal Protective Equipment (PPE) refers to specialized clothing, or equipment designed to protect individuals from various hazards during welding process.

✓ **Selection of PPE used in welding process**

The selection of Personal Protective Equipment (PPE) for welding processes is crucial to ensure the safety and well-being of workers. **The choice of PPE depends on the specific hazards associated with the welding process and the materials being welded.**

✚ **Here is a guide to the selection of PPE for welding**

Personal Protective Equipment	Selection Criteria
➤ Welding Helmet  <i>Figure1: welding helmet</i>	➤ Choose a helmet with an appropriate shade level for the welding process (e.g., auto-darkening for convenience), good visibility, and a comfortable
Safety Glasses or Goggles  <i>Figure2: Goggles</i>	➤ Select eye protection that meets the standards, provides coverage from all angles, and is compatible with a welding helmet.
Welding Gloves	➤ Choose gloves made of flame-resistant materials such as leather, with sufficient insulation to protect against heat and sparks.



Figure3: Gloves

Welding boots



Figure: Welding boots

- Choose Welding boots which is able to protect your body against any various of hazards such as sparks, molten metal, and heavy objects pose a risk to the feet.

➤ **Welding Overall**



Figure5: Welding Overall

- Select Welding overalls which can provide comprehensive protection to welders from various hazards encountered during welding activities.

Ear Protection



Figure6: Ear Protection

- choose suitable ear protection which is able to safeguard the welder's ears from the potentially damaging effects of loud noise generated during welding operations.

Respiratory Protection



Figure7: Respiratory Protection

- Select the right respiratory protection is able to safeguard the welders against harmful airborne contaminants, including fumes and particles, during welding processes

✓ **Wearing of PPE during welding process**

The wearing of Personal Protective Equipment (PPE) during the welding process refers to the practice of using specialized clothing designed to protect welders from various hazards encountered in the welding environment. PPE is essential to ensure the safety and well-being of individuals engaged in welding activities, as welding processes involve numerous potential risks, including exposure to heat, sparks, ultraviolet (UV) radiation, metal fumes, and more.



Points to Remember

- **Personal Protective Equipment** (PPE) refers to specialized gear, clothing, or equipment designed to protect individuals from various hazards during welding process.

Indicative content 1.2: Application of safety precautions in working area

✓ **Work area safety**

Work area safety is a critical aspect of ensuring a healthy and productive working environment. It involves implementing measures and practices to minimize the risk of accidents, injuries, and occupational hazards in welding workplace.

Here are guidelines and practices to enhance work area safety:

- **Risk Assessment:** Conduct regular risk assessments to identify potential hazards in the work area. This includes evaluating equipment, processes, materials, and the physical environment.
- **Equipment Maintenance:** Establish regular maintenance schedules for equipment and machinery to prevent malfunctions and accidents
- **Emergency Evacuation Plans:** Develop and communicate emergency evacuation plans. Conduct regular drills to ensure that employees are familiar with evacuation routes and assembly points.
- **Employee Training:** Provide comprehensive safety training to all employees. This should cover proper equipment use, emergency procedures, and awareness of potential hazards

✓ **Tool and equipment safety**

Tool and equipment safety is a crucial aspect of workplace safety in various industries. Proper usage, maintenance, and handling of tools and equipment can significantly reduce the risk of accidents and injuries. Such as Tool Inspection and Maintenance, Proper Tool Selection, Machine Guarding, Electrical Safety, etc.

✓ **Personal safety**

Personal safety is a fundamental aspect of well-being, both in and outside the workplace. It involves adopting behaviours, habits, and precautions to minimize the risk of harm and ensure the physical and mental well-being of individuals. Such as Avoid Risky Behaviours Emergency Contacts, Awareness, etc.

 Here are guidelines for ensuring personal safety

- **Awareness:** Stay aware of your surroundings. Pay attention to people, activities, and potential hazards in your environment.
- **Travel Safety:** Plan your routes and inform someone you trust about your plans, especially if you are going to an unfamiliar or isolated area.
- **Time Management:** Plan your schedule to avoid rushing, especially during late hours.



Points to Remember

- **Work area safety** is a critical aspect of ensuring a healthy and productive working environment. It involves implementing measures and practices to minimize the risk of accidents, injuries, and occupational hazards in welding workplace.

Indicative content 1.3: Cleaning and arrangement of the Workplace

Identification of cleaning types

Identifying different cleaning types is crucial for maintaining a clean and hygienic environment. Cleaning methods vary depending on the setting, the nature of the surfaces or items being cleaned, and the specific cleaning requirements.

Types of cleaning

MECHANICAL CLEANING

1.Sweeping: Using brooms or brushes to remove loose debris and dirt from surfaces.



Figure 8: wire brush

2.Vacuuming: Employing vacuum cleaners to remove dust, dirt, and other particles from welding area.

3.Wet Cleaning

4.Mopping: Using a mop and water or a cleaning solution to clean disinfect floors.



Figure 1: Mopping

5.Abrasive Cleaning: Propelling abrasive materials (such as sand) with high pressure to clean or prepare surfaces.

CHEMICAL CLEANING

1.Solvent Cleaning: Using solvents to dissolve and remove greases, oils, and certain types of stains

3.Dry Cleaning: Applying dry powders (such as baking soda or absorbent powders) to absorb and lift dirt from surfaces and using dry clothes or dusters to remove dust without the use of water.

Cleaning of workplace, tools, materials, and equipment

Cleaning the workplace, tools, materials, and equipment is crucial to maintaining a safe, efficient, and productive work environment. Proper cleaning practices contribute to the longevity of equipment, ensure the quality of work, and promote a healthy and organized workspace.

Here are guidelines for cleaning different aspects of the workplace:

+ Workplace Cleaning

Cleaning during the welding process is crucial to maintain a safe and efficient work environment. Welding can produce various by-products such as fumes, spatter, and debris, and proper cleaning helps minimize hazards and ensures the longevity of equipment.

+ Cleaning tool

1. **Hand Tools:** Wipe down hand tools with a clean cloth after use to remove dirt, grease, and debris. Inspect tools for damage and perform any necessary maintenance.
2. **Power Tools:** Follow manufacturer guidelines for cleaning and maintenance. Regularly check and clean air vents, blades, or moving parts to ensure optimal performance.
3. **Tool Storage:** Store tools in a clean and organized manner to prevent damage and make them easily accessible.

Arrangement of workplace layout

The arrangement of workplace layout is a critical aspect of optimizing efficiency, productivity, and overall functionality. The layout of a workplace can significantly impact employee workflow, communication, and safety.

This includes:

- + Safety and Accessibility:** Ensure that the workplace layout complies with safety regulations and accessibility standards. Consider emergency exit routes, first aid stations, and accessibility for individuals with disabilities.



Figure 10: Emergency exit

- + Aesthetics and Branding:** Use colors, graphics, and branding elements to create a visually appealing and cohesive environment.
- + Consider Traffic Flow:** Plan the layout to facilitate smooth traffic flow throughout the workspace and Minimize congestion points.
- + Provide Adequate Lighting:** Ensure sufficient natural and artificial lighting in the workspace to create a well-lit and comfortable of welder.

- ✚ **Ventilated:** workplace layout must allow the free movement of air. This means air is allowed to go out and go in, for maintaining air quality to the welder in workplace.
- ✚ **Provide Adequate Storage:** Ensure that employees have access to sufficient storage space for personal belongings, work materials, and documents. Optimize storage solutions to keep the workspace organized and clutter-free

ARRANGEMENT OF FIRST AID TOOL KIT

Arranging a first aid kit is crucial for quick and efficient access to medical supplies in case of emergencies.



Figure11: first aid tool kit

- ✚ **Container:** Choose a durable, waterproof container to protect the contents from moisture and damage. Consider a transparent container or one with clear compartments to easily locate items.
- ✚ **Labeling:** Clearly label the first aid kit with a prominent, easily readable sign indicating its purpose. Include an emergency contact list and any relevant medical information.
- ✚ **Accessible Location:** Store the first aid kit in a central and easily accessible location, known to all employees or household members. Ensure that the kit is visible and reachable in case of an emergency.
- ✚ **Basic Supplies:** Include essential items such as adhesive bandages, gauze, sterile dressings, adhesive tape, and antiseptic wipes. Provide a variety of bandage sizes to accommodate different wounds.
- ✚ **Wound Care Supplies:** Include items for wound care, such as sterile gloves, tweezers, scissors, and a first aid manual. Add a CPR face mask and instructions for cardiopulmonary resuscitation (CPR).
- ✚ **Medications:** Include common over-the-counter medications like pain relievers, antihistamines, and anti-inflammatory drugs. If there are specific prescription medications for individuals, ensure they are stored securely and clearly labelled.
- ✚ **Emergency Tools:** Add emergency tools like scissors, tweezers, and a small flashlight with extra batteries. Include a multipurpose tool or knife for various uses.

- ✚ **Burn Treatment:** Include burn dressings or gels for treating minor burns. Have a cold pack or instant cold compress for relieving pain and reducing swelling.
- ✚ **Eye Care:** Include an eye wash solution and an eye cup for flushing out foreign particles. Include an eyewash station if there is a higher risk of eye injuries.
- ✚ **Personal Protective Equipment (PPE):** Provide disposable gloves, face masks, and other necessary PPE for the safety of the first aider and the victim.

ARRANGEMENT OF FIRE EXTINGUISHERS

Arrangement of fire extinguishers is essential for ensuring quick access in the event of fire emergency.



Figure12: fire extinguishers

Here are guidelines for arranging fire extinguishers:

- ✚ **Clear Visibility:** Ensure that fire extinguishers are clearly visible and not obstructed by furniture, equipment, or other objects.
- ✚ **Mounting Height:** mount fire extinguishers at a height that is easily accessible to adults but not so low that they are at risk of being damaged or obstructed. Common mounting heights are between 3 and 5 feet above the floor.
- ✚ **Near Potential Fire Hazards:** Place fire extinguishers near areas with a higher risk of fire, such as kitchens, electrical rooms, laboratories, or areas with flammable materials. Ensure that there is a fire extinguisher within easy reach of potential ignition sources.
- ✚ **Emergency Exits:** Place fire extinguishers near emergency exits to provide an additional safety measure as individuals evacuate. Ensure that they are positioned in a way that does not impede exit routes.
- ✚ **Adherence to Regulations:** Follow local fire safety regulations and codes for the placement of fire extinguishers in different types of buildings and facilities. Ensure that the height and mounting requirements specified by regulations are met.

ARRANGEMENT OF FIRE BLANKET

Arranging fire blankets in a strategic and easily accessible manner is crucial for their effective use during a fire emergency. Fire blankets are designed to smother small fires, especially those involving people or objects.



Figure13: fire blanket

The following are steps guide on how to arrange a fire blanket:

- ✚ **Identify Potential Fire Risks:** Determine areas with a higher risk of fires, such as kitchens, laboratories, workshops, or places with electrical equipment.
- ✚ **Clear Visibility:** Ensure that fire blankets are clearly visible and easily identifiable. Consider using signage or markings to indicate their location.
- ✚ **Accessible Height:** Mount or store fire blankets at a height that is easily reachable by adults but not so low that they are at risk of being damaged or obstructed.
- ✚ **Close to Workstations:** Place fire blankets near workstations where there may be a higher risk of small fires, such as those involving electrical equipment or machinery
- ✚ **Close to the flammable:** install fire blankets in areas where flammable materials are present, such as near curtains, fabric-covered furniture, or other combustible items.
- ✚ **Emergency Exit Routes:** Position fire blankets near emergency exit routes so that they can be easily accessed during evacuation.
- ✚ **Regular Inspection:** Conduct regular inspections of fire blankets to ensure that they are in good condition, free of damage, and easily accessible. Replace any fire blankets that show signs of wear and tear.



Points to Remember

- **Emergency Tools:** Add emergency tools like scissors, tweezers, and a small flashlight with extra batteries. Include a multipurpose tool or knife for various uses.

