BASIC WELDING WORK

Level – I

Based on March 2021, Curriculum Version 1

Module Title: - Performing Routine Metal Arc Welding

Module code: IND BWW1 M06 0322

Nominal duration: 80Hour

Prepared by: Ministry of Labour and Skill

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Addis Ababa, Ethiopia

Table of Content

ACKNOWLEDGMENT

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ACRONYM

MMAW Manual metal arc welding

ASME_ American Society of Mechanical Engineers

TTLM_ Trainees Training Learning Materials

PPE_ Personal Protective Equipment

ASTM _American Society foresting and Materials

Introduction to the Module

In this module, we are primarily concerned with in the fundamental working principles of routine metal arc welding process work welding requirement and typical items of arc-welding equipment and tools, rather than the specific types. For specific information about the equipment in the working station has to available, you should consult the manufacturer's instruction manual.

This module is designed to meet the industry requirement under the welding occupational standard, particularly for the unit of competency: Routine Metal Arc Welding.

This module covers the units:

- Plan and prepare welding work
- welding Practices
- quality and clean up

Learning Objective of the Module

- Identify the basic requirements of welding process
- Perform welding practices and principles
- Apply the quality assurance and clean up

Module Instruction

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

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

Unit One: . Plan And Prepare Welding Work

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

- Welding work requirements
- Welding materials and equipment

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

- Identify welding work requirements
- Select materials and appropriate welding tools and equipment

1.1. Welding Work Requirements

Introduction

Welding is the process of joining together two pieces of metal so that bonding takes place at their original boundary surfaces". When two parts to be joined are melted together, heat or pressure or both is applied and with or without added metal for formation of metallic bond. The arc is struck between the electrode and the metal. It then heats the metal to a melting point. The electrode is then removed, breaking the arc between the electrode and the metal. This allows the molten metal to "freeze" or solidify. The arc is like a flame of intense heat that is generated as the electrical current passes through a highly resistant air gap. There are various welding processes but commonly used types include the following:

- SMAW (Shielded Metal Arc Welding)
- GMAW (Gas Metal Arc Welding)
- GTAW (Gas Tungsten Arc Welding)

In this level, SMAW/MMAW welding is to be discussed.

Welding terminology

Electrode – a rod that is used in arc welding to carry a current through a work piece to fuse two pieces together. In some welding processes, the electrode may also act as the filler metal.

Filler metal – metal deposited into the weld to add strength and mass to the welded joint.

Flux – a chemical cleaning agent that is applied to a joint just prior to the welding process to clean and protect the metal surface from surface oxides that form as a result of heating.

Porosity – the appearance of tiny bubbles on a weld bead as a result of gas entrapment; excessive porosity can weaken a weld.

Root opening – the separation at the joint root between the base metals.

Shielding Gas – inert or semi-inert gas that is used to protect the weld puddle and arc from reacting negatively with the atmosphere.

Slag – cooled flux that forms over the top of the weld; slag protects the cooling metal and is then chipped off.

Spatter – liquid metal droplets expelled from the welding process.

Weldability– the ability of a material to be welded under prescribed conditions and to perform as intended.

Bead- the weld/deposited melted metal

Ripple - Shape of the bead

Pass – Each layer of the weld bead deposited

Crater- Depression in the base metal

Penetration – Depth of fusion with metal

Arc Length – Distance from electrode to metal

Weld Face - Exposed surface of weld

Root - Base of weld

Toe - Where the face meets metal

Leg - Distance between toe and root

Porosity – Voids of gas pockets in the weld

Post-Heating – Heating after welding

Pre-Heating – Heating before welding

Spatter – Metal particles expelled during welding

Weaving – Back and forth movement

Undercut – Toe below metal surface

Overlap – Toe above metal surface

General working principle of MMAW

The electrode is placed in an electrode holder, which is connected to one lug of a constant current welding power supply. This power supply can be operated on alternating current (AC), direct current electrode positive (DCEP), or direct current electrode negative (DCEN) depending on the type of electrode being used. A cable connected to the work is attached to the other lug. The machine is energized and the electrode is lightly touched to the work—the arc is then initiated. The welder then manually moves the electrode along the weld joint. Thus, an electric arc will be created because of the resistivity of the air gap between metallic pieces what we are going to join. This arc causes the pieces to melt and join together. The flux cover of the electrode induces shielding gases and forms a slag on the top of the weld that are important to protect the weld from exposure to oxidation.

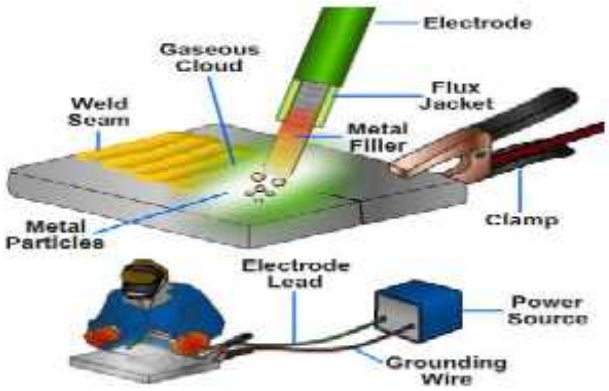


Figure 1 Manual metal arc welding diagram

Polarity

There are two common types of current flow:

1. Alternating current (AC)
2. Direct current.(DC)

1. Alternating current (AC)

Alternating current (AC): Is an electrical current that has alternating negative and positive values.

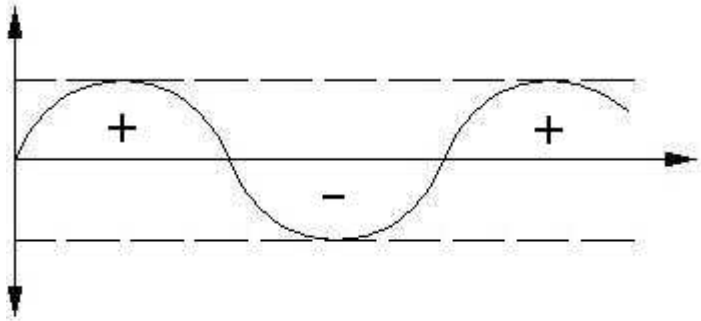


Figure 2 Alternating current

Then, here the electric current will change constantly its polarity.

However this problem is good to avoid the arc blow when large intensity of current and electrode diameter are in use.

Advantages:

- It is less susceptible to arc blow than direct current. (You will be able to weld with higher current and large diameter electrodes.

Disadvantages:

- Atmosphere gases (oxygen, nitrogen) penetrate to the weld puddle (Although that quantity is just small). This can produce a weld bead with a slightly less strength and ductility than that obtained with direct-current.
- You cannot change the polarity. (Then DC will be better when you are welding in out of positions, for example: overhead position) In this case you should use reverse polarity.

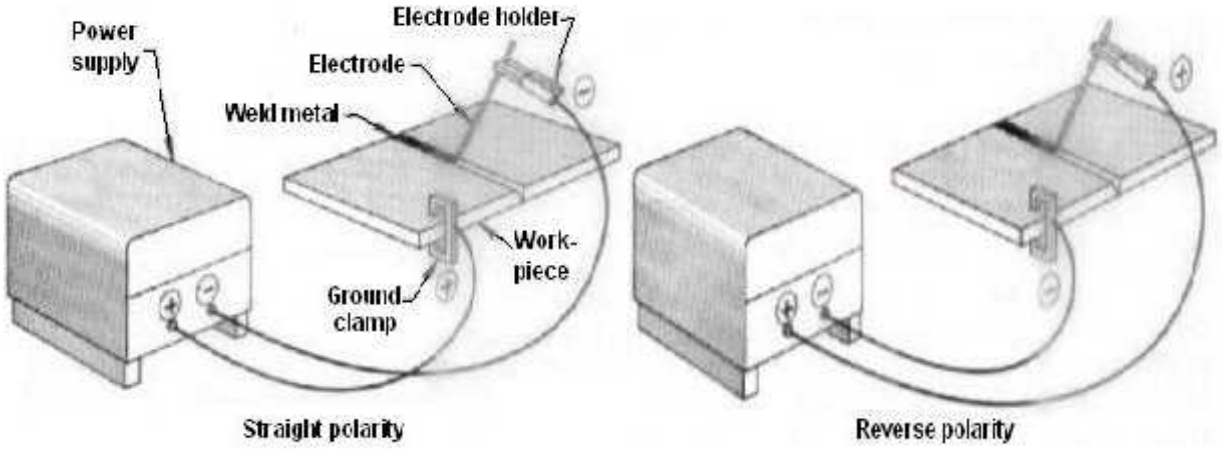
2. Direct current. (DC)

Like you know direct current is an electrical current that flows in one direction only. When using dc welding machines, you can weld with either:

- Straight polarity. (Negative electrode)
- Reverse polarity. (Positive electrode)

In straight polarity, the electrode is negative and the work piece positive; the electrons flow from the electrode to the work piece.

In reverse polarity, the electrode is positive and the work-piece negative; the electrons flow from the work piece to the electrode.



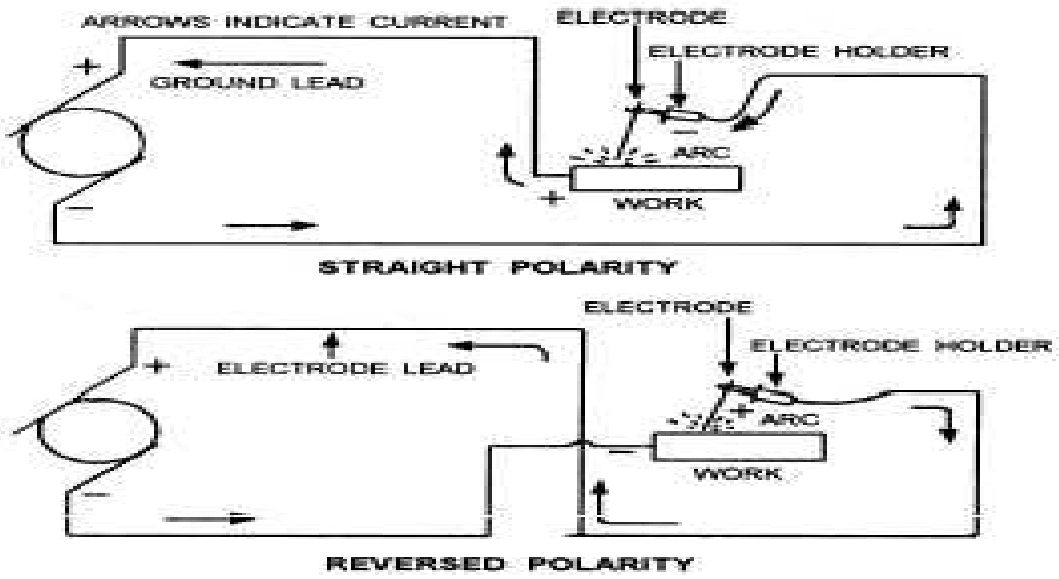


Figure 3 Straight and Reverse Polarity of arc welding process

Polarity affects the amount of heat going into the base metal. By changing polarity, you can direct the amount of heat to where it is needed. In some welding situations, it is desirable to have more heat on the work piece because of its size and the need for more heat to melt the base metal than the electrode: In general:

Straight polarity:

- All mild steel, bare, or lightly coated electrodes.
- With these types of electrodes, the majority of heat is developed at the positive side of the current, the work piece.
- When making large heavy deposits

Reverse polarity:

- In the welding of nonferrous metals, such as aluminum, bronze, Monel, and nickel.
- Less heat is concentrated at the work piece. This allows the filler metal to cool faster, giving it greater holding power.
- Reverse polarity is also used with some types of electrodes for making vertical and overhead welds.
- The heat is concentrated on the electrode.(For this reason it is good for welding in overhead position.