Indicative content 1.4 Tools, Equipment and Materials selection

✓ **Types of welding tools**

✚ Measuring tools

Measuring tools are instruments used to quantify and determine the dimensions, size, or distance of objects.

Here are some common measuring tools:

➤ **Vernier calliper**

A Vernier calliper, also known as a Vernier scale, is a precision measuring instrument used to measure the dimensions of small objects with high accuracy. It consists of a main scale and a sliding Vernier scale, allowing for precise measurements of length, width, and thickness.

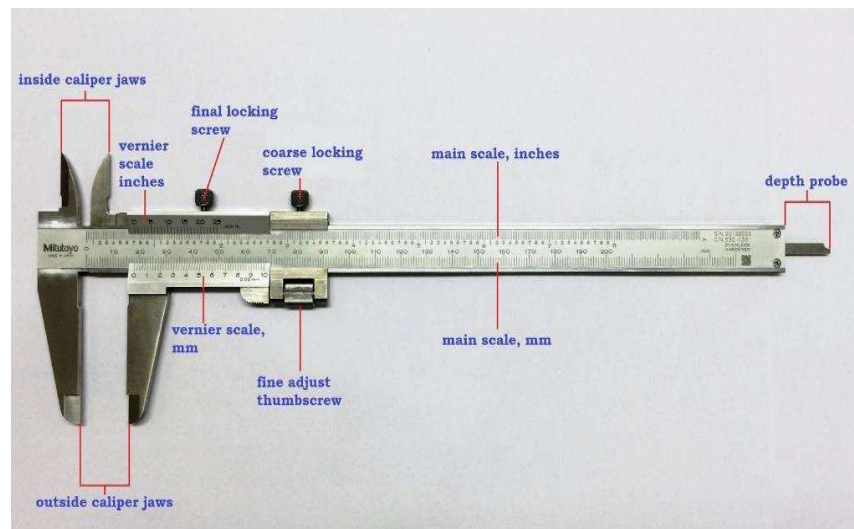


Figure14: Vernier calliper

➤ **Micrometers**

Micrometers, also known as micrometer screw gauges, are precision measuring instruments designed for accurate and detailed measurement of small distances with high resolution.

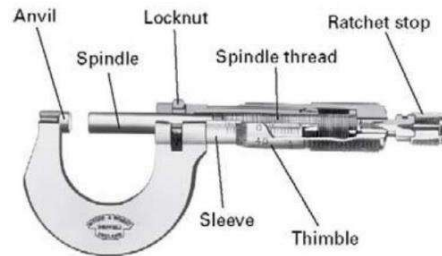


Figure15: Micrometer

➤ **Tape Measure**

A measuring tape is a flexible tool used for measuring length.

➤ **Protractor**

A protractor is a geometric tool used for measuring and drawing angles. It typically consists of a flat, circular disk marked with degree graduations from 0 to 180 or 0 to 360.

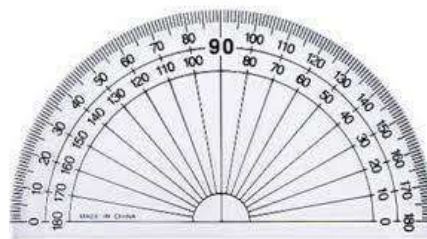


Figure17: Protractor

✚ **Marking tools**

Marking tools are instruments used to make visible marks or indications on surfaces for various purposes, such as measurement, identification, or guidance in cutting or assembly.

Here are some common Marking tools:

➤ **Steel scriber**

Steel scriber is a hand tool used to mark or scribe a guide line onto a workpiece prior to it being certain process.

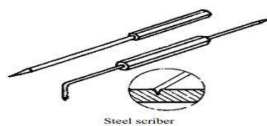
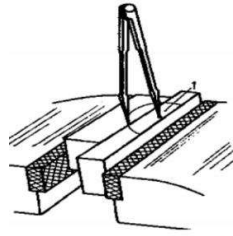


Figure 18: Steel scriber

➤ **Dividers**

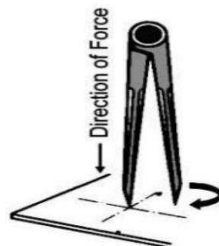
Dividers are a drawing and measuring tool with two pointed legs used to transfer distances, draw circles, or scribe arcs with precision.



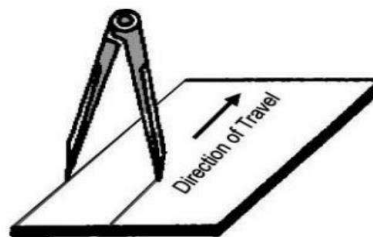
Scribing with toolmakers' dividers using an insert (1)

➤ **Laying Out Circles with the Divider**

- Lay out the center of the circle
- Punch the center of the circle
- Adjust the divider to the proper radius while using a steel rule or a Vernier calliper
- Place one point of the divider in the center punch hole and give some force to this leg.
- Move around the fixed leg and scratch the surface.



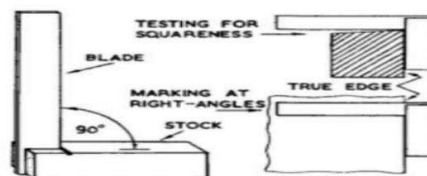
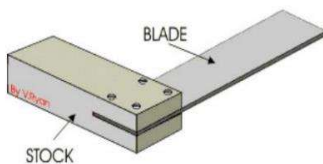
Laying out circles



Laying out parallel lines

➤ **Engineers Try-Square**

Engineer's square is made of hardened tool steel. It is used for checking the straightness and the squareness of a work piece. It can also be used for marking perpendicular lines onto a work piece.



Engineers Try Square

Figure19: Engineers Try-Square

➤ **Center punch**

A center punch is a hand tool used to create a small, precise indentation or mark on a workpiece. Punch marks are not only made to mark the scribed lines but also to determine insertion points for the dividers and whole centers. Punching serves to mark scribed lines, insertion points of dividers and whole centers.

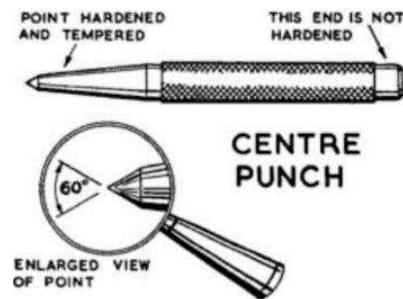
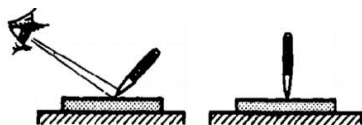


Figure20: Center punch

➤ **Center Punch Procedure**

- Make sure that the point of the punch is sharp before starting.
- Hold the punch at a 45-degree angle and place the point carefully on the layout line.
- Tilt the punch to a vertical position and strike it gently with a light hammer.
- If the punch mark is not in the proper position, correct it as necessary.



✚ **Cutting tools**

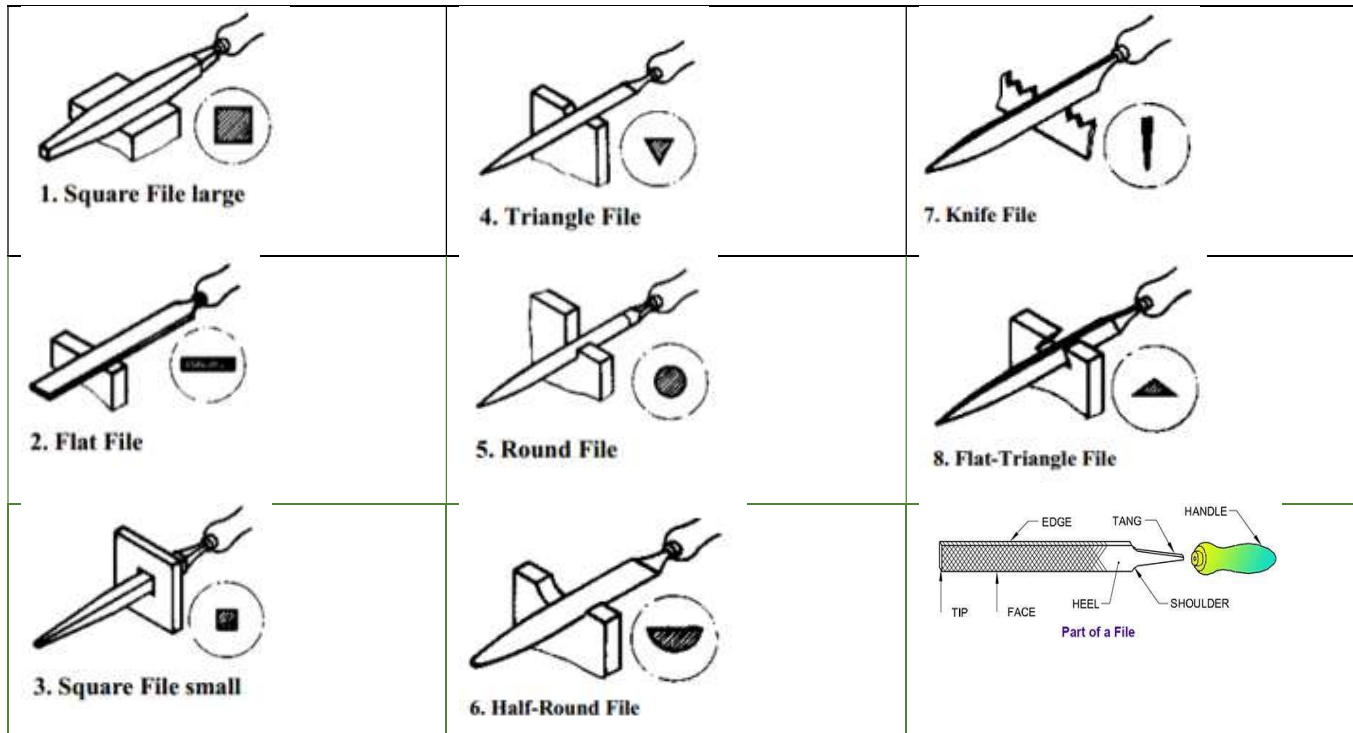
Cutting tools are tools used to separate metal into different parts of metals.

In those cutting tools we have;

➤ **Hand file**

The file is a cutting tool to work materials. It has many cutting edges which are like small chisels (file teeth) and are harder than the material being worked upon. For cutting metals normally Cross-Cut files are used. These files have an overcut, and an up cut. When using a file, several cutting wedges always act at the same time.

➤ Types of Files



To file different materials there are various courses available, such as **smooth-cut**, **second-cut**, and **bastard cut**. The length of the file body normally used is between 100 mm and 350 mm. The file handle is either from wood or from plastic.

➤ File Handling

- Clamp the work piece as close as possible to the jaws of the vice. Use protective jaws (Aluminium) to protect the work piece.
- Start with a rough file for removing more material than take a smooth file to reach a good surface.
- Forward stroke with pressure; Return stroke without pressure.
- Move with the file crosswise to control the area of filing.
- Clean the file from time to time (especially smooth files) with a wire brush to prevent messy finishes.

- Never work with a file without a file grip.
- Make sure that the file grip is properly attached, that it has the right dimension and that it is not splitted.

➤ **Hand Hacksaw**

The hacksaw is used to cut steel and other metals. It can also be used to cut plastics, although it is not normally used to cut woods. It is sometimes called an adjustable hacksaw because the length of the frame can be altered to hold blades of different sizes. Blades are supplied in two lengths, 250mm and 300mm. If the adjusting screw is unscrewed, the frame can be pushed into the handle so that the smaller blades fit the hacksaw.

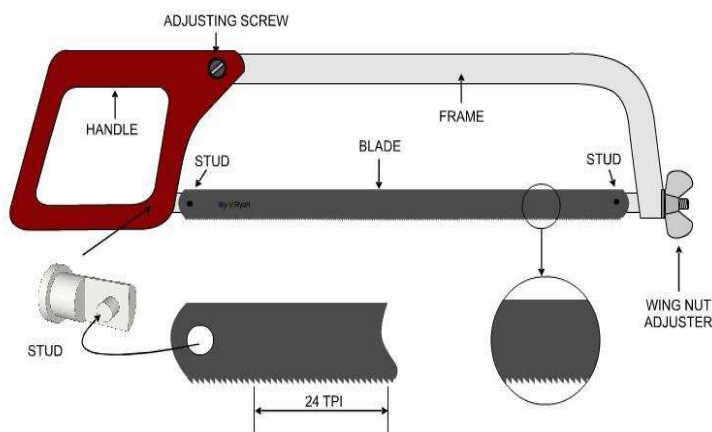


Figure 21: Hand Hacksaw

➤ **Chisel**

In chiselling the cutting edge of a chisel is driven into a work piece by impact. A chisel must be harder than the piece being worked. Most chisels are made of alloyed tool steels.

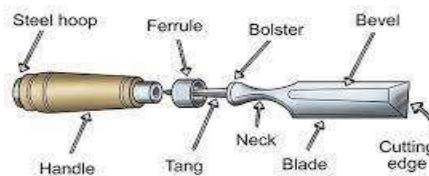


Figure 22: Chisel

Cleaning tools

Cleaning tools used during the welding process are designed to remove contaminants and prepare surfaces for welding. Keeping the workpiece and welding equipment clean is essential for achieving high-quality welds.

➤ **Wire Brush**

Use a wire brush to clean welding clamps, ground clamps, and other metal tools. Remove any spatter or debris that may have adhered to the surfaces. Ensure that the wire brush is appropriate for the material of the tool.



Figure23: Wire Brush

➤ **Chipping Hammer**

A chipping hammer is a hand tool commonly used in welding and metalworking applications. It is designed for the removal of welding slag, spatter, and other debris created during the welding process.



Figure24: Chipping Hammer

➤ **Grinding Discs/Wheels**

If grinding discs or wheels were used, inspect them for wear and replace them if necessary. Clean any accumulated metal particles or debris from the grinder.



Figure25: Grinding Discs

Clamping tools

Clamping tools refer to devices and equipment designed to secure and hold workpieces in place during the welding process.

✓ **Types of welding equipment**

This module focused on two types welding such as Arc welding and Oxy- acetylene gas welding

Types of arc welding equipment

- **Welding machine:** The equipment for the shielded metal arc welding process consists of a power source which is actually a welding machine, welding cable, electrode holder, and work clamp or attachment.

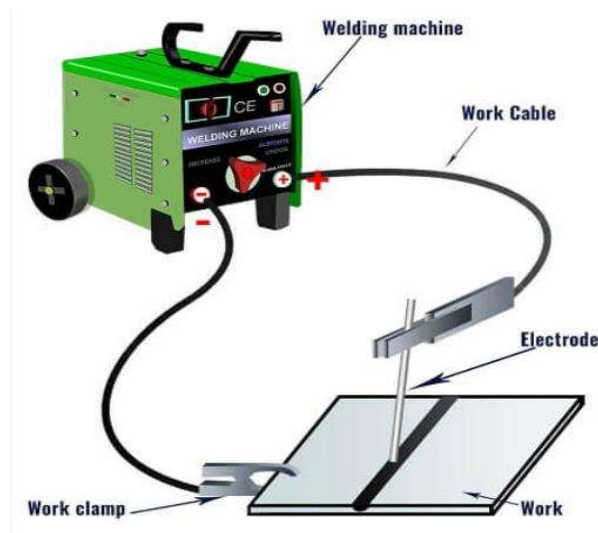


Figure26: Welding machine

-  **The purpose of the welding machine or power source is to provide the electric power of the proper current and voltage to maintain a welding arc.**

➤ **Types of Arc welding machine**

- **DC machine:** Direct current welding machine is a type of machine which produces direct current as an output power. In this type of machine, the transformers feed into a rectifier bridge, which then produces direct current for the arc. The three-phase rectifier unit is more efficient electrically than a generator and provides quiet operation.



Figure27: DC machine

This type of machine also gives the least voltage ripple and produces the smoothest arc of the static type welding machines. It automatically monitors output voltage and makes required changes to compensate for line voltage fluctuation.

- **AC machine:** In this type of welding machine, the power from the line is first rectified to pulsing direct current. This current then goes to a high frequency oscillator or chopper, which changes the DC into high-voltage, high frequency AC in the range 5 to 30 kHz. The output of the chopper circuit is controlled in accordance with welding procedure requirements. The high frequency AC is then transformed down to the operating welding voltage. These machines provide higher electrical efficiency, a higher power factor, and a faster response time.



Figure28: AC machine

- **AC/DC machine:** A method of supplying direct current power to the arc without using a rotating generator is adding a rectifier, an electrical device which changes alternating current into direct current. Transformer-rectifier welding machines operate on single-phase input power. These machines are used when both AC and DC current are needed. A single-phase type of AC welder is connected to the rectifier, which then produces DC current for the arc. By means of a switch that can change the output terminals to the transformer or the rectifier, the operator can select either AC or DC current for the welding requirement.

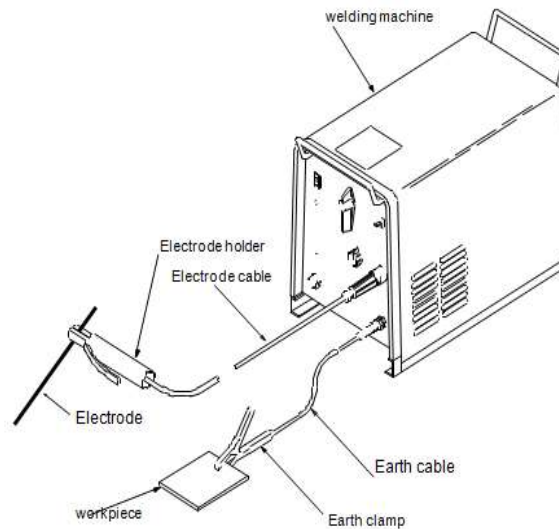


Figure29: AC/DC machine

➤ **Arc welding materials**

Arc welding is a welding process that uses an electric arc to melt and join metals. The materials used in arc welding can vary depending on the specific welding method and the type of metals being joined.

Here are some common materials used in arc welding:

- **Electrodes**

An electrode is a conductor through which an electric current is passed. Electrodes can be Consumable Electrodes or Non-Consumable Electrodes. These electrodes are consumed during the welding process and contribute filler material to the weld.

Common types include:

- ❖ **Shielded Metal Arc Welding (SMAW) Electrodes:** These are often coated with a flux material to protect the molten metal from atmospheric contamination.



Figure30: Electrodes

- ❖ **Gas Metal Arc Welding (GMAW) Electrodes:** These are usually solid wires or flux-cored wires that provide the filler material.



Figure 31: Gas Metal Arc Welding Electrodes

- ❖ **Flux-Cored Arc Welding (FCAW) Electrode**

Flux-Cored Arc Welding (FCAW) electrodes are a type of consumable welding electrode used in the Flux-Cored Arc Welding process. FCAW is a variation of the arc welding process where a tubular wire electrode filled with flux is used instead of a solid wire.



Figure32: Flux-Cored Arc Welding Electrode

✚ Types of Oxy-acetylene gas welding equipment

- **Oxygen gas cylinder**

It is made of seamless steel container used to store oxygen gas safely and in large quantity under a maximum pressure of 150kg/cm² for use in welding and cutting purpose. The cylinder valve has right hand threads to which all pressure regulators are attached. The cylinder body is painted black.



Figure33: Oxygen gas cylinder

- **Caution on oxygen cylinder**

- ❖ Always refer to oxygen as oxygen, never as air.
- ❖ Combustibles should be kept away from oxygen, including the cylinder, valves, regulators, and other hose apparatus.
- ❖ Oxygen cylinders and apparatus should not be handled with oily hands or oily gloves.
- ❖ Pure oxygen will support and accelerate combustion of almost any material, and is especially dangerous in the presence of oil and grease.
- ❖ Oil and grease in the presence of oxygen may spontaneously ignite and burn violently or explode.
- ❖ Oxygen should never be used in any air tools or for any of the purposes for which compressed air is normally used.

- **Acetylene gas cylinder**

- Acetylene gas is shipped in special cylinders designed to keep the dissolved gas.
- Acetylene cylinder is a steel container used to store high pressure acetylene gas safely in dissolved state for gas welding or cutting purposes.
- The acetylene gas cylinder is made up of seamless or welded steel container.
- The cylinder valve has a left hand threads to which the acetylene regulator is attached.
- The body of the cylinder is painted maroon.
- The base of acetylene cylinder (curved inside) is fitted with a fuse plug (safety plug) which will melt at a temperature of 100°C approximately. In case, the cylinder is subjected to high temperature fuse plugs will melt and allow the gas to escape. Fuse plugs are also fitted on the top of the cylinder.



Figure 34: Acetylene gas cylinder

➤ **Oxygen and Acetylene pressure regulators**

The gases compressed in oxygen and acetylene cylinders are held at pressures too high for oxyacetylene welding. Regulators reduce pressure and control the flow of gases from the cylinders. The pressure in an oxygen cylinder can be as high as 2200 psi (15,169 kPa), which must be reduced to a working pressure of 1 to 25 psi (6.90 to 172.38 kPa). The pressure of acetylene in an acetylene cylinder can be as high as 250 psi (1724 kPa). A gas pressures regulator will automatically deliver a constant volume of gas to the torch at the adjusted working pressure.

NOTE: The regulators for oxygen, acetylene, and liquid petroleum fuel gases are of different construction. They must be used only for the gas for which they were designed. A regulator is a device used in welding to control the amount of the gases to be used for performing proper welding operations. The regulator consists of two gauges one is cylinder pressure gauge (used to show amount inside the cylinder) another one is the working pressure gauge (used for setting the pressure to be used for welding). Also, it has the adjusting screws or Knob which is used to regulate the amount of the gas to be used during welding, a connection to hosepipes and a connection to cylinder.



Figure35: Oxygen and Acetylene pressure regulators

➤ **Oxygen gas hose (blue) and Acetylene gas hose (red)**

Oxygen and acetylene hoses are specially designed hoses used in welding and cutting operations where oxygen and acetylene gases are employed. These hoses play a crucial role in safely transporting these gases from the cylinders to the welding or cutting equipment.

Here's a brief explanation of each gas and its use in welding:

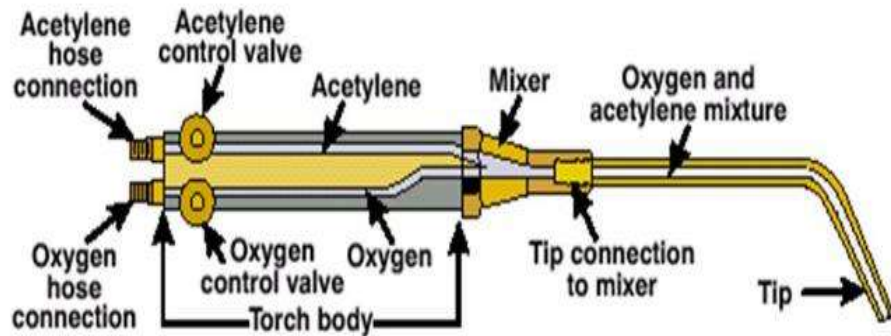
- **Oxygen (O₂)**: Oxygen is used as an oxidizer in welding and cutting processes. In welding, oxygen supports the combustion of the fuel gas (such as acetylene) to generate the heat needed for melting metals. In cutting, oxygen is used to react with the metal, producing metal oxide and facilitating the cutting process.
- **Acetylene (C₂H₂)**: Acetylene is a fuel gas commonly used in oxy-acetylene welding and cutting. It produces a high-temperature flame when burned with oxygen, making it suitable for various applications in metalworking.