1.2.1.Welding symbol and requirements

Special symbols are used on a drawing to specify where welds are to be located, the type of joint Special symbols are used on a drawing to specify where welds are to be located, the type of joint to be used, as well as the size and amount of weld metal to be deposited in the joint

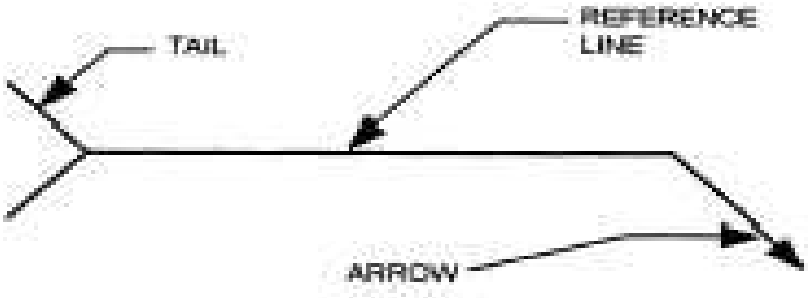
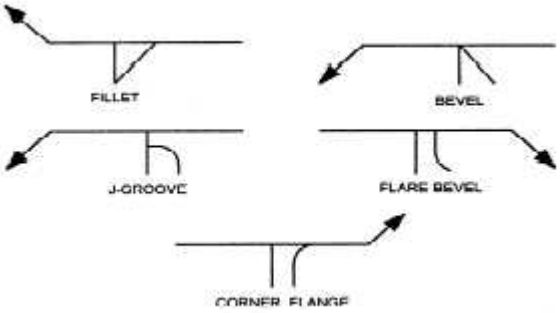


Figure 4. Standard welding symbols

1.2.3. Weld Symbols

The term ***weld symbol*** refers to the symbol for a specific type of weld. (Fillet, groove, surfacing, plug, and slot are all types of welds. The weld symbol is only part of the information required in the welding symbol



(How a weld symbol is applied to the reference line.)

Figure; 5. Weld symbol applied to reference line

What is the significance of the positions of the weld symbols position on the reference line? If the weld symbol is on the lower side of the reference line that is termed the ***arrow side.*** Ifthe weld symbol is on the upper side of the reference line that is termed the ***other side***.When weld

symbols are placed on both sides of the reference line, welds must be made on both sides of the joint.

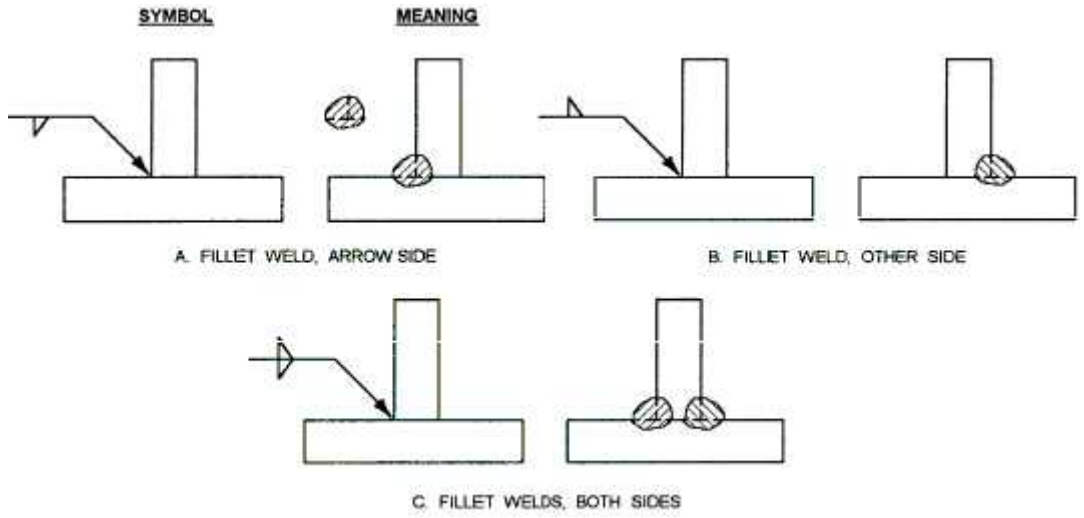
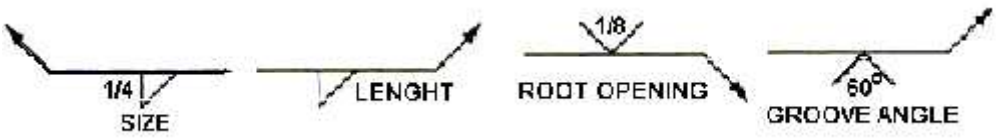
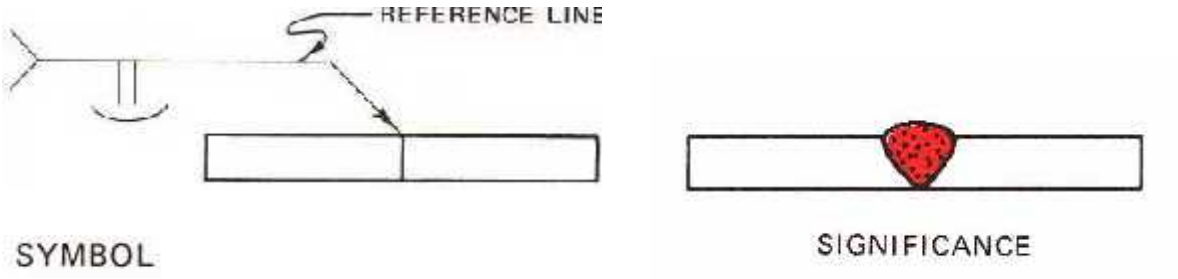


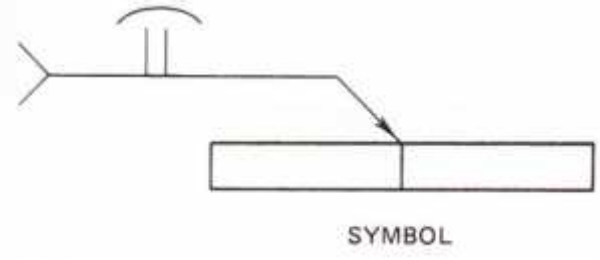
Figure . 18. Specifying weld location

Dimensions: Left side of a weld symbol you place the size and on the right side you place the length of weld.



Figure; 6. Dimension

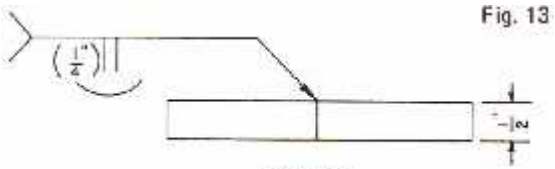




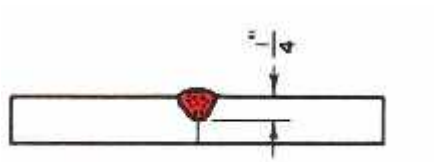
SYMBOL

SIGNIFICANCE

Fig. 13



SYMBOL



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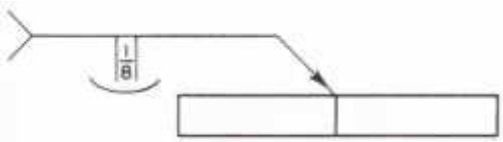
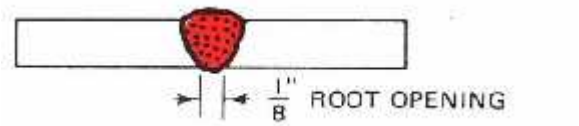


SYMBOL



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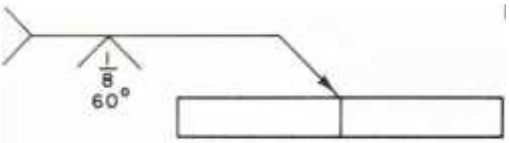

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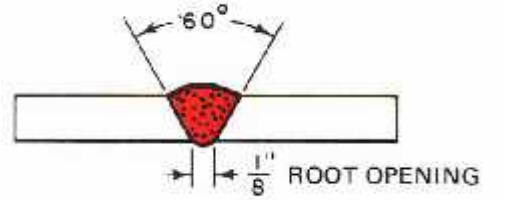

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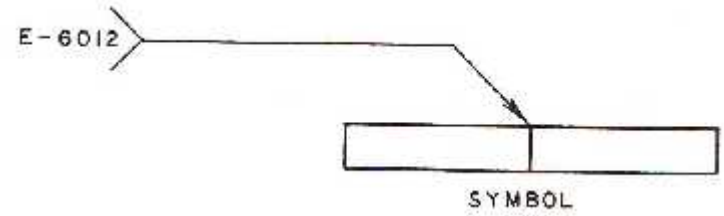

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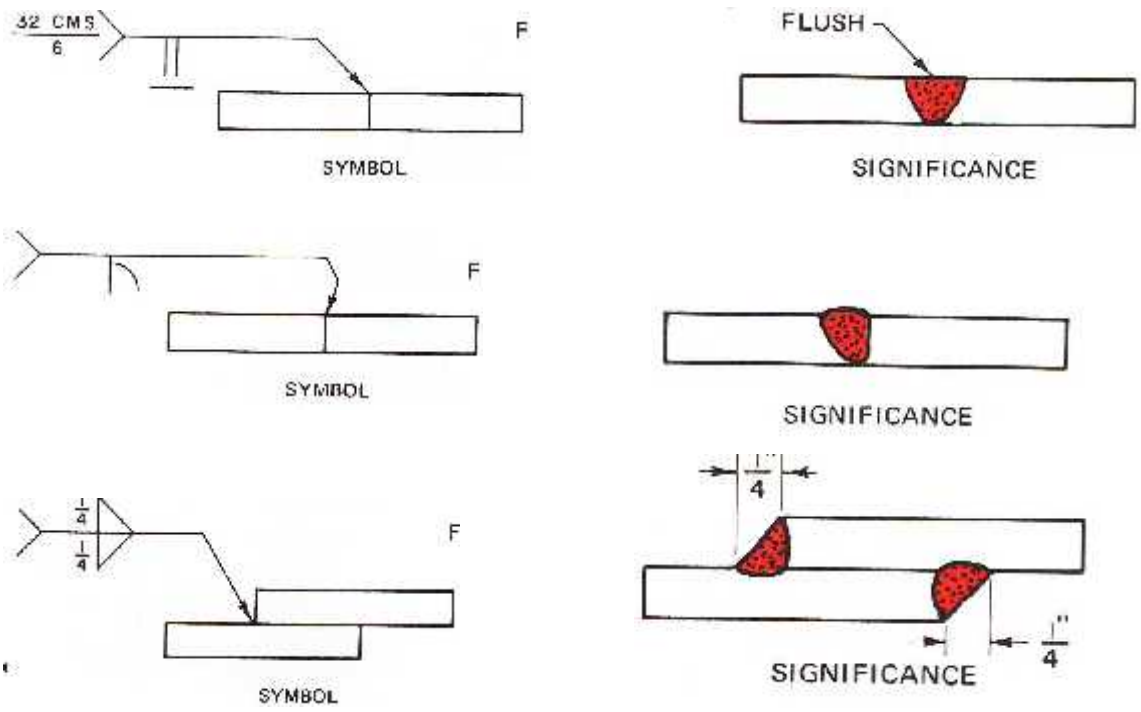


Figure7 Preparing materials to the required weld specification

Some of the other welding requirements are: select proper welding machine, Select welding current, and Identify welding location within the recommended safety precautions. Under welding location, the term by itself means that the area of welding operation is performed and typical welding shop would incorporate in the following feature:

- Heavy duty load bearing flours, preferably of concrete.
- Fire resistance structure
- Well ventilated building and have provision for localized exhaust ventilation
- Means of transportation heavy materials
- Heavy duty power supply
- All personal safety equipment should be exist
- Welding area should be free of flammable structure
- Welding area should be convenient for performing welding operation.