Figure36: Oxygen gas and Acetylene gas hoses

➤ **Welding torch**

A welding torch is a tool used in various welding processes to generate and control the flame necessary for melting metals and creating a strong bond between them. The torch is a crucial component in oxy-fuel welding and cutting systems, including oxy-acetylene welding.



Figures37: Welding torch

➤ **Filler rods**

The rod which provides additional metal in completing the welding is known as filler. The composition of filler metal should be the same as that of the metal to be welded.



Figures36: Filler rods

➤ **Protective clothing for welders (overall, gloves, goggles, safety shoes)**

Protective clothing for welders is crucial to ensure the safety of the individuals performing welding and related tasks. Welding involves exposure to various hazards, including intense heat, sparks, and molten metal and potentially harmful fumes. Proper protective clothing helps minimize the risk of injuries and provides a barrier against these hazards.

➤ **Trolleys for cylinder transportation**



Figures 39: Trolley

✓ **Types of welding materials**

Most materials fall into one of three classes that are based on the atomic bonding forces of a particular material. These three classifications are metallic, ceramic and polymeric, different materials can be combined to create a composite material. Materials are organized into groups based on their chemical composition or certain physical or mechanical properties.

The following are classifications of materials:

✚ **Metals**

A metal is a solid material which is typically, shiny, malleable, fusible and ductile, with good electrical and thermal conductivity. **Metals and alloys are further classified into two major kind namely ferrous metals and non-ferrous metals:**

- **Ferrous metals** are those which have the iron as their main constituent, such as pig iron, cast iron, wrought iron and steels. Ferrous metals are magnetic and give little resistance to corrosion.
- **Non-ferrous metals** are those which have a metal other than iron as their main constituent, such as copper, aluminium, brass, bronze, tin, silver zinc, invar etc. Non-ferrous metals are not magnetic and are usually more resistance to corrosion than ferrous metals.

✚ **Ceramics**

Ceramic materials refer to a class of inorganic, non-metallic compounds or substances that are typically formed through the combination of metallic and non-metallic elements. These materials are known for their unique properties, which include hardness, brittleness, resistance to high temperatures, and often electrical insulating properties.

➤ **Examples of ceramic materials**

- Glasses
- Glasses ceramics
- Graphite
- Diamond

Polymers

Polymers" refers to large molecules composed of repeating structural units called monomers. These macromolecules are formed through a process known as polymerization, where monomers are chemically bonded to create a chain-like or network structure.

➤ **Examples of polymer materials**

- Thermoplastics plastics
- Thermoset plastics
- Elastomers

Composite

Composite materials are engineered materials made from the combination of two or more distinct materials with different physical or chemical properties.

➤ **Examples of composite materials**

- Reinforced plastics
- Metal -matrix composites
- Ceramic-matrix composites
- Sandwich structures
- Concrete

Points to Remember:

1

Ceramic materials refer to a class of inorganic, non-metallic compounds or substances that are typically formed through the combination of metallic and non-metallic elements. These materials are known for their unique properties, which include hardness, brittleness, resistance to high temperatures, and often electrical insulating properties.

LEARNING OUT COME 1. FORMATIVE ASSESSMENT

I. Read carefully and answer the following questions:

1. Define correctly the Following terms used in welding process :

- a) PPE
- b) Welding
- c) Arc Welding
- d) Gas Welding

Answers :

- a) PPE Personal Protective Equipment (PPE) refers to specialized gear, clothing, or equipment designed to protect individuals from various hazards during welding process.
- b) Welding is a process of joining two or more similar or dissimilar metals by means of heat or pressure with or without using filler metal.
- c) Arc Welding is a welding process that utilizes an electric arc to melt and join metals. It is one of the most common and versatile welding techniques, widely used in various industries for its ability to create strong and durable welds.
- d) Gas Welding Gas welding is a welding process that uses the heat generated by the combustion of a fuel gas mixed with oxygen to melt and join metals.

II. Respond the following questions with True for the correct statement and False for the incorrect statement

- a) Measuring tools are instruments used to make visible marks or indications on surfaces for various purposes. **False**
- b) Cutting tools are tools used to separate metal into different parts of metals. **True**
- c) Marking tools are a hand tool commonly used in welding and metalworking applications for removing slag, spatter, and other debris created during the welding process. **False**
- d) Cleaning tools are tools designed for removing contaminants and prepare surfaces for welding. **True**

III. Discuss the at least four guidelines and practices to enhance work area safety.

❖ **Answer:** work area safety is a critical aspect of ensuring a healthy and productive working environment. Here are guidelines and practices to enhance work area safety

- Risk Assessment
- Equipment Maintenance
- Emergency Evacuation Plans
- Employee Training

IV. Mr x went to weld door and his team leader told him to wear welding helmet but Mr X refuse by saying that he is experienced in welding field. Do you agree to Mr X? if yes or No explain your answer?

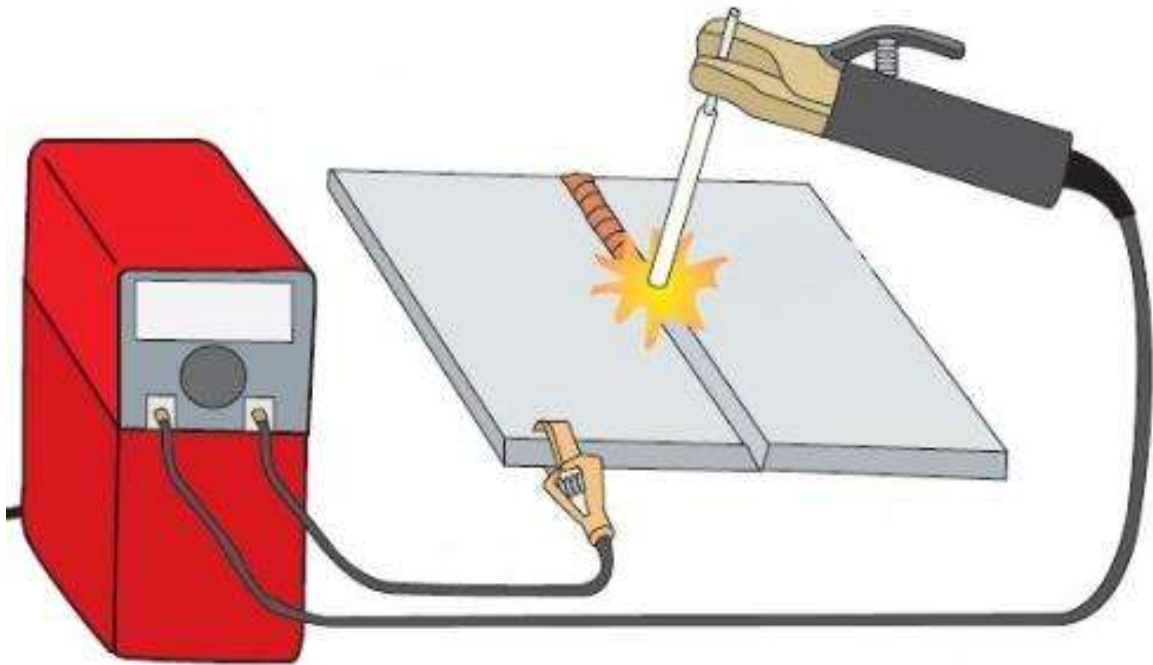
Answer: NO, because welding helmet will protect eyes and respiratory system from welding smokes.

V. Briefly explain the role of ventilated welding workplace

Answer: Ventilated workplace allow air to flow in and flow out which provide good health to welder.

LEARNING OUTCOME 2: PERFORM ARC WELDING

Learning outcome 2



LEARNING OUTCOME 2. PERFORM ARC WELDING

Indicative contents

- 2.1 Types of Arc Welding
- 2.2. Edge preparations
- 2.3. Application of arc welding techniques in all positions

Indicative content 2.1: Types of Arc Welding

1. Shielded Metal Arc Welding

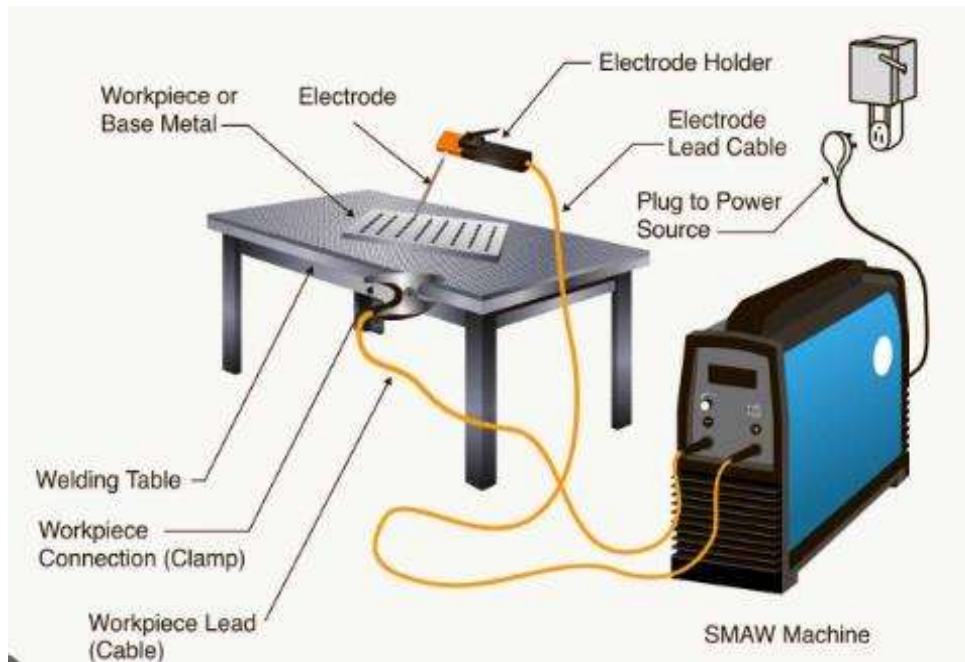
Shielded Metal Arc Welding (SMAW), also known as manual metal arc welding (MMA or MMAW), flux shielded arc welding, or stick welding, is a welding process where an electric arc is maintained between the end of a coated electrode and the workpiece. The electrode and the weld area are covered by a layer of flux, which melts during welding and forms a protective gas shield and a slag layer.



Figures 40: Shielded Metal Arc Welding equipment

Equipment:

Welding machine: The equipment for the shielded metal arc welding process consists of a power source which is actually a welding machine, welding cable, electrode holder, and work clamp or attachment.



The purpose of the welding machine or power source is to provide the electric power of the proper current and voltage to maintain a welding arc. Many different sizes and types of welding machines are designed for shielded metal arc welding. Most welding machines operate on 230 or 460 volt input electric power, but welding machines that operate on 200- or 575-volt input power are also available.

Different welding machines:

- ✚ **DC machine**
- ✚ **AC machine**
- ✚ **AC/DC machine**

Difference between AC from DC

	AC Transformer	DC Generator
1)	No polarity	Since the current flows in one direction there's polarity
2)	Arc is unstable	The arc is stable
3)	Arc is rough	The arc is smooth
4)	All types of electrodes cannot be used	Any type of electrode can be used

5)	All types of metals cannot be welded easily	All type of metals can be welded easily
6)	The machine produces alternating current as an out put	The machine produces Direct current as an out put
7)	Cost and Maintenance of the machine is low	Cost and Maintenance of the machine is high

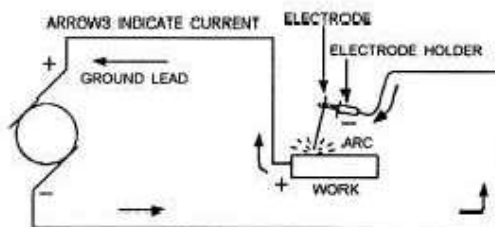
POLARITY is the path and direction of current flow in an electric circuit is known as **polarity**. In a DC Machine the positive connection receives 66% or $\frac{2}{3}$ rd of heat and negative connection receives 34% or $\frac{1}{3}$ rd of heat. This difference caused by polarity helps the welding to be easier.