1.2. Welding materials tools and equipment

1.2.1 Welding materials by MMAW

MMAW dominates other welding processes in the maintenance and repair industry in particular. Although flux-cored arc welding is growing in popularity, SMAW continues to be used extensively in the construction of steel structures and in industrial fabrication. The process is used primarily to weld iron and steels, including stainless steel, but most alloys can be welded with this method In practice, welding of medium, high carbon steels (>0.25%) can cause the formation of structural defects; application of the electrode procedure is recommended mainly for welding medium to thick joins using basic electrodes: in these cases a high quality weld is obtained with good breakage resistance.

Steel pipe welding is carried out using cellulose electrodes, where high penetration and good electrode workability are required. Beveling is always recommended, with a bevel angle that is sufficient to allow almost complete electrode insertion into the welding gap. For special materials such as stainless steel, aluminum and its alloys, cast iron, specific electrodes for the particular material are used.

Stainless steels are welded with direct current (DC) with reverse polarity; special electrodes are used and are differentiated by the metallurgical composition of the material to be welded (presence of chrome (Cr) and of Nickel (Ni) in variable proportions).

Aluminum and light alloys are welded with direct current (DC) with reverse polarity. The machine should be equipped with rather a high strike dynamic to guarantee electrode strike. Also in this case special electrodes are used and are differentiated by the metallurgical composition of the material to be welded (presence of Magnesium (Mg) and of Silicon (Si) in variable proportions).

Cast iron is welded with direct current (DC) with reverse polarity; the majority of cast iron structures and machine members are obtained by casting, so that welding is used to correct possible casting defects or for repairs. Special electrodes are used and the base material should be heated sufficiently before use.

Arc welding tools

Arc welding tools are used to perform a welding operation: some of them are:

3. Chipping hammer: Has two striking ends, a pointed end and a flat end that runs parallel to the handle as shown fig.

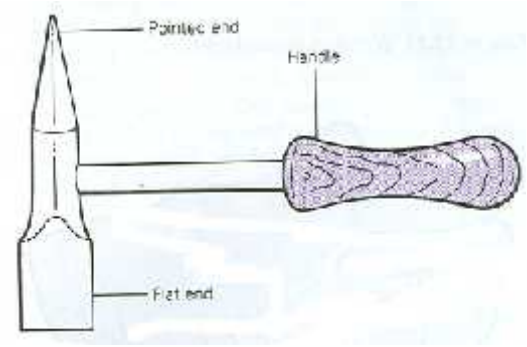


Figure 2.1.Chipping hammer

4. Wire brushes: are used to clean the work piece and for further cleaning of the weld bead. This helps to expose any blowholes that might need to be refilled. The bristles are made from steel or stainless steel. See the following fig.

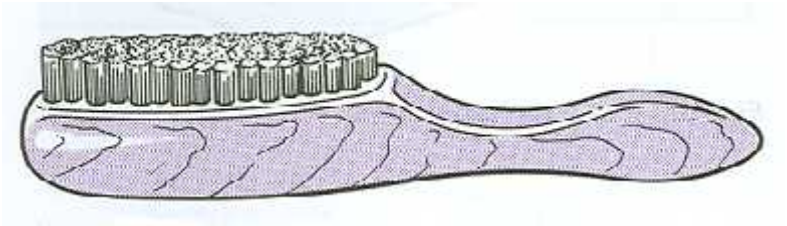


Figure 2.2.Wire brush

5. Tongs: are used for holding and picking up hot metals in welding. It is made of wrought iron or mild steel, in lengths from 400 mm to 650 mm in steps increasing by 50 mm, and is sold by weight. Its parts are: Handles or reins, Pin and Jaws.

There are varieties of Tongs designed to grip different types of work pieces with various shapes. The common types are shown in fig 6

- Close mouth: you use this type for holding very light rectangular work pieces.

Figure 2.3 .Close mouth tong

- Open mouth: this has a flat open mouth that, when closed still has the jaws opened. You Use it for holding thick regular pieces.

Figure 4Figure 2.4.Open mouth tong

- *Hollow bit* the mouth forms acicular hole when closed, which makes it useful for holding round or square bars length wise .it is also referred to as a *round bit.*

Figure 5Figure 1.13.Hollow bit tong

- Pick – up or dandy: _you use this for picking up and holding hot metals, but not for holding work during forging.

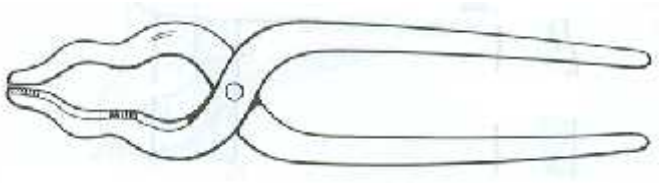


Figure 2.5. Pick – up or dandy ton

- Veer bit: this has a veer mouth for holding square bars lengthwise.

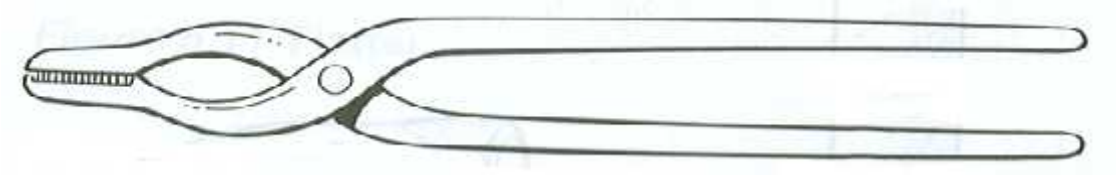


Figure 2.6. Veer bit tong

- Box or square mouth: you uses this for holding heavy square or rectangular pieces.

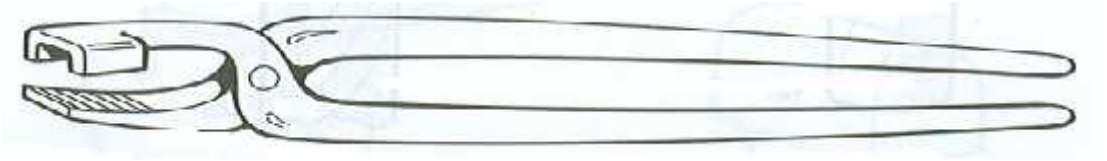


Figure 2.7. Box or square mouth tong

- Scroll tongs: you uses these for making scrolls.

Figure 2.8.Scroll tong

6. Universal tongs: these have three holes and a grove along the jaws, for general use.

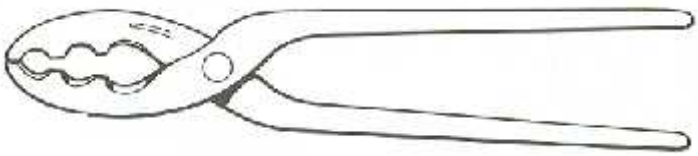


Figure 2.9.Universal tongs

1.2.2Arc welding equipment

A wide variety of welding equipment is available, and there are many differences between the makes and models of the equipment produced by the manufacturers. However, all types of arc-welding equipment are similar in their basic function of producing the high-amperage, low-voltage electric power required for the welding arc. In this discussion, we are primarily concerned with the typical items of arc-welding equipment, rather than the specific types. For specific information about the equipment your battalion or duty station has available, consult the manufacturer's instruction manual.

The basic parts of a typical shielded metal-arc welding outfit include a welding machine, cables, electrode holder (stinger), and electrodes. The steelworkers also requires a number of accessories that include a combination chipping hammer and wire brush, welding table (for shop work), C-clamps, and protective apparel. Before we discuss the different types of welding machines, you must first have a basic knowledge of the electrical terms used with welding.

Arc welding equipment is the basic equipment used for the purpose of joining two or more work pieces together. This equipment is:

- Welding machine
- Welding cables
- Electrode holders
- Ground clamps

1. **Arc welding machines**

The power source used in arc welding is called a welding machine or a welder. Arc welding machines are equipment that provides current to produce an electric arc when the electrode is struck on the work pieces. The three basic types of arc welding machines are; -

1. The generator (engine driven) welding machines
2. The transformer (AC) welding machines
3. The rectifier (motor generator) welding machines

Among the three machines mentioned above, the common one that is mostly applicable in the workshops is the transformer (AC) welding machines; and is explained below

The transformer (ac) welding machines: The transformer welding machines operate on an electrical supply. The powers supply may be 220 volts or more, which is too high for welding. The transformer therefore reduces the voltage and provides the appropriate current for welding. Transformer welding machines are strongly built light and run quietly. They cannot be used at sites where there is no electricity.

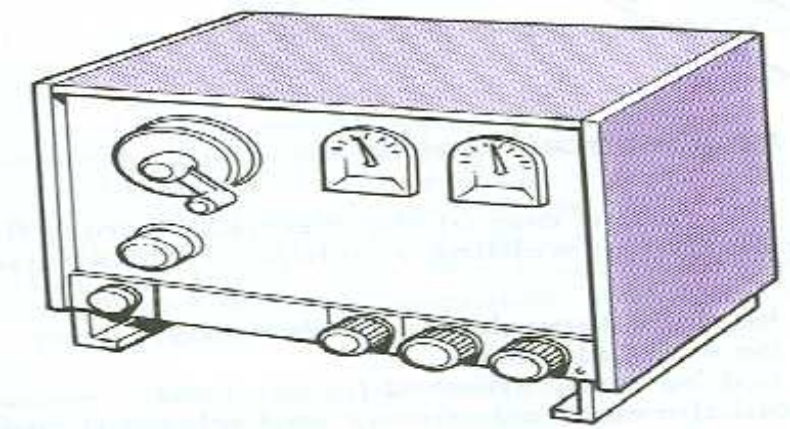


Figure2.1.0.Arc welding machine

2. welding cables

Two cables of adequate sizes and well-built are necessary to carry the current from the welder to the work and back to the welder. The ground cable is attached to the work pieces or table and the other cable is attached to the electrode holder.

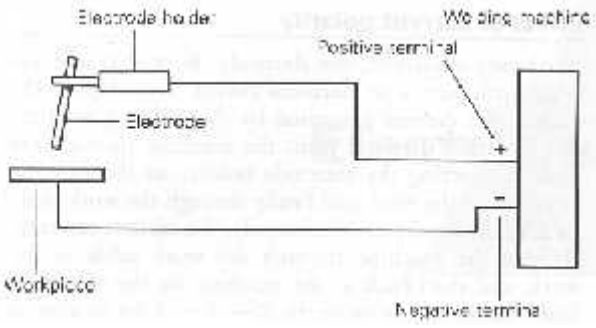


Figure2.11.Arcwelding cable

3. Electrode holder

The electrode holder is the part of the arc welding equipment held by the welder. It is attached to the electrode cable on the welding machine. An electrode holder, commonly called a stinger, is a clamping device for holding the electrode securely in any position. The welding cable attaches to the holder through the hollow insulated handle. The design of the electrode holder permits quick and easy electrode exchange. Two general types of electrode holders are in use: insulated and non-insulated. The non-insulated holders are not recommended because they are subject to Accidental short circuiting if bumped against the work-piece during welding. For safety reasons, try to ensure the use of only insulated stingers on the jobsite.

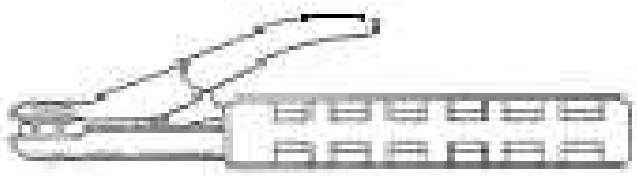
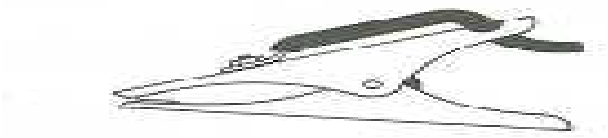


Figure 2.12. Electrode holder

4. Ground clamp

The use of a good ground clamp is essential to producing quality welds. Without proper grounding, the circuit voltage fails to produce enough heat for proper welding, and there is the possibility of damage to the welding machine and cables. Three basic methods are used to ground a welding machine. The ground cable from the machine to the work is generally connected to a spring-loaded clamp, which can be easily attached to the work. In order to do a good job of welding, the ground must be solidly connected to the work.



Figure; 2.13. Ground clamp

5. Cleaning Equipment

Strong welds require good preparation and procedure. The surface area of the work piece must be free of all foreign material, such as rust, paint, and oil. A steel brush is an excellent cleaning tool and is an essential part of the welder's equipment. After initial cleaning and a weld bead have been deposited, the slag cover must be removed before additional beads are added. The chip-ping hammer was specifically designed for this task. The chipping operation is then followed by more brushing, and this cycle is repeated until the slag has been removed. When the slag is not removed, the result is porosity in the weld that weakens the weld joint.

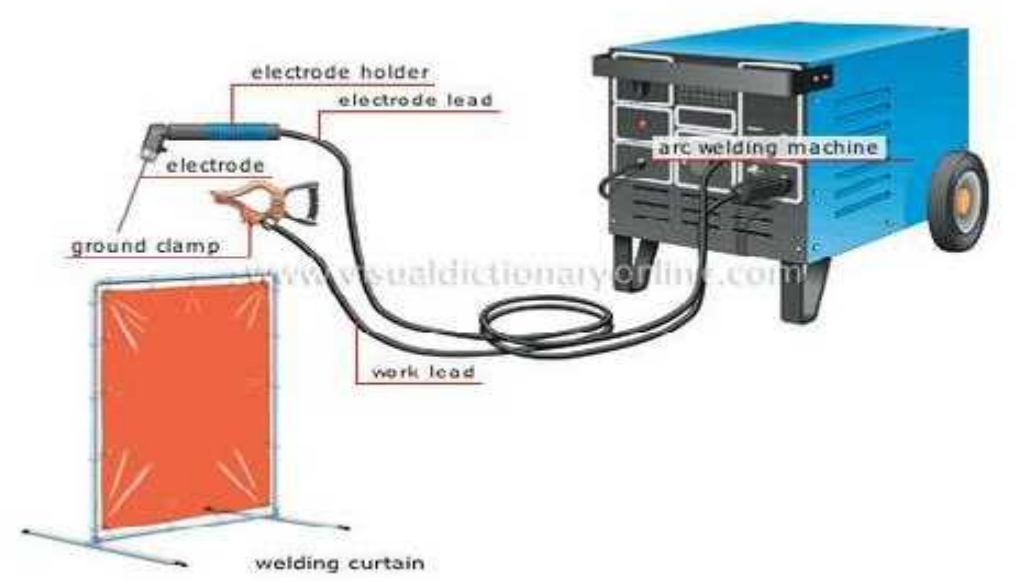


Figure 2.14. The overall view of manual arc welding equipment and tools

Aspects	AC welding	DC welding
Power consumption	Low	High
Arc stability	Arc unstable	Arc stable
Cost	Less	More
Weight	Light	Heavy
Efficiency	High	Low
Operation	Noiseless	noisy
Suitability	Only ferrous	Suitable for ferrous and non ferrous
Electrode used	Only coated	bare electrode
Welding of thin sections	Not preferred	preferred

Type of electrodes to be used and metals to be welded

- Available power source (AC or DC)
- Required output
- Duty cycle
- Efficiency
- Initial costs and running costs
- Available floor space
- Versatility of equipment

Self-Check -1	Written Test

PART-I: Select the best answer from the given alternatives and write its letter on the space provided (1 pt each)

1. Which of the following is the other name of shielding metal arc welding?
   A. Manual metal arc welding C. stick welding
   B. Submerged arc welding D. A and C
2. ____is the area of application for shielding metal arc welding.
   A. Structural work C. site work
   B. General fabrication D. All
3. Which one is used to slag cleaning purpose
   A. Wire brush C. Ground clamp
   B. sand paper D. gloves
4. Which one of the following is the current flows from the electrode to the work piece
   A. Straight polarity C. indirect polarity
   B. Reverse polarity D. none of the above
5. The voltage is directly related to_____
   A. The length of the electrode C. The amount of heat input.
   B. the length of the arc D. the amount of current input
6. ----------is used for holding the electrode manually and conducting current to it.

   A. Welding cables B. Electrode holder C. Welding machine D. Welding electrode.

7. Which one of the following is not the type of welding equipment?

   A. Welding cable B. ground clamp C. anvil D. welding machine

8. _____ are used for holding and picking up hot metals in welding.

   A. Anvil B. Close mouth tong C. Wire brush D. Chipping hammer
9. Which one of the follow is not part of the tong?
   A. Handles or reins B. Pin C. blade D. Jaws
10. What are the distance b/n electrode and the work piece in SMAW process?

    A. Arc length B. Welding speed C. Welding current D. Welding cable

PART-III: Match the items listed under column "A" with those expressions listed under "B" (1 pt each)

"Column A"	"Column B"
_____1. It provides current to produce an electric arc	A. Electrode holder
_____2. Personal protective equipment	B Tongs
_____3. Used for holding and picking up hot metals in welding	C Welding machine
_____4 A rod that is used in arc welding to carry a current through a work piece	D Toughness
	E. Apron
_____5 manually hold the electrode	F Electrode

PART-II- Short Answer Questions

7. List the welding machine

_____

_____

_____

_____

_____

Operation sheet: 1

Operation title: Identification of welding tools and equipment

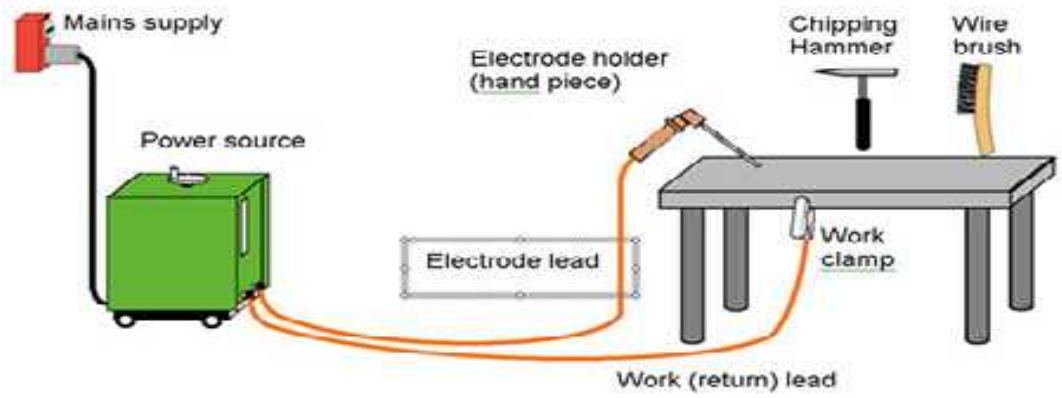
Purpose: the main purpose of the operation is to now the correct welding equipment and tools

Condition or situation of the operation: to identify the proper tools and equipment will ready or available the necessary material.

Equipment tools and materials: Standard AC or DC welding machine, welding cables, welding clamp, electrode holder, Chipping hammer and Wire brush.

Procedure:

1. Understand the welding requirements
2. Know the main use of the tools and equipment
3. Identify the fundamental working process of the operation
4. Check the functionality of the operation



Precaution: The welder must have properly now the each welding equipment and tools of the operation.

Lap Test: Practical Demonstration

Quality criteria: fully understand the working conditions of the equipment and tools.

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 4 hour.

Task 1. Identifying the correct welding requirements

Task 2. Selecting the welding material

Task 3.Identify appropriate welding equipment

Unit Two welding Practices

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

- Set up of welding current
- Electrode Selection
- Materials preparation and Cleaning
- Welding materials
- Clean welding seams or joints
- Measurement of OHS

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

- Identify the welding parameters
- Select the proper welding electrode
- Perform welding materials preparation and cleaning
- Identify the welding material
- Perform clean in welding seams or joints
- Applying OHS measures

2.1. Setup of welding parameters

The welding quality of the shielded metal arc welding is determined by the welding parameters / characteristics including the welding slot forms, electrode diameter, welding current, welding speed, arc length, electrode advance angle, electrode oscillation angle and movement, welding direction and position, etc. In an effort to obtain high quality welds in shielded metal arc welding method, selection of ideal parameters should be performed according to engineering facts. To properly selecting the welding current we considered the following mentioned points:

- Welding current is one factor to obtain a proper bead.
- Factors to be secure a weld that has a proper penetration:-
- Correct arc length
- Correct types of electrode
- Correct current setting
- Correct speed of travel
- Correct electrode angles
- Select proper polarity for the given welding

2.1.1. Material type

Welding application will be realized for three different materials; namely plain carbon steel, alloy steel and stainless steel. Aluminum is not recommended for shielded metal arc welding method; therefore it is excluded in this technique.

2.1.2. Electrode diameter

The electrodes used in shielded metal arc welding are divided in two main groups as joining and filler welding ones according to the purpose of the welding. The coated electrodes are also classified by the tensile strength of the deposited weld metal, the welding position in which they may use, the preferred type of current and polarity, and the type of coating. The metal wire used in the process is usually from 1.5 to 6.5 mm in diameter and 20 and 45 cm in length. The electrode material in welding is desired to be high strength, ductile and tough. The molten electrodes provide both forming of arc and filling the welding area. According to EN ISO 2560:2005 standard, the electrodes are determined in the welding for plain carbon and low alloy steels. For selection of electrode; material type, welding position, welding current, welding slot

form and work piece thickness above all are taken into consideration. The electrode diameter changes according to the material thickness and welding slot form. The most used electrodes in shielded metal arc welding applications are 2.50, 3.25 and 4.00 mm core diameter ones .The values of electrode core diameters are determined in Table 2.1, depending on work piece thickness .Electrode Size are commonly made in lengths 250 mm, 300 mm, 350 mm, 450 mm, and the diameters are 1.6 mm, 2 mm, 2.5 mm, 3.2 mm, 4 mm, 7 mm, 8 mm and 9 mm.

Table 2. current setting for common electrode

Diameter of Electrode	**Amperage Used**					
	E-6010	**E-601 1**	**E-6012**	**E-6013**	**I E-6020**	**E-6030**
1/8”	**80-120**	**80-120**	**80-130**	**70-120**	**100-140**	**100-140**
5/32”	**120-160**	**120-160**	**120-180**	**120-170**	**120-180**	**120-180**
36”	**140-220**	**140-220**	**140-250**	**140-240**	***175-250***	***175-250***

2.1.3.Welding current

During the welding, that is, while arc occurs in welding period, current against working voltage is called as welding current. Welding machine is plugged into the alternative current and poles are determined. The cable tips connecting to electrode pliers and ground one are prepared, then electrode is attached to the pliers and arc occurs when electrode touches to work piece and consequently a permanent current circle continues. Welding current is set by welders prior to welding application. During the welding application, the value of welding current is not changed. However, arc is cut or current can be increased depending on welding application. Welding current is selected as 40 folds of electrode core diameter ($I = d \times 40$). This value can be changed as 10% depending on thickness of materials and position.

Table 2.1.Electrode core diameters suggested by program according to work piece thickness(s)

Work piece thickness (s)	Electrode core diameter (d)	Unit
S≤3	2.5	mm
3<S≤20	3.25	mm
S>20	4.00	mm

Table 2.2.Welding speeds according to work piece thickness (s), weld current (I) and electrode diameter (d).