There are two types of polarity namely:

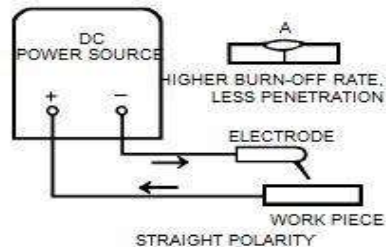
✚ **Straight Polarity**

✚ **Reverse Polarity**

Straight Polarity: In this straight polarity the electrode is connected to Negative connection of the machine and the job is connected to the positive connection of the welding generator.

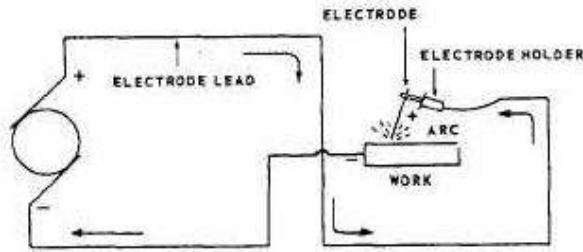


Electrode negative (-) produces welds with shallow penetration; however, the electrode melt-off rate is high. The weld bead is rather wide and shallow as shown at "A" in Figure below.

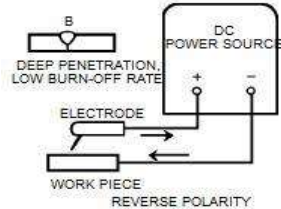


Since the metal receives large amount of heat, thicker sections are preferred to be welded easily with the help of this polarity.

Reverse Polarity: In this polarity the electrode is connected to positive Connection of the welding generator and the job is connected to the negative connection of the welding machine.



Electrode positive (+) produces welds with deep penetration and a narrower weld bead as shown at "B" in Figure below.



Since the base metal receives the less amount of heat thin sheets are preferred to be welded easily with the help of this polarity.

Electrodes used in SMAW have a core wire made of metal, and the outer coating consists of various materials, including flux. The flux serves multiple purposes, such as providing a shielding gas, stabilizing the arc, and creating a slag to protect the weld.



Sizes of Electrode: The electrode size refers to diameter of its core wire each electrode has a certain current range. The welding current rises with the electrode size (diameter).

Electrode Size in mm	Current range in Amps
1.6	10-50
2.0	60-80
2.5	80-90
3.15	90-120
4.00	120-160
5.00	160-220
6.30	220-250

Selection of electrodes:

- ✚ Depend upon the nature of the base metal (ferrous or nonferrous)
- ✚ Depends upon welding power source / machine
- ✚ According to thickness of the base metal
- ✚ Depending upon the welding position

Functions of Flux Coating: During welding with the heat of the arc, the electrode coating melts and performs the following functions:

- ✚ It stabilizes the arc
- ✚ It forms a gaseous shield around the arc which protects the molten weld pool from atmospheric contamination
- ✚ It helps in easy arc striking
- ✚ It helps in maintaining proper arc gap
- ✚ It helps to give good appearance and penetration to the weld
- ✚ It makes the welding in all positions easy

Both AC and DC can be used for welding.

Welding electrode specifications

The American Welding Society (AWS) numbering system can tell a welder quite a bit about a specific stick electrode including what application it works best in and how it should be used to maximize performance. With that in mind, let's take a look at the system and how it works. The prefix "E" designates an arc welding electrode. The first two digits of a 4-digit number and the first three digits of 5-digit number indicate minimum tensile strength. For example, E6010 is a 60,000-psi tensile strength electrode while E10018 designates a 100,000-psi tensile strength electrode.

E	60	1	10
Electrode	Tensile Strength	Position	Type of Coating and Current

The next to last digit indicates position. The "1" designates an all-position electrode, "2" is for flat and horizontal positions only; while "4" indicates an electrode that can be used for flat, horizontal, vertical down and overhead. The last 2 digits taken together indicate the type of coating and the correct polarity or current to use. See chart below

Digit	Type of Coating	Welding Current
0	High cellulose sodium	DC+
1	High cellulose potassium	AC, DC+ or DC-
2	High titania sodium	AC, DC-
3	High titania potassium	AC, DC+
4	Iron powder, titania	AC, DC+ or DC-
5	Low hydrogen sodium	DC+
6	Low hydrogen potassium	AC, DC+
7	High iron oxide, iron powder	AC, DC+ or DC-
8	Low hydrogen potassium, iron powder	AC, DC+ or DC-

Electrodes: As a welder, there are certain electrodes that you will most likely see and use time and time again as you go about your daily operations. A DC machine produces a smoother arc. DC rated electrodes will only run on a DC welding machine. Electrodes which are rated for AC welding are more forgiving and can also be used with a DC machine.

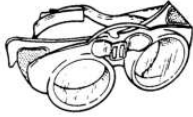
Here are some of the most common electrodes and how they are typically used:

E60 series

- E6010:** DC only and designed for putting the root bead on the inside of a piece of pipe, this is the most penetrating arc of all. It is tops to dig through rust, oil, paint or dirt. It is an all-position electrode that beginning welders usually find extremely difficult, but is loved by pipeline welders worldwide.
- E6011:** This electrode is used for all-position AC welding or for welding on rusty, dirty, less-than-new metal. It has a deep, penetrating arc and is often the first choice for repair or maintenance work when DC is unavailable.
- E6013:** This all-position, AC electrode is used for welding clean, new sheet metal. Its soft arc has minimal spatter, moderate penetration and an easy-to-clean slag.
- E7018:** A low-hydrogen, usually DC, all-position electrode used when quality is an issue or for hard-to-weld metals. It has the capability of producing more uniform weld metal, which has better impact properties at temperatures below zero.
- E7024:** Typically used to make a large weld down hand with AC in plate that is at least ¼" thick, but more commonly used for plate that is ½" and up.

Shield metal arc welding accessories (SMAW Accessories)

Names	Pictures
Wire brush	 <i>Figure41: Wire brush</i>
Hand shield	 <i>Figure 42: Hand shield</i>

Welding Helmet	 Figure 2: Welding Helmet
Chipping goggles	 Figure 3: Chipping goggles

2. Gas Metal Arc Welding (MIG or MAG Welding)

Gas Metal Arc Welding (GMAW), commonly known as MIG (Metal Inert Gas) welding or MAG (Metal Active Gas) welding, is a welding process in which an electric arc forms between a consumable wire electrode and the workpiece, while a shielding gas is used to protect the weld area from atmospheric contamination. The choice between "inert" or "active" in the shielding gas depends on the specific requirements of the welding application.

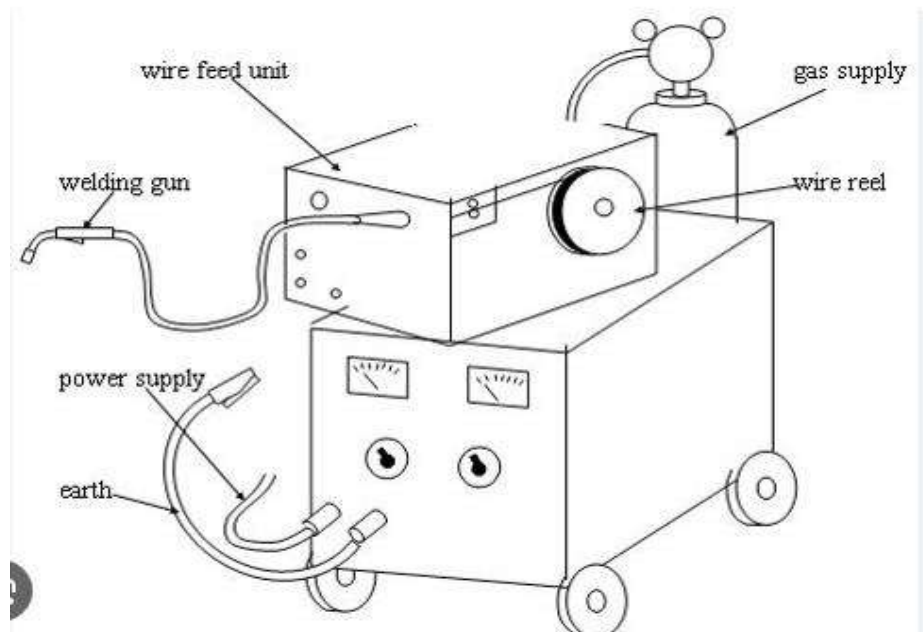


Figure 4: Gas Metal Arc Welding

The welding circuit consists essentially of the following elements:

-  **Power source**
-  **Torch with cable bundle**
-  **Wire feeder**
-  **Water cooling unit**
-  **Gas cylinder with regulation system**
-  **Clamp with earth cable**

Equipment of Gas Metal Arc Welding

Power Source

The power source provides the electrical energy needed for the welding process. MIG/MAG welding machines typically operate on either direct current (DC) or alternating current (AC), with DC being more common.

Wire Feeder

The wire feeder is a crucial component that feeds the consumable electrode wire from a spool to the welding gun. It controls the speed and consistency of wire feed, contributing to stable and uniform welds.

Welding Gun or Torch

The welding gun or torch is held by the welder and is responsible for directing the electrode wire to the weld joint. It also releases the shielding gas to protect the weld pool from atmospheric contamination. The trigger on the gun controls the wire feed and, in some cases, the gas flow.

Consumable Electrode Wire

MIG/MAG welding uses a continuously fed consumable electrode wire, which is often spooled on a reel. The wire is selected based on the material being welded and the welding parameters.

Shielding Gas Supply

MIG welding requires a shielding gas to protect the weld from atmospheric contamination. The choice of shielding gas depends on the material being welded. Common gases include argon, helium, and carbon dioxide, as well as mixtures of these gases.

Gas Regulator and Flowmeter

The gas regulator controls the pressure of the shielding gas coming from the gas cylinder. A flowmeter indicates and controls the flow rate of the gas to ensure proper shielding during welding.

Ground Clamp

The ground clamp connects the welding machine to the workpiece, completing the electrical circuit. It is essential for the welding process to have a stable ground connection.

Power Cable and Leads

The power cable connects the welding machine to the power source. Leads connect the wire feeder, welding gun, and ground clamp to the power source.

Control Panel

The control panel on the welding machine allows the welder to adjust various settings, such as voltage, wire feed speed, and sometimes inductance or arc control. These settings affect the welding parameters and help achieve the desired weld characteristics.

Drive Rolls and Tensioning System

The drive rolls, located in the wire feeder, help pull the electrode wire from the spool and feed it through the welding gun. A tensioning system ensures proper and consistent wire feeding.

Cooling System

Some high-powered MIG/MAG welding machines, especially those used for heavy-duty applications, may have a built-in cooling system to prevent overheating of the equipment.

WELDING PROCESS

Arc Initiation: The welding arc is initiated by the electrical current passing between the electrode wire and the workpiece.

Melting and Deposition: As the arc heats the electrode wire, it melts, and droplets are transferred across the arc to the workpiece. This forms the weld bead as the molten metal solidifies, during this process shielding gas is released through the welding gun to protect the molten weld pool from atmospheric contamination. It prevents the formation of oxides and nitrides that could weaken the weld.