Work piece thickness (S)	Welding speed (V_k), mm/s	Welding current (I)
S ≤ 3	4.50	d x 40 ampere
S > 3 ≤ 8	4.00	dx40 ampere
S > 8	3.50	d x 40 ampere

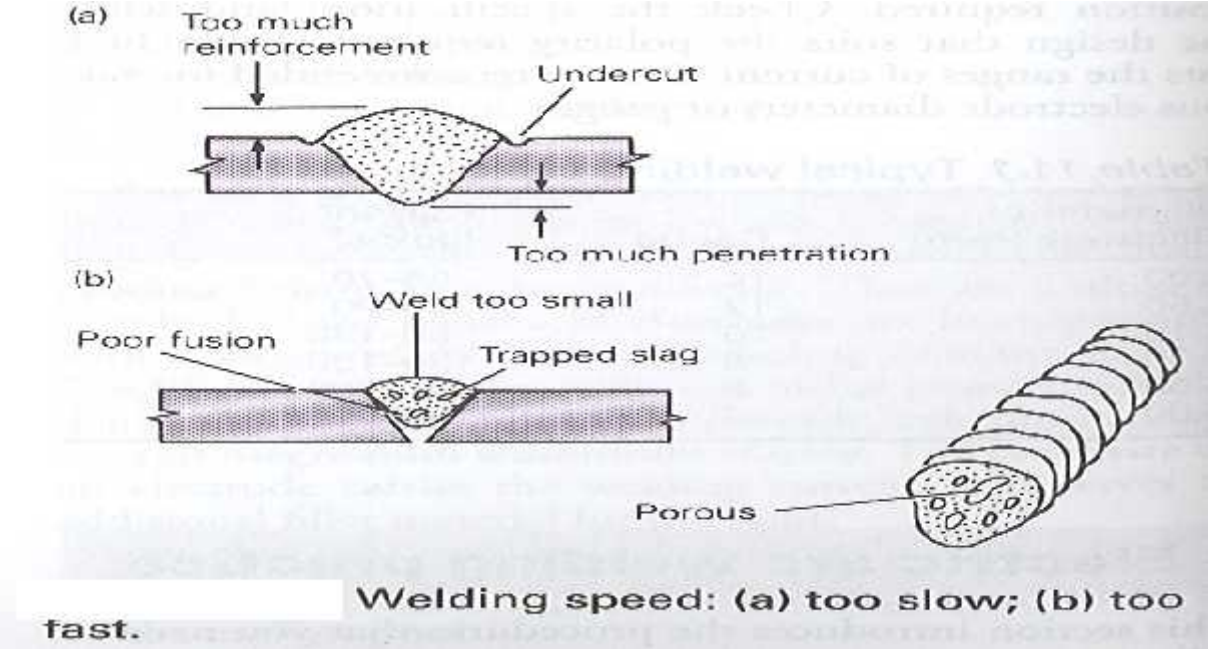
Table 2.3.The values of ideal advance angle and tolerances depending on welding position.

Welding position	Advance angle	Tolerance (°)
Plain weld	80	±5
Cornice (overlap) weld	80	±5
Vertical weld	105	±5
Overhead weld	80	±5

2.1.4. Welding speed

The movement of arc welding along work piece or the length of weld seam made in unit time is known as welding speed. When the speed is slow during the welding process, stock weld metal increases in the unit length and eventually it causes to enlarge the welding pool. With growing of weld metal and increasing of heat input, the molten metal flows into the front of arc within the

welding slot and it affects the regular arc formation. The increment of speed causes to reduction of welding heat given to unit length and consequently the molten quantity of main metal decreases, this negatively affects the wetting of weld seam. The determined welding speeds are given in table 2.2, according to the thickness of work piece (s), welding current (I) and diameter of electrode .



Welding speed: (a) too slow; (b) too fast.

2.1.5. Arc length

The importance of distance between electrode and work piece is vital for arc occurrence. The mentioning of arc length in various welding applications is required to understand the difference between arc lengths. If arc length is equal to electrode diameter, this is called as normal arc length. Long arc is obtained whenever arc length is greater than electrode diameter. The distances less than the electrode diameter are called as short arc length. Experience shows that arc blowing is more effective in case of long arc length comparing to short arc one. For this reason, short arc length is always recommended for the work. It is also observed from the previous experience that, arc blowing will be less comparing to the uncoated or cored ones in case of welding with coated electrodes. In addition, blowing effect is more in thin coated electrodes comparing to thick ones.

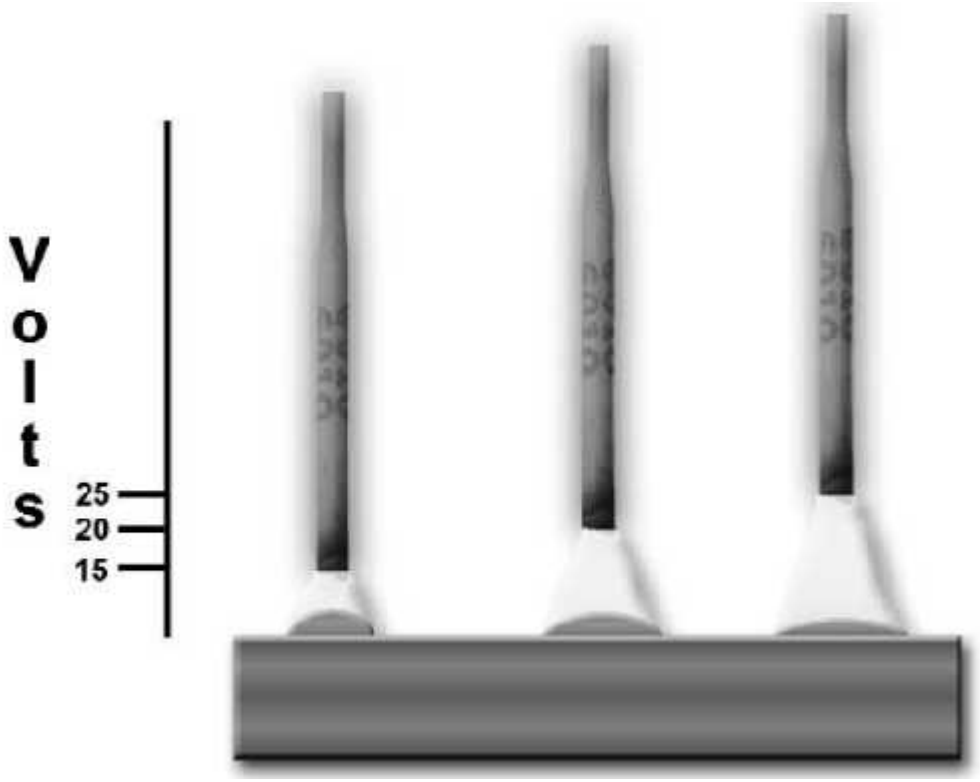
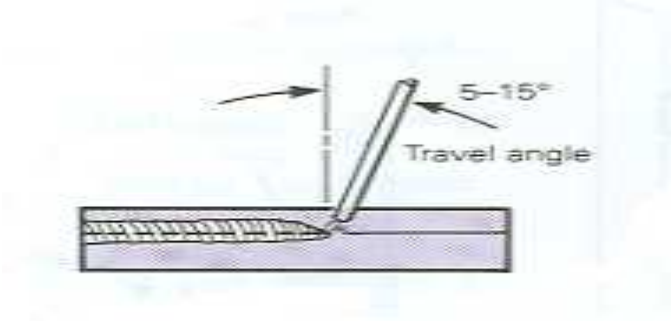


Figure: **Arc Length-Arc Voltage**

2.2.6.Electrode advance angle

The molten metal can be transferred by arc along the welding process and the welder should orientate the arc to form melting on joining surfaces. The angle between electrode and advance direction is generally 45 to 70°, however this value can also be changed between 45to 90°. The main principle here is the angle should prevent the flowing of slag in front of arc excluding vertical welding from top to down. The values of ideal advance angle and tolerances are given in Table 4 depending on welding position. The advance angle values are given according to advance direction. The schematic view of advance angles is illustrated in Figure below depending on welding position. Welding seam form changes in case of lowering tolerances and linear curves are extremely decreases, and burning grooves are seen in borders and penetration is reduced. Similar alteration in seam welding is obtained if tolerances are passed over, and arc blowing is realized (below 50°) and damage in borders is formed



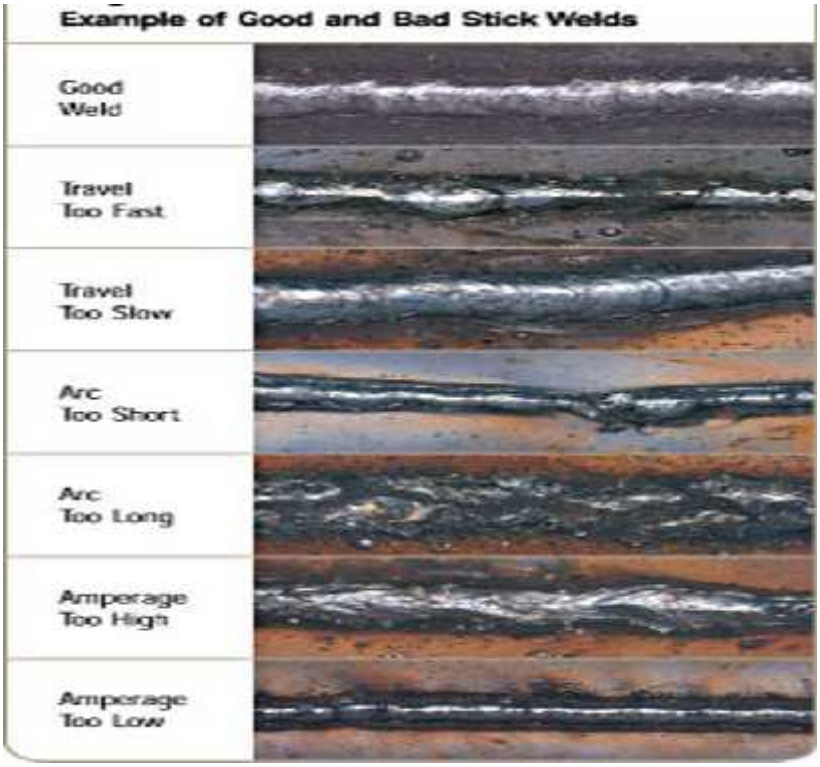


Figure 2.1.Effects of the major weld parameters: speed, current and arc length

2.2.Welding Electrodes

In electric arc welding, the term electrode refers to the component that conducts the current from the electrode holder to the metal being welded. Electrodes are classified in to two major groups: consumable and non-consumable.

- Consumable electrodes not only provide a path for the current but they also supply filler metal to the joint. An example is the electrode used in shielded metal arc welding.
- Non-consumable electrodes are only used as a conductor for the electrical current, such as in gas tungsten arc welding. The filler metal for gas tungsten arc welding is a hand fed welding rod.

The consumable electrodes may be of following two types

- **Types of electrode arc**
  - ✓ **Bare electrode**
  - ✓ **Coated electrode**

A. Bare Electrodes

These are available in the form of continuous wire or rods. They must be used only with straight polarity in D.C. welding. Bare electrodes do not provide any shielding to the molten metal pool from atmospheric oxygen and nitrogen.

Hence, the welds obtained by these electrodes are of lower strength, lower ductility and lower resistance to corrosion. They find limited use in minor repair and poor quality work. They used to weld wrought iron and mild steel. In modern practice they are not used or rarely used. They are also known as plain electrodes.

B. Coated Electrodes:

The core of the coated electrode consists of either a solid metal rod of drawn or cast material or one fabricated by encasing metal powders in a metallic sheath. The core rod conducts the electric current to the arc and provides filler metal for the joint. The primary functions of the electrode covering are to provide arc stability and to shield the molten

metal from the atmosphere with gases created as the coating decomposes from the heat of the arc. These are sometimes also called as conventional electrodes. A coating (thin layer) of flux material is applied all-round the welding rod, and hence termed as coated electrode. .

Common Types of welding electrodes used are

- **E-6010**
- **E-6012**
- **E-6011**
- **E-6013**

A good electrode provides good arc stability, a fast build up of the weld, minimum spatter, maximum weld strength and slag that is easy to remove. Electrodes are classified with the letter E, followed by four or five digits-E-xxxx.

Example-E-6011

- **E**, stands for electrode, **60**, stands for tensile strength (60,0001b/in^2), **1**, stands for welding position,**1**, stands for either **AC, DCRP or DCSP** and stands for flux (type of flux)

Selection of electrode will be governed by the following factors:

a) Properties of the base metals
b) Joint design and penetration
c) Welding position
   - ✓ Flat position
   - ✓ Vertical position
   - ✓ Over head position
   - ✓ Horizontal position
d) Welding current and polarity
   - ✓ Electrodes are made for use with other Ac or DC arrant
e) Electrode diameter
   - ✓ As a rule, electrode diameter is equal to thickness of the materials

Selecting an electrode based on

- Welding Position
- Welding current
- Joint design and fit-up
- Service conditions Production efficiency.

The necessary task to perform routine arc welding process was to prepare & clean materials for welding operation. Before you start to weld, ensure that you have all the required equipment and accessories. Listed below are some additional welding rules that should be followed.

- Clear the welding area of all debris (Remain) and clutter.
- Do not use gloves or clothing that contains oil or grease.
- Check that all wiring and cables are installed properly.
- Ensure that the machine is grounded and dry.
- Follow all manufacturers' directions on operating the welding machine.
- Have on hand a protective screen to protect others in the welding area from flash bums.
- Always keep fire-fighting equipment on hand.
- Clean rust, scale, paint, that are to be welded.

2.2.1. Electrodedesignations

Electrodes are often referred to by a manufacturer's trade name. The American Welding Society (AWS) and the American Society foresting and Materials (ASTM) have set up certain requirements for electrodes to assure some degree of uniformity in manufacturing electrodes.

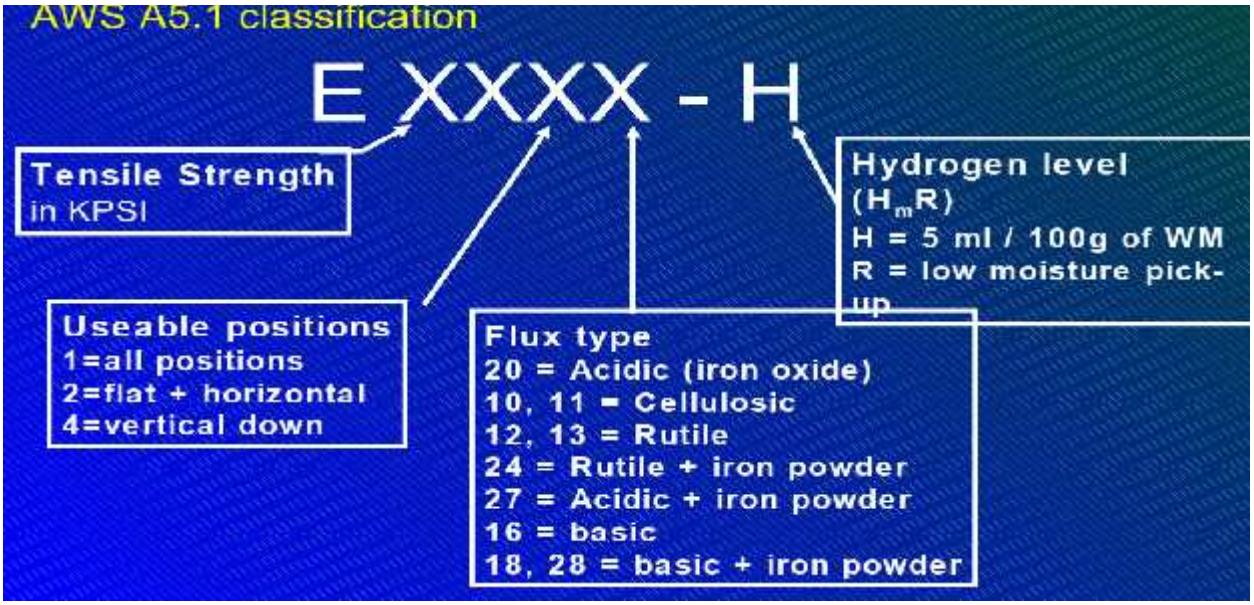
All major manufacturers of welding electrodes use the American Welding Society (AWS) code of specifications. Each company makes basically the same quality which is established by the AWS.

Electrodes are classified according to type of coating, composition of the weld metal and operating characteristics. The numbering system is started with "E" for electrode and then followed by a four digit number each number in the four number sequences has a specific meaning. Electrodes are classified into 5 main groups depending on their composition.

i. **Mild steel: Majority of welding**
ii. **High-carbon steel**
iii. **Special-alloy steel**
iv. **Cast iron**
v. **Non-ferrous**

Example: Aluminum, Copper, & Brass

Thus different manufacturer's electrodes that are within the classification established by the AWS and ASTM should have the same welding characteristics. (See figure 2.2.).



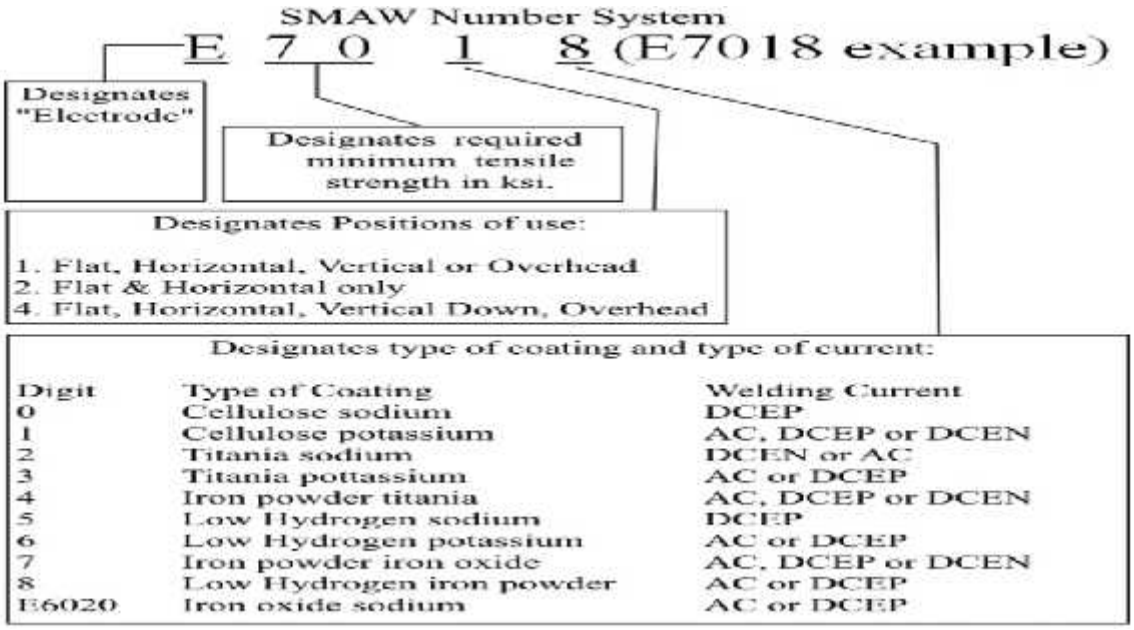


Figure 2.2 . Explanation of AWS classification numbers

In this classification, each type of electrode is assigned a specific symbol, such as E-6010, E-7010, and E-8010. The prefix E identifies the electrode for electric-arc welding. The first two digits in the symbol designate the minimum allowable tensile strength in characteristics of the electrode, thousands of pounds per square inch. For example, the 60-series electrodes have a minimum tensile strength of 60000 psi. The third digit of the symbol indicates the joint position for which the electrode is designed. Two numbers are used for this purpose:

- Number 1 designates an electrode that can be used for welding in any position.
- Number 2 represents an electrode restricted for welding in the horizontal and flat positions only.

2.3. Materials preparation and Cleaning

2.3.1. Material Preparation

The necessary task to perform routine arc welding process was to prepare & clean materials for welding operation. Before you start to weld, ensure that you have all the required equipment and accessories. Listed below are some additional welding rules that should be followed.

- Clear the welding area of all debris (Remain) and clutter.
- Do not use gloves or clothing that contains oil or grease.
- Check that all wiring and cables are installed properly.
- Ensure that the machine is grounded and dry.
- Follow all manufacturers' directions on operating the welding machine.
- Have on hand a protective screen to protect others in the welding area from flash bums.
- Always keep fire-fighting equipment on hand.
- Clean rust, scale, paint, that are to be welded.

The edges or surfaces of parts selected and to be joined by welding shall be prepared by shear, hack saw, power cutter or plasma arc cutting. Where hand cutting is involved the edge will be ground to a smooth surface. All surfaces and edges shall be free from fins, tears, cracks or any other defects which would adversely affect the quality of the weld. Before welding, the work pieces must be thoroughly cleaned of rust, scale and other foreign material. The piece for metal generally welded without beveling the edges; however, thick work pieces should be beveled to ensure adequate penetration and fusion of all parts of the weld. But, in either case, the parts to be welded must be separated slightly to allow better penetration of the weld.

All moisture, grease or other foreign material that would prevent proper welding or produce objectionable fumes, shall be removed. Contact with lead, zinc, or lead or zinc compound shall

be avoided due to the potential for hot cracking. All surfaces to be welded shall be wire brushed prior to welding. In multi-pass welds the weld bead shall be wire brushed between passes.

The brushes shall be of stainless steel and be kept exclusively for use on stainless steel and be kept clean and free of contaminants. All other equipment such as grinding discs shall be kept exclusively for use on stainless steels. Back gouging of welds shall produce a groove having a profile and a depth adequate to ensure fusion with the adjacent base metal and penetration into the root of the previously deposited weld metals.

Material preparation for arc welding is depend: Thickness of material being weld, Properties of material, welding Process, you must make sure that the best welding metal surface. Free from oil, grease, pain, rust and other substances. Which affect the welding: Welding should not be performed over excessive oxide scale, Oxide scale: can be removing with a solution, machining or Sanding, Oxide scale causes: dull & desk surface. Material preparation for welding can be done by:

- Machining
- Sanding
- Filing
- Using Solution
- Using wire brushing

Equipment used for preparing materials for welding are: Grinder, Sand paper, File, Wire brush. if excessive Oil & Grease Paint, Rust. It can contaminate the weld and causing welding defect.

The edges or surfaces of parts selected and to be joined by welding shall be prepared by shear, hack saw, power cutter or plasma arc cutting. Where hand cutting is involved the edge will be ground to a smooth surface. All surfaces and edges shall be free from fins, tears, cracks or any other defects which would adversely affect the quality of the weld. Before welding, the work pieces must be thoroughly cleaned of rust, scale and other foreign material. The piece for metal

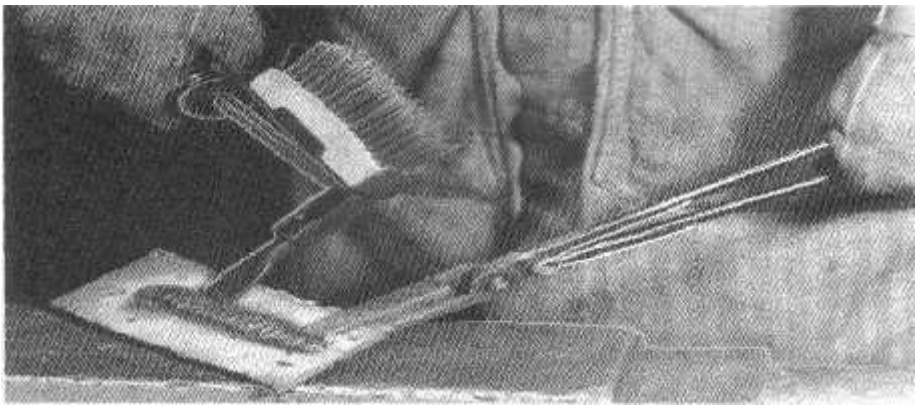


Figure 6Strike the weld with a chipping hammer to remove slag

Always wear safety glasses when chipping. Do not pound the bead too hard; otherwise the structure of the weld may be damaged. After the slag is his will remove the remaining particles of slag. Follow the chipping with a good, hard brushing, using a stiff wire brush as illustrated Figure

Figure 7 After chipping, brush the weld with a wire brush

2.3.2. Preparation of a Joint Edge

To produce good quality welds, the surfaces of the weld joint should be clean of rust, scale, dirt, oil and grease. Grinding is useful for removing rust and scale. Grease and oil must be removed from the joint surfaces by wiping or using degreasers. Scale, rust, dirt, oil, and grease can contaminate the weld metal and cause defects in the weld.