APPLICATIONS

GMAW is widely used in various industries, including:

-  **Automotive**
-  **Manufacturing**
-  **construction**
-  **shipbuilding**

- ✚ **It is suitable for welding a variety of materials, including carbon steel, stainless steel, aluminium, and other non-ferrous metals.**

ADVANTAGES AND LIMITATIONS

Advantages

- ✚ **High Deposition Rates:** MIG/MAG welding allows for high deposition rates, making it a fast and efficient process, especially in industrial applications.
- ✚ **Versatility:** MIG/MAG welding can be used to weld a wide range of materials, including carbon steel, stainless steel, aluminium, and various alloys.
- ✚ **Reduced Cleanup:** The process produces minimal slag, reducing the need for post-weld cleanup compared to some other welding methods.
- ✚ **Continuous Wire Feeding:** The continuous feeding of the consumable electrode wire from a spool through a wire feeder allows for longer welding times without interruption.
- ✚ **Suitable for Automation:** MIG/MAG welding is easily adaptable to automation and robotic welding systems, enhancing precision and repeatability in large-scale production.
- ✚ **Good Weld Quality:** When performed correctly, MIG/MAG welding can produce high-quality welds with good penetration and mechanical properties.
- ✚ **All-Position Welding:** MIG/MAG welding is versatile and can be used in various welding positions, including flat, horizontal, vertical, and overhead.
- ✚ **Minimal Skill Requirement:** While skill is still necessary for high-quality welds, MIG/MAG welding is generally considered easier to learn and use compared to some other welding processes.

LIMITATIONS

- ✚ **Sensitivity to Environmental Factors:** MIG/MAG welding is sensitive to wind and drafts because the shielding gas can be easily disrupted, leading to potential weld defects.
- ✚ **Cleanliness Requirements:** The work surface and materials must be clean and free of contaminants to ensure the quality of the weld, as the process is sensitive to impurities.
- ✚ **Portability:** MIG/MAG welding equipment can be less portable than some other welding methods, limiting its use in certain remote or challenging locations.
- ✚ **Equipment Cost:** The initial setup cost for MIG/MAG welding equipment, including the power source, wire feeder, and shielding gas supplies, can be relatively high.
- ✚ **Limited Penetration in Thick Materials:** While suitable for many applications, MIG/MAG welding may have limitations in achieving deep penetration in thick materials compared to processes like submerged arc welding.

- ✚ **Gas Shielding Costs:** The cost of shielding gases (argon, helium, or gas mixtures) can contribute to the overall cost of the welding process.
- ✚ **Not Ideal for Thin Materials:** MIG/MAG welding may not be the best choice for welding very thin materials, as it can lead to burn-through or lack of fusion

3. Flux Cored Arc Welding (FCAW)

Flux-Cored Arc Welding (FCAW) is a welding process that combines elements of both MIG/MAG welding and stick welding. Like MIG/MAG welding, it uses a continuously fed consumable electrode, but the electrode has a flux core similar to that used in stick welding. This eliminates the need for a separate shielding gas, as the flux generates a protective atmosphere during welding.

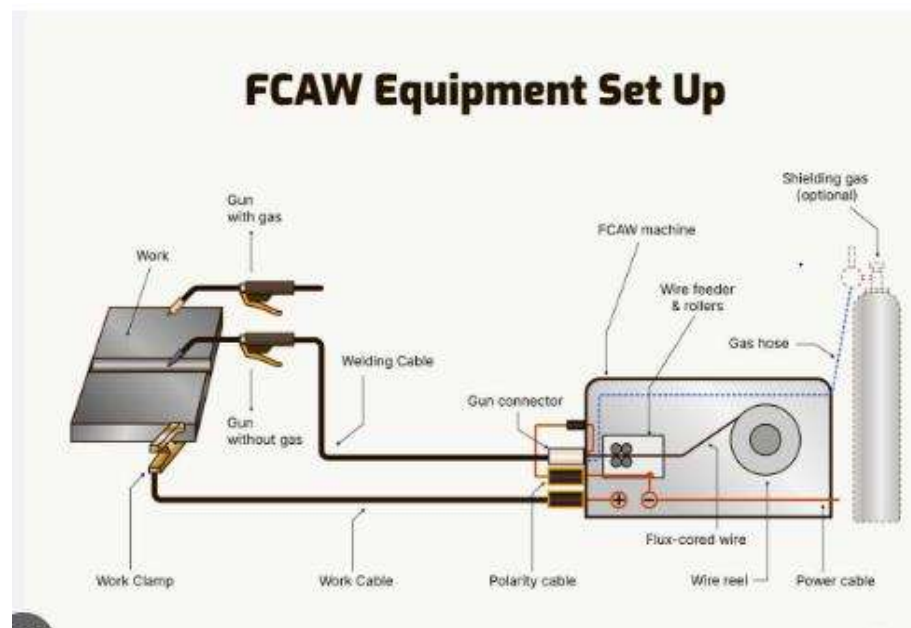


Figure 5: Flux Cored Arc Welding equipment

Equipment Flux Cored Arc Welding (FCAW)

✚ **Power Source**

The power source provides the electrical energy needed to generate the welding arc. FCAW is typically performed using constant voltage (CV) power sources.

✚ **Wire Feeder**

The wire feeder is a critical component that feeds the flux-cored electrode wire from a spool to the welding gun. It controls the speed and consistency of wire feed, ensuring a steady deposition of filler metal.

Welding Gun or Torch

The welding gun or torch holds and directs the flux-cored electrode wire to the weld joint. It also plays a role in the release of shielding gas when gas-shielded FCAW is used.

Flux-Cored Electrode

The flux-cored electrode is a tubular wire with a flux core. The flux serves multiple purposes, including generating a protective gas shield, stabilizing the arc, and creating a slag layer to protect the weld.

Shielding Gas Supply (for Gas-Shielded FCAW)

In gas-shielded FCAW, an external shielding gas is used in addition to the flux. Common shielding gases include mixtures of argon and carbon dioxide. A gas cylinder, pressure regulator, and flowmeter are needed to supply and control the shielding gas.

Ground Clamp

The ground clamp connects the welding machine to the workpiece, completing the electrical circuit. It is essential for proper current flow during welding.



Points to Remember

Shielded Metal Arc Welding (SMAW), also known as manual metal arc welding (MMA or MMAW), **flux shielded arc welding**, or stick welding, is a welding process where an electric arc is maintained between the end of a coated electrode and the workpiece.

Indicative content 2.2: Edge preparations

✓ **EDGES PREPARATION TECHNIQUES**

Edges preparation techniques

Edge preparation is a critical step in the welding process, as it significantly influences the quality and strength of the weld joint. Proper edge preparation ensures good penetration, fusion, and overall weld integrity. The specific edge preparation technique depends on factors such as the welding process, material type, thickness, and joint configuration.

➤ **Here are some common edge preparation techniques in welding**

➤ **V-Groove Joint**

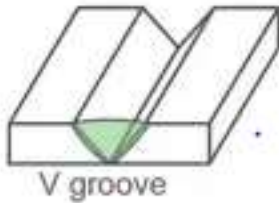


Figure 6 : V-Groove Joint

- Suitable for materials with good weldability and thicknesses up to about 6 mm.
- The edges are cut square to each other, forming a 90-degree angle.

➤ **U-Groove Joint**

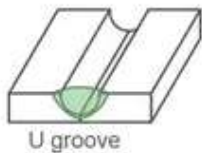


Figure 7: U-Groove Joint

- Similar to the V-groove, but the groove is U-shaped.
- It is used for thicker materials and allows for better access to the root of the joint.

➤ **Double V-Groove Joint**

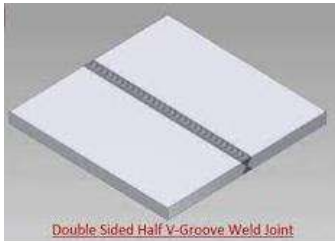
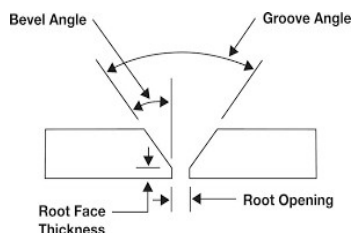


Figure 8: Double V-Groove Joint

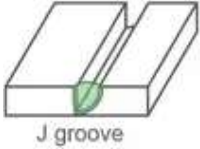
- Both edges are beveled, forming a V on each side.
- Ideal for thicker materials and provides good accessibility for welding.

➤ **Beveling**



Figures 50 : Beveling

- The edges are cut or ground at an angle to allow for better fusion during welding.
- Bevel angles can vary based on material thickness and welding requirements.

➤ J-Groove Joint  Figure 9: J-Groove Joint	➤ One side is given a J-shape, and the other side remains square. ➤ Provides good penetration while requiring less material removal.
➤ Flare bevel Groove joint  Figure 10: Flare bevel Groove joint	➤ Combines a bevel with a flare on one side, providing better joint accessibility.



Points to Remember

Edge preparation is a critical step in the welding process, as it significantly influences the quality and strength of the weld joint

Indicative content 2.3 Application of arc welding techniques in all positions

✓ **APPLICATION OF DIFFERENT TYPES OF JOINTS TO PRODUCE BUILDING ELEMENTS (WINDOWS, DOORS AND TRUSSES)**

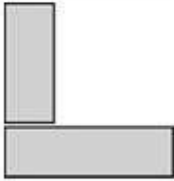
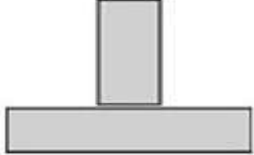
Butt joint



Butt Joint

Figure 11: Butt joint

- Refers to a type of joint between two pieces of metal where the edges are aligned and joined together without any overlapping.

	<u>Corner joint</u>  Corner Joint <i>Figure 12: Corner joint</i>	➤ Is a type of joint formed by the intersection of two pieces of metal at right angles to each other, creating a corner
	<u>Edge joint</u>  Edge Joint <i>Figure 13: Edge joint</i>	➤ Is a type of joint in welding where two pieces of material are joined along their edges. The welding process for an edge joint depends on various factors, including the type of material, its thickness, and the specific requirements of the application
	<u>Lap joint T-joint</u>  Lap Joint <i>Figure 14: Lap joint T-joint</i>	➤ Is a type of joint where two overlapping pieces of metal are joined to gather.
	<u>T-joint</u>  Tee Joint <i>Figure 15: T-joint</i>	➤ T- joint is used in the construction of various structural elements where joints are formed two pieces intersect at a 90° angle.

✓ **APPLICATION OF WELDING POSITIONS**

Flat positions



Figure 16: Flat positions

- Welding is performed on the upper side of a horizontal surface. Commonly used in welding plates and sheet metal.

Horizontal positions

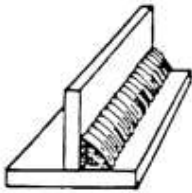


Figure 17: Horizontal positions

- Welding is performed on the side of a horizontal surface. Used in applications where the joint is positioned horizontally.

Vertical positions

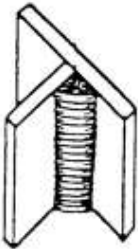


Figure 18: Overhead positions

- Welding is performed on a vertical surface, often used in the fabrication of upright structures.

Overhead positions

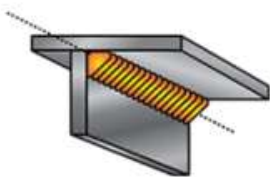


Figure 19: Overhead positions

- Is performed from the underside of the joint area. Overhead welding position is the most complicated and difficult position



Points to Remember

Butt joint: Refers to a type of joint between two pieces of metal where the edges are aligned and joined together without any overlapping.

Learning outcome 2. Formative Assessment

Q1. Answer true or false the following:

- a) in welding process there are many different joints to produce building elements like Butt joint, full joint, Corner joint and Edge joint.

Answer: false

- b) Cost and Maintenance of the machine is low for AC transformer while DC Cost and Maintenance of the machine is high.

Answer: true

Q2. Discuss the advantages for shield metal arc welding in field of building construction.