The efficiency and quality of welded joint also depends upon the correct preparation of the edges of the plates to be welded. It is necessary to remove all scales, rust, grease, paint, etc. from the surface before welding. The cleaning of the surface should be carried out mechanically by wire brush or power wire wheel, and then chemically by carbon tetrachloride. Proper shape to the edges of the plate should be given to produce a proper joint. The shape of edges may be plain,

V-shaped, U-shaped, re-shaped, etc. The choice of various edge shapes depends upon the kind, thickness of metal to be welded. Some different types of grooves for edges of the work are shown in Figure 2.3.

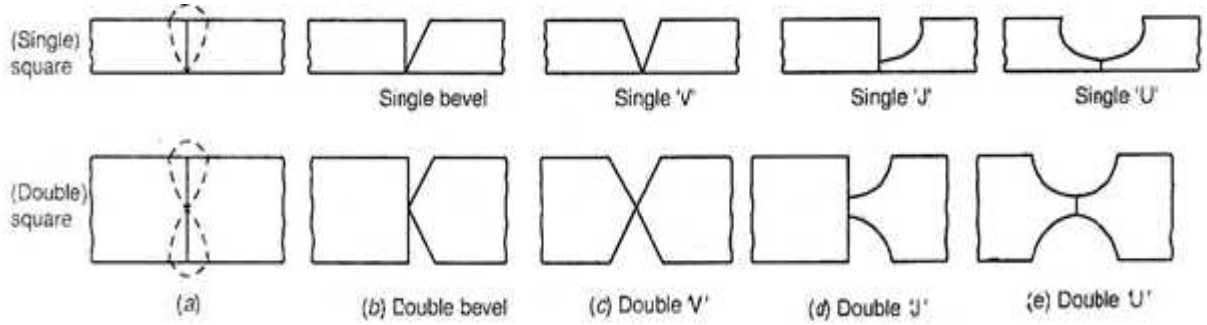


Figure 2.3.Edge Preparation

(i) Square Butt:

It is used when the thickness of the plate is from 3 to 5 mm. Both the edges to be weld should be spaced about 2 to 3mm apart as shown in Fig 2.3. (a).

(ii) Single- V-Butt:

It is used when the thickness of the plates is from 8 to 16 mm. Both the edges are beveled to form an angle of about 70° to 90°, as shown if Fig.2.3 (b).

(Iii) Double-V-Butt:

It is used when the thickness of the plates is more than 16mm and where welding can be performed on both sides of the plate. Both the edges are beveled to form a double-V, as shown in Figure 2.3 (c).

(iv) Single and Double-U Butt:

It is used when the thickness of the plate is more than 20mm. The edge preparation is difficult but the joints are more satisfactory. It requires less filler metal, as shown in the above Figure 2.3. (d) and (e).

2.4. Weld Materials

2.4.1. 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

The basic elements involved in manual arc welding process are shown in figure 2.3 below, this process employs coatings or fluxes to prevent the weld pool from the surrounding atmosphere.

- Switch box.
- Secondary terminals
- Welding machine.
- Current reading scale.
- Current regulating hand wheel.

- Leather apron.
- Asbestos hand gloves.
- Protective glasses strap
- Electrode holder.
- Hand shield
- Channel for cable protection.
- Welding cable.
- Chipping hammer.
- Wire brush.
- Earth clamp.
- Welding table (metallic).
- 17) Job.

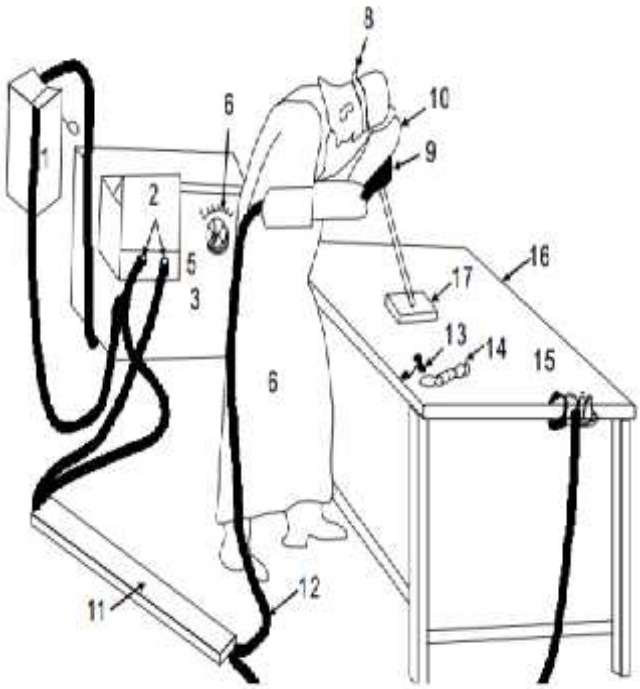


Figure 2.10.The basic elements of arc welding equipment

2.4.2. Welding joints

Most welding projects use at least one of the five welding joint types shown below. Understanding each welding joint type is an important part of becoming an experienced, successful welder

1. **Butt joint**
   - Joins two members that meet at their edges on the same plane
   - Used in applications where a smooth weld face is required
   - Fillet or groove welded; groove welding requires added expertise and expense
   - Improper design/welding risks distortion and residual stresses

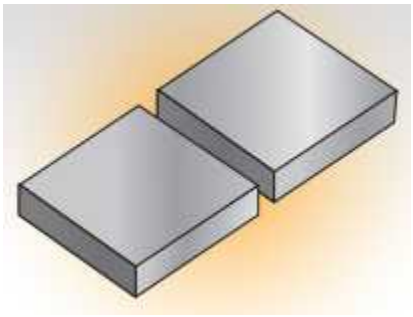
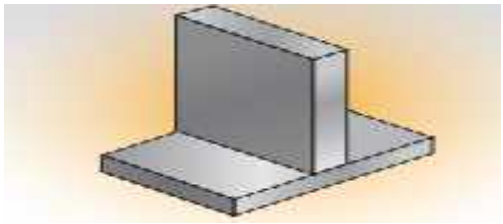


Figure 2.11.Butt joint

2. T-joint

- Joins two members that meet at a T-shaped angle
- Good mechanical properties, especially when welded from both sides
- Easily welded with little or no joint preparation
- Usually fillet welded, although J-grooves are possible



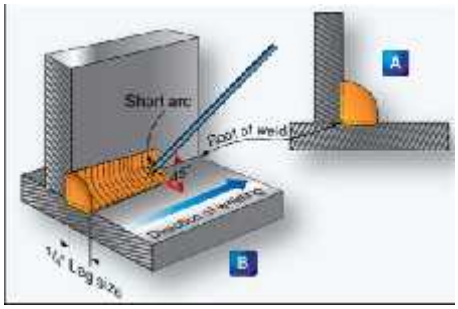
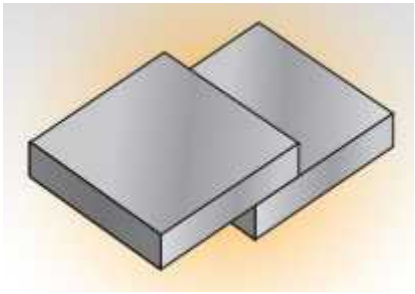


Figure 2.12.T-joint

3. Lap Joint

- Joins two members having overlapping surfaces
- Good mechanical properties, especially when welded from both sides
- Usually fillet welded
- Thicker material requires more overlap



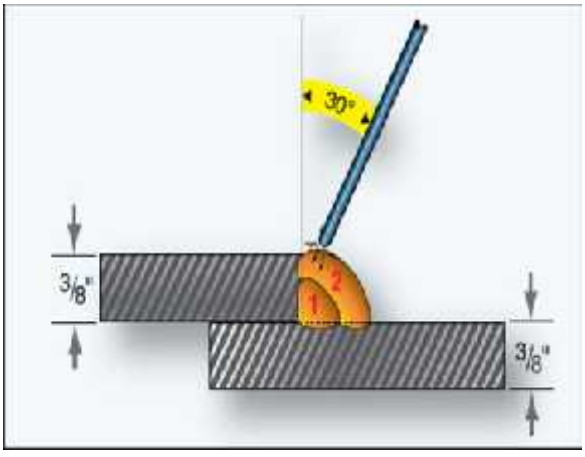


Figure 2.13. Lap joint

4. Corner Joint

- Joins two members that meet at an angle
- Two main types: open corner and closed corner
- Easily welded with little or no joint preparation
- Increase travel speed on light-gauge material to avoid burn-through

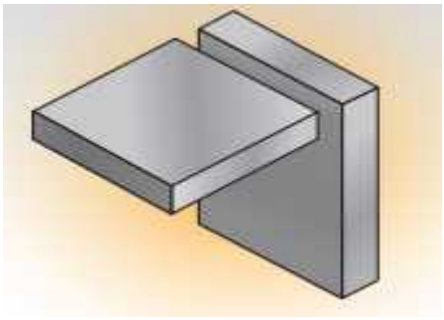


Figure 2.14. Corner joint

5. Edge Joint

- Joins two parallel, or nearly parallel, members
- Not recommended if either member will be subject to impact or high stresses
- Square groove is most common, but other groove configurations are possible
- Very deep penetration is impossible

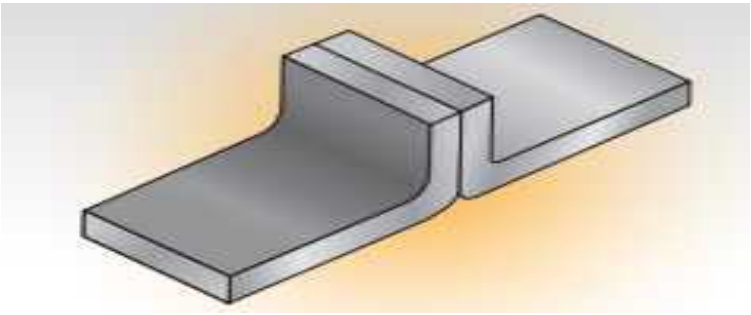


Figure 2.15. Edge joint

2.4.3. Welding positions

The welding positions are classified on the basis of the plane on which weld metal is deposited. The positions are flat, horizontal, vertical and overhead.

1. **Flat welding**

In flat welding, plates to be welded are placed on the horizontal plane and weld bead is also, deposited horizontally (Fig. below). This is one of most commonly used and convenient welding position. Selection of welding parameters for flat welding is not very crucial for placing the weld metal at desired location in flat welding.

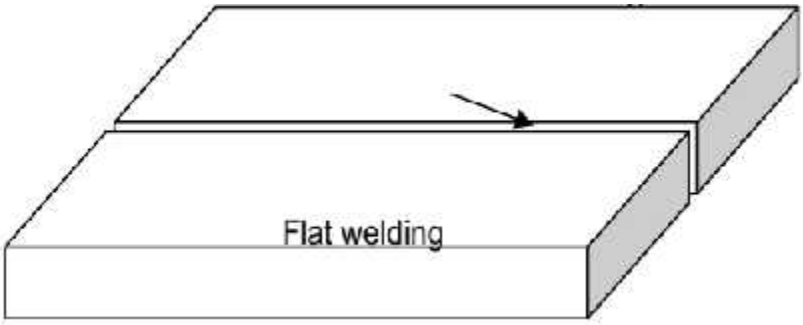


Figure 2.16.Scheme of placement of components to be welded for flat welding

There are four types of welds commonly used in flat position welding: bead, groove, fillet, and lap joint. Each type is discussed separately in the following paragraphs.