Answer:

- Low Equipment Cost: The initial cost of stick welding equipment is often lower compared to other welding processes such as TIG or MIG.
- Suitable for Thick Materials: SMAW is well-suited for welding thick materials
- No External Gas Required: Unlike processes like TIG (Tungsten Inert Gas) or MIG (Metal Inert Gas), SMAW does not require an external shielding gas.
- Welding in Tight Spaces: The compact nature of stick welding equipment allows for welding in tight and hard-to-reach spaces, making it applicable in various construction and repair scenarios.
- Deep Weld Penetration: SMAW is capable of achieving deep weld penetration, making it suitable for welding joints with thicker materials

Q3. Match the following column A with column B

COLUMN A	COLUMN B
1. 	I. 
2. Flare Bevel Groove Joint	II. is released through the welding gun to protect the molten weld pool from atmospheric contamination
3. The shielding gas	III. welding helmet

4. 	IV. lap joint
--	---------------

Answer: 1-III

2-I

3-II

4-IV

Q4. After welding operations, the welded structural component breaks down into pieces. This resulted in severe injuries to several workers, and tragically, one worker lost their life. Suggest different measures to prevent such structural component break.

Answer:

- Material Inspection and Quality Control
- Verification of all Welding Procedure
- Qualified Welders
- Supervision and Inspection
- Preventive Maintenance for welding tools, equipment and materials
- Training and Education for welding process

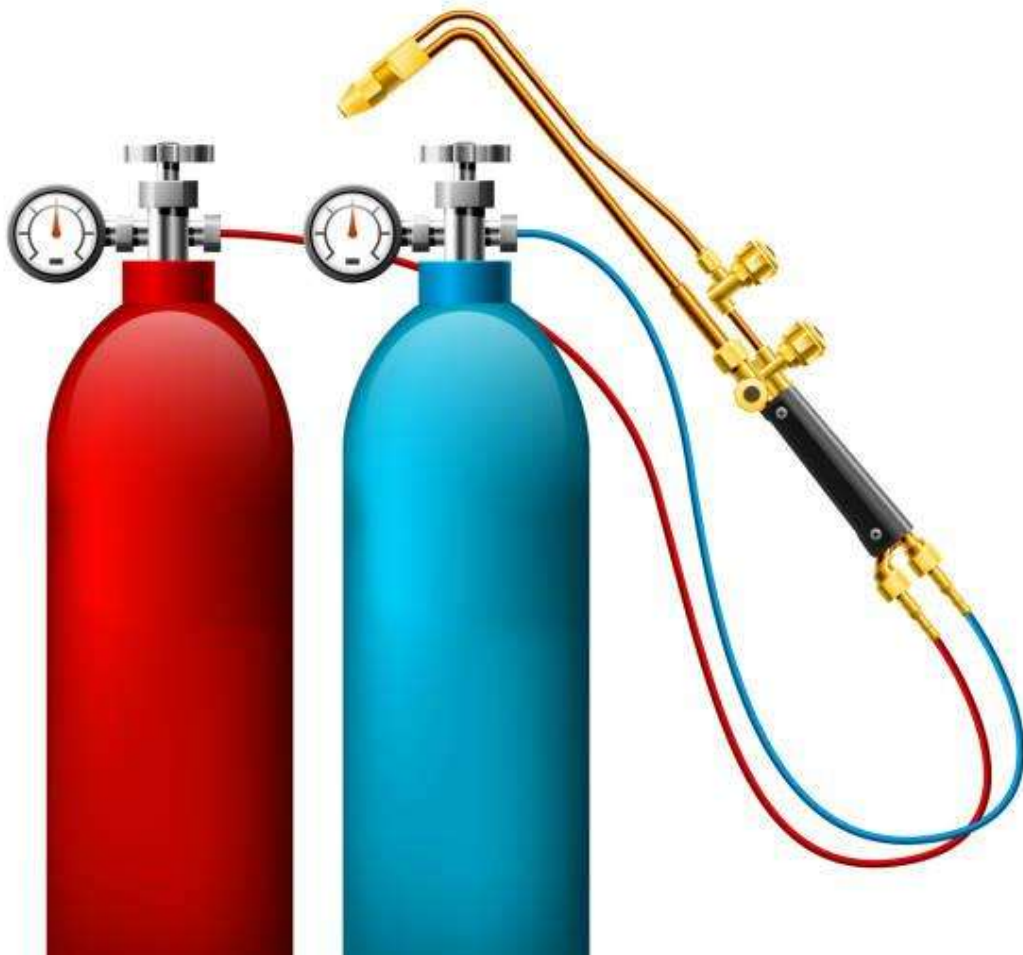
Q5. Describe shield metal arch welding components

Answer:

- Welding machine
- Electrode
- Electrode holder
- Electrode cable
- Earth cable
- Earth clamp

LEARNING OUTCOME 3: PERFORM OXYACETYLENE GAS WELDING

Learning outcome 3



LEARNING OUTCOME 3: OXY-ACETYLENE GAS WELDING

Indicative contents:

1. Setting up of the equipment pressure
2. Flames used during oxy-acetylene gas welding process
3. Edge preparations during oxy-acetylene gas welding process
4. Application of oxy-acetylene gas welding

Indicative content 3.1: Setting up of the equipment pressure

- **Operation pressure of oxy-acetylene gas welding**

The operation pressure for oxy-acetylene gas welding typically depends on the specific requirements of the welding process, the type of equipment used, and the materials being welded. However, there are common ranges that are often recommended for oxy-acetylene welding.

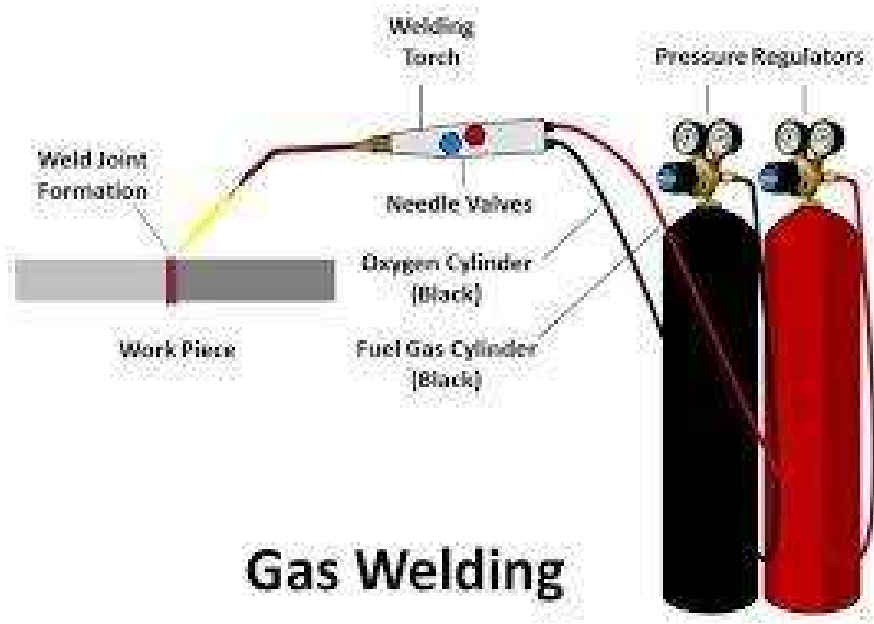


Figure 20: Gas welding equipment

- **Acetylene Pressure used during welding process**

Acetylene is usually supplied in cylinders at pressures ranging from 250 psi to 300 psi (pounds per square inch). However, for welding operations, the recommended working pressure for acetylene is often around 5 psi to 15 psi.

- **Oxygen Pressure used during welding process**

Oxygen is supplied in cylinders at higher pressures compared to acetylene. Typically, oxygen cylinder pressures range from 2,000 psi to 2,200 psi. For welding, the recommended working pressure for oxygen varies but is often in the range of 20 psi to 40 psi.

- **Cutting pressure of oxy-acetylene gas welding**

When using oxy-acetylene gas welding for cutting operations, the cutting pressure refers to the pressure settings for the oxygen and acetylene gases in the cutting torch. The cutting process involves preheating the metal to its ignition temperature using the oxy-acetylene flame and then introducing a high-pressure stream of oxygen to accelerate the burning of the metal, resulting in a cut. The cutting pressure settings can vary depending on the thickness and type of material being cut. Here are some general guidelines

- **Acetylene Pressure used during cutting operation**

The acetylene pressure during cutting is typically set in the range of 5 psi to 15 psi. This pressure is used to create the preheating flame that brings the metal to its ignition temperature.

- **Oxygen Pressure used during cutting operation**

The oxygen pressure for cutting is significantly higher than that used for welding. Oxygen pressures for cutting generally range from 25 psi to 60 psi or even higher, depending on the thickness of the material. The high-pressure oxygen stream supports the combustion of the preheated metal, facilitating the cutting process.

➤ **Oxy-acetylene gas welding accessories**

- **Spark lighter** is designed for lighting the flame.

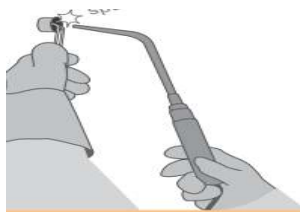


Figure 21: Spark lighter

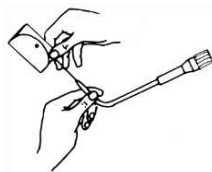
- **Welding goggles** is designed to prevent the welding fumes reaching the welder's eyes



- **Wire brush** is used in cleaning the weld.



- **Nozzle cleaner** is used for cleaning the welding tip.



- **Cylinder key** is designed for opening and closing the gas on oxygen and acetylene gas cylinder



Figure 22 : Cylinder key

- **Spanner** is designed for tightening all connections of ox-acetylene gas welding equipment
- **Trolley** is designed for transportation of gas and oxygen cylinder

➤ **Procedures for lighting the flame**

- Open the cylinder valve on the acetylene tank ~1/4 turn. This charges the pressure regulator at the top of the tank.
- Open the pressure regulator valve on the acetylene tank (turn clockwise to open) and adjust the pressure in the acetylene line to 5 psi. DO NOT pressurize the acetylene over 15 psi - it will explode.
- Open the acetylene control valve on the handle of the welding torch, letting acetylene escape. Tweak the acetylene adjusting knob until the working pressure is constant at 5 psi. Close the acetylene control valve.
- Open the cylinder valve on the oxygen tank. Turn the valve until it is fully open (until its tops turning).
- Open the valve on the oxygen tank (turn clockwise to open) and adjust the pressure in the oxygen line to 10 psi.
- Open the oxygen pin valve on the handle of the welding tool, letting oxygen escape. Tweak the pressure regulator valve until the regulator pressure is constant at 10 psi. Close the oxygen pin valve.
- Slightly open the acetylene valve (~1/8), until you can just barely hear acetylene escaping.
- Make sure there is no person or anything flammable in the path of the nozzle. Use the striker to ignite the acetylene. The flame should be yellow and will give off a lot of soot. To start the welding torch, hold it so as to direct the flame away from the operator, gas cylinders, hose, or any flammable material and ignite the gas by striking the spark lighter in front of the tip.
- Since the oxygen torch valve is closed, the acetylene is burned by the oxygen in the air. There is not sufficient oxygen to provide complete combustion, so the flame is smoky and produces a soot of fine unburned carbon. Continue to open the acetylene valve slowly until the flame burns clean. The acetylene flame is long, bushy, and has a yellowish color. This pure acetylene flame is unsuitable for welding

- Slowly open the oxygen valve. The flame changes to a bluish-white and forms a bright inner cone surrounded by an outer flame. The inner cone develops the high temperature required for welding.

➤ **Procedures for shutting off the oxyacetylene flame/ Extinguishing the flame**

- When the welding operation is finished, close the acetylene control valve first and then turn off the oxygen control valve.
- Close oxygen cylinder valve.
- Release the pressure in the hosepipe and regulator by opening the oxygen control valve on the torch.
- Release the pressure of the oxygen regulator diaphragm by turning the oxygen adjusting knob to the minimum pressure position.
- Close the oxygen control valve on the torch.
- Close acetylene cylinder valve.
- Release the pressure in the hosepipe and regulator by opening the acetylene control valve on the torch.
- Release the pressure of the acetylene regulator diaphragm by turning the acetylene adjusting knob to the minimum pressure position.
- Close the acetylene control valve on the torch.
- Position the hosepipes and welding torch properly.



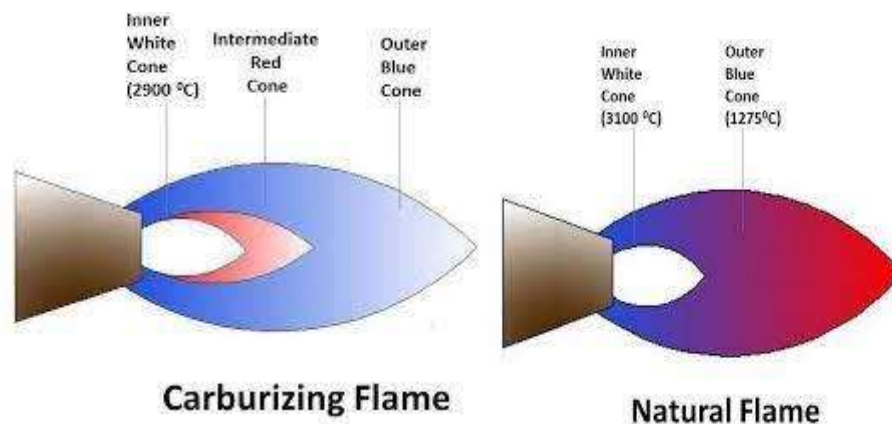
Points to Remember

- **The acetylene pressure during welding process** is typically set in the range of **5 psi to 15 psi** and **oxygen cylinder pressures** range from **2,000 psi to 2,200 psi**. For welding, the recommended **working pressure for oxygen** varies but is often in the range of **20 psi to 40 psi**.
- **The acetylene pressure during cutting operation** is typically set in the range of **5 psi to 15 psi** while **Oxygen pressures for cutting** generally range from **25 psi to 60 psi**

Indicative content 3.2: Frames used during oxy-acetylene gas welding process

✓ Brazing flame

"brazing flame" refers to **the specific type of flame used during the brazing process where two or more metals are joined together by melting and flowing a filler metal into the joint.** The filler metal has a lower melting point than the base metals, typically above 450°C (842°F) but below their melting points. The flame used for brazing is often adjusted to be either slightly carburizing or neutral. A neutral flame has a balanced mixture of acetylene and oxygen, with complete combustion in the inner cone and a slightly reducing atmosphere in the outer envelope while carburizing flame is obtained when there is an excess amount of acetylene gas over oxygen gas, this flame is obtained by first adjusting to neutral and then slowly opening the acetylene valve until an acetylene streamer or "feather" is at the end of the inner cone.



✓ Welding flame

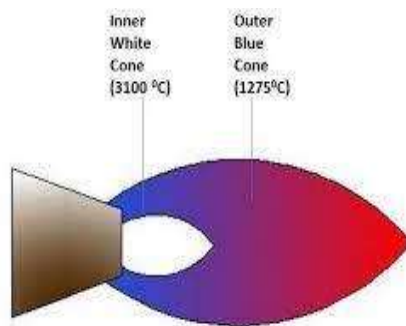
In gas welding processes, the term **"welding flame"** refers to **the specific type of flame produced by the combustion of gases that are used to generate heat for welding.**

The characteristics of the welding flame play a crucial role in the success of the welding operation, as different types of flames are suitable for different welding tasks.

✚ **THERE ARE GENERALLY THREE TYPES OF FLAMES USED IN GAS WELDING DURING WELDING PROCESS:**

➤ **Neutral Flame**

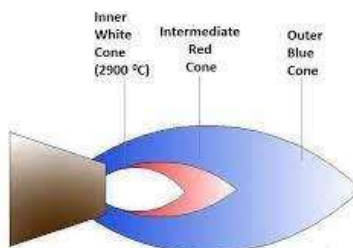
- This is the ideal flame for most welding operations.
- It has a well-balanced proportion of oxygen and acetylene, resulting in a neutral or balanced chemical reaction.
- The neutral flame has a distinct cone shape and is characterized by a sharp inner blue cone surrounded by a broader, lighter blue outer envelope.



Natural Flame

➤ **Carburizing Flame**

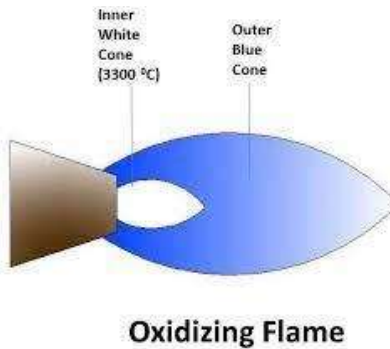
- This flame has an excess of acetylene compared to oxygen.
- It is recognized by a longer inner luminous cone and is often accompanied by a feather-like outer envelope.
- Carburizing flames are not suitable for welding ferrous metals, as they can introduce excess carbon, making the metal brittle.



Carburizing Flame

➤ **Oxidizing Flame**

- This flame has an excess of oxygen compared to acetylene.
- It is characterized by a shorter inner cone and a hissing sound.
- Oxidizing flames are generally used for cutting operations rather than welding. They provide an oxygen-rich environment that promotes the oxidation and removal of metal during cutting.



✓ **Cutting flame**

A cutting flame is a specific type of flame used in oxy-acetylene cutting processes, where the primary goal is to melt and remove metal through the chemical reaction of oxygen with the workpiece.



Points to Remember

- **"Brazing flame"** refers to the specific type of flame used during the welding process where two or more metals are joined together by melting and flowing a filler metal into the joint. The filler metal has a lower melting point than the base metals, typically above 450°C (842°F) but below their melting points.

Indicative content 3.3: Edge preparations

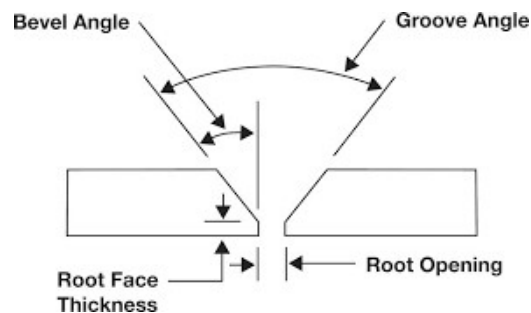
✓ **Edges preparation techniques**

Edge preparation techniques for oxy-acetylene gas welding refer to the process of shaping and cleaning the edges of metal pieces that will be joined through gas welding using oxy-acetylene equipment. **Proper edge preparation is essential for achieving strong and reliable welds.**

✚ **Here there are the key techniques involved in edge preparation for oxy-acetylene gas welding:**

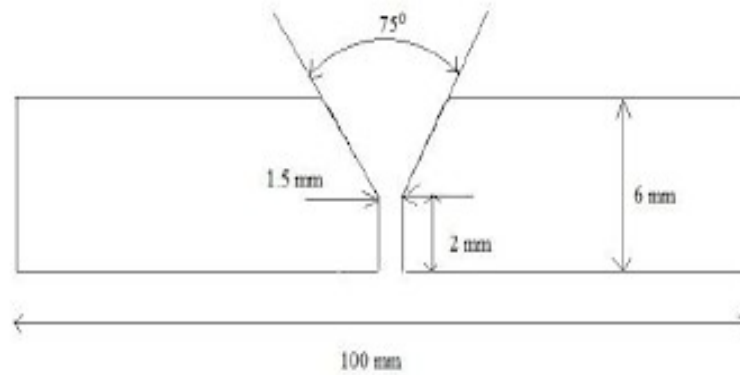
➤ **Beveling**

Beveling involves cutting or grinding an angled edge on the metal pieces. The angle of the bevel depends on factors such as material thickness and welding process. Beveling enhances weld penetration and fusion.



➤ **V-Groove**

V-groove preparation involves shaping both edges of the metal pieces to form a V. This increases the weld area, allowing for better penetration. V-groove preparation is often used for thicker materials. Below there is sample v- groove edge preparation.



➤ **U-Groove**

Similar to the V-groove, the U-groove involves shaping the edges to form a U shape. This provides more space for the weld metal and is suitable for thicker materials or when deeper penetration is needed.

➤ **Chamfering**

Chamfering creates a beveled edge by removing material along the length of the joint. This helps reduce the risk of incomplete fusion and improves the appearance of the weld. Chamfering is suitable for materials with limited thickness.

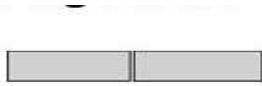
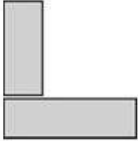
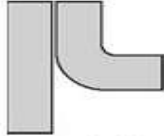
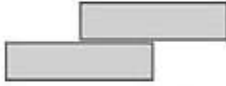


Points to Remember

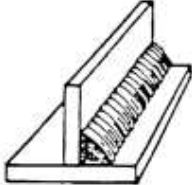
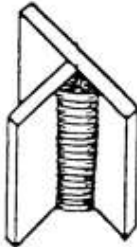
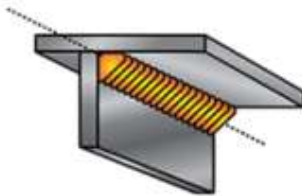
Edge preparation techniques for oxy-acetylene gas welding refer to the process of shaping and cleaning the edges of metal pieces that will be joined through gas welding using oxy-acetylene equipment.

Indicative content 3.4 Application of oxy-acetylene gas welding

- ✓ **Application of different types of joints to produce building elements (windows, doors, trusses)**

Types of joints	Applications
 Butt Joint	➤ But joint is used to join two pieces of metal in the same plane, end-to-end. Commonly used in the production of structural elements.
 Corner Joint	➤ It used to join two pieces of metal at right angles, commonly used in the construction of frames for doors and windows.
 Edge Joint	➤ It Connects two parallel or nearly parallel edges of metal, often used in joining sheet metal components.
 Lap Joint	Lap joints are usually used for sheet metal and are rarely used on thicker materials.

✓ APPLICATION OF WELDING POSITIONS

Flat positions		Is very easy to perform and it can be learnt within a short period of time. It is also known as down-hand position as it involves welding on the top side of the joint
Horizontal positions		In the vertical welding position, the plate and the weld lie vertically or almost vertically. Force of gravity pushes the molten metal downward and having a tendency to it pile up.
Vertical positions		Refers to the orientation of the joint being welded, where the axis of the joint is vertical.
Overhead positions		Is performed from the underside of the joint area. Overhead welding position is the most complicated and difficult position



Points to Remember

1

Corner joint: It used to join two pieces of metal at right angles, commonly used in the construction of frames for doors and windows.

Learning outcome 3 formative assessment

1. Define the following terms

- i. Neutral flame
- ii. A cutting flame

Answer:

- I. **Neutral flame:** The neutral flame has a distinct cone shape and is characterized by a sharp inner blue cone surrounded by a broader, lighter blue outer envelope.
- II. **A cutting flame:** is a specific type of flame used in oxy-acetylene cutting processes, where the primary goal is to melt and remove metal through the chemical reaction of oxygen with the workpiece

2. List out any five oxy-acetylene gas welding accessories

Answer:

- Wire brush
- Nozzle cleaner
- Cylinder key
- Spanner
- Trolley
- Spark lighter

3. Respond the following questions with True for the correct statement and False for the incorrect statement

A) Cutting flame refers to the specific type of flame used during the welding process where two or more metals are joined together by melting and flowing a filler metal into the joint. The filler metal has a lower melting point than the base metals, typically above 450°C (842°F) but

A) Answer: False

B) Brazing flame is a specific type of flame used in oxy-acetylene cutting processes, where the primary goal is to melt and remove metal through the chemical reaction of oxygen with the workpiece.

B) Answer: false

4. a welder A says that when the welding operation is finished “close the acetylene control valve first and then turn off the oxygen control valve”. It involves in Procedures for shutting off the oxyacetylene flame. Do you agree with welder A? Explain your answer

Answer: yes, When the welding operation is finished, close the acetylene control valve first and then turn off the oxygen control valve involves in Procedures for shutting off the oxyacetylene flame.