A. **Bead Weld**

The bead weld utilizes the same technique that is used when depositing a bead on a flat metal surface. [Figure 2.17] The only difference is that the deposited bead is at the butt joint of two steel plates, fusing them together. Square butt joints may be welded in one or multiple passes. If the thickness of the metal is such that complete fusion cannot be obtained by welding from one side, the joint must be welded from both sides. Most joints should first be tack-welded to ensure alignment and reduce warping.

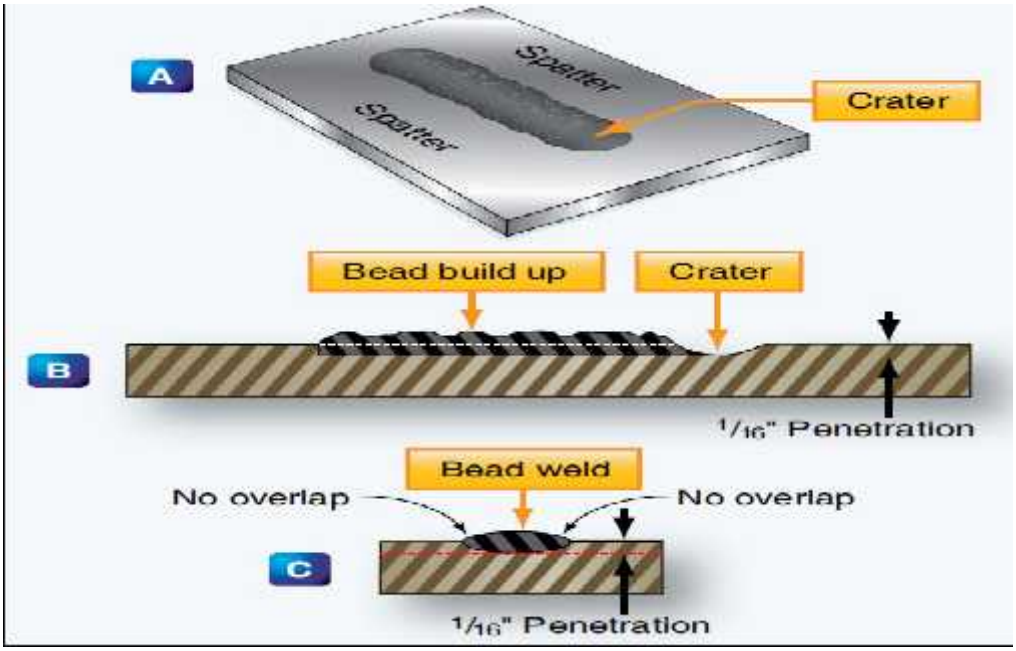


Figure 2.17. Bead weld

B. Groove Weld

Groove welding may be performed on a butt joint or an outside corner joint. Groove welds are made on butt joints where the metal to be welded is ¼-inch or more in thickness. The butt joint can be prepared using either a single or double groove depending on the thickness of the plate. The number of passes required to complete a weld is determined by the thickness of the metal being welded and the size of the electrode being used.

Any groove weld made in more than one pass must have the slag, spatter, and oxide carefully removed from all previous weld deposits before welding over them. Some of the common types of groove welds performed on butt joints in the flat position are shown in Figure 2.18.

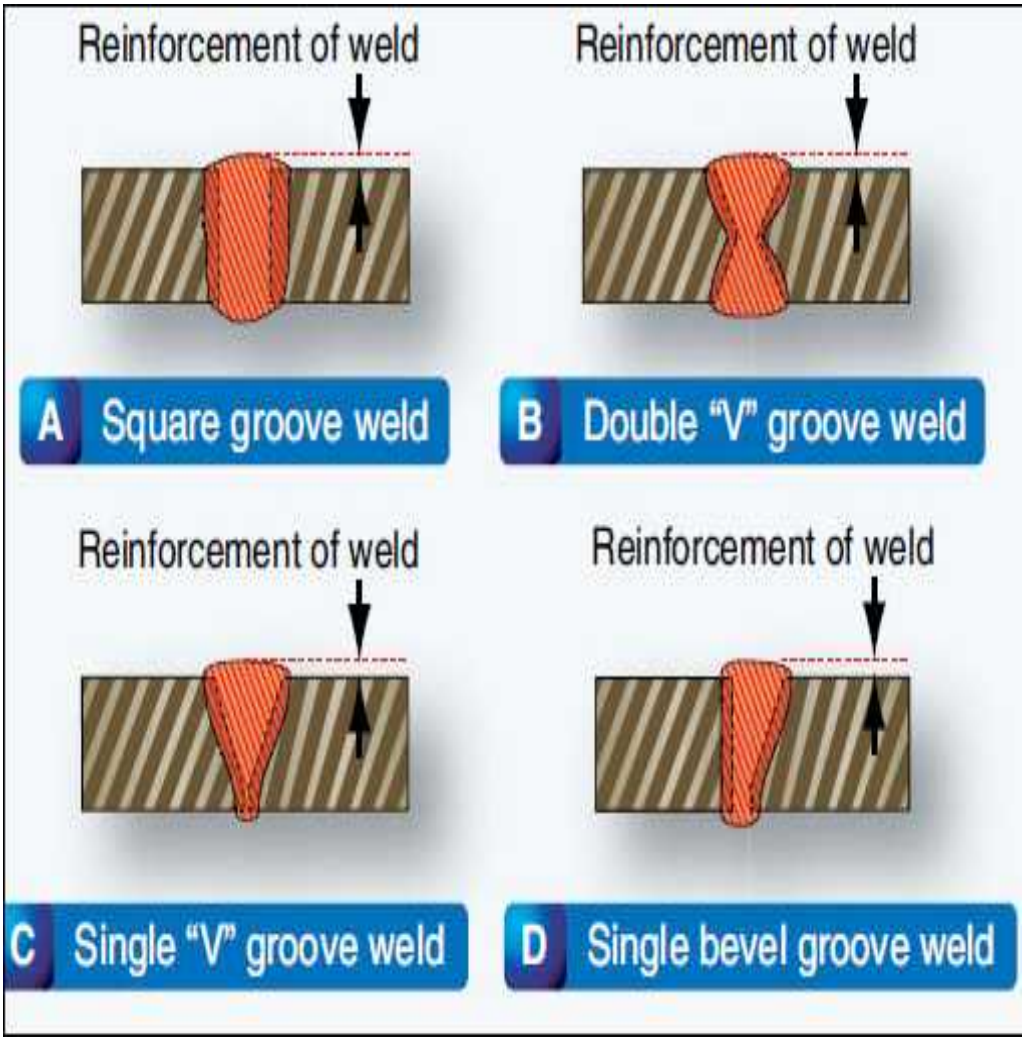


Figure 2.18. Groove weld

C. Fillet Weld

Fillet welds are used to make tee and lap joints. The electrode should be held at an angle of 45° to the plate surface. The electrode should be tilted at an angle of about 15° in the direction of welding. Thin plates should be welded with little or no weaving motion of the electrode and the weld is made in one pass. Fillet welding of thicker plates may require two or more passes using a semicircular weaving motion of the electrode. [Figure 2.19]

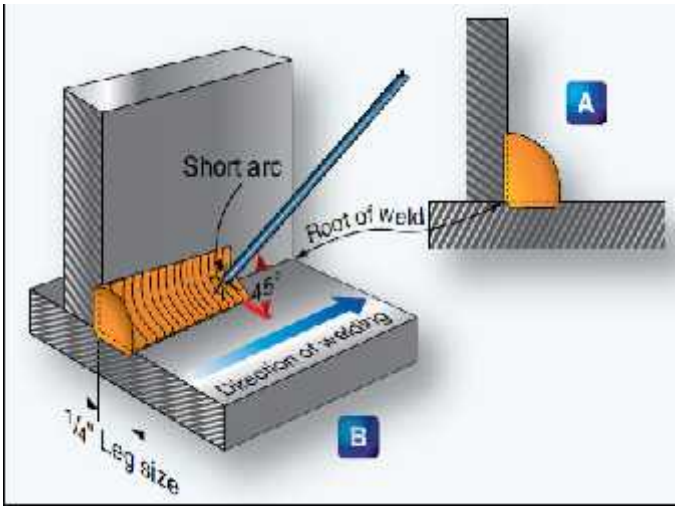


Figure 2.19. Fillet weld

D. Lap Joint Weld

The procedure for making fillet weld in a lap joint is similar to that used in the tee joint. The electrode is held at about a 30° angle to the vertical and tilted to an angle of about 15° in the direction of welding when joining plates of the same thickness. [Figure 2.20]

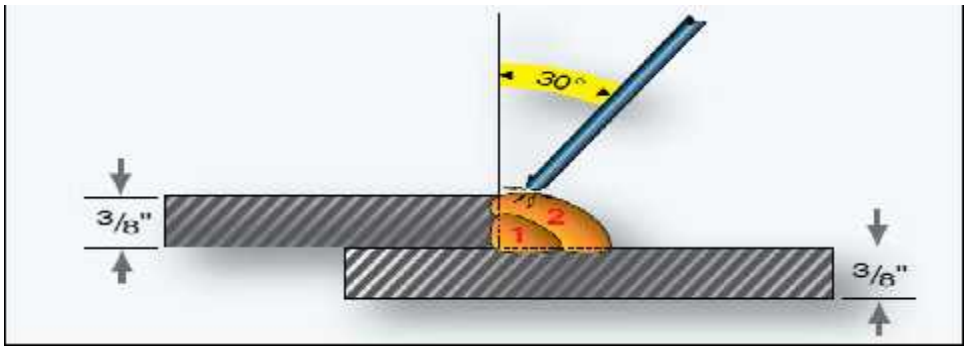


Figure 2.20.Lap joint weld

2. Horizontal welding

In horizontal welding, plates to be welded are placed in vertical plane while weld bead is deposited horizontally (Figure 2.21.). This technique is comparatively more difficult than flat welding. Welding parameters for horizontal welding should be selected carefully for easy manipulation/placement of weld metal at the desired location.

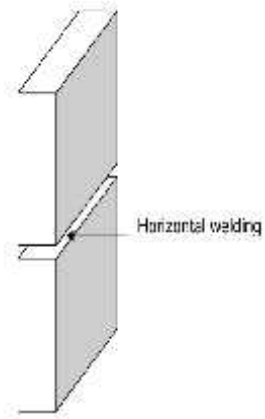


Figure 2.21Scheme of placement of components to be welded for horizontal welding

3. Vertical welding

In vertical welding, plates to be welded are placed on the vertical plane and weld bead is also deposited vertically (Figure 2.22.). It imposes difficulty in placing the molten weld metal from electrode in proper place along the weld line due to tendency of the melt to fall down under the influence of gravitational force. Viscosity and surface tension of the molten weld metal which are determined by the composition of weld metal and its temperature predominantly control the tendency of molten weld metal to fall down due to gravity. Increase in alloying elements/impurities and temperature of melt in general decrease the viscosity and surface tension of the weld metal and thus making the liquid weld metal more thin and of higher fluidity which in turn increases tendency of weld metal to fall down conversely these factors increase difficulty in placing weld metal at desired location. Therefore, selection of welding parameters (welding current, arc manipulation during welding and welding speed all are influencing the heat generation) and electrode coating (affecting composition of weld metal) dilution becomes very crucial for placing the weld metal at desired location in vertical welding.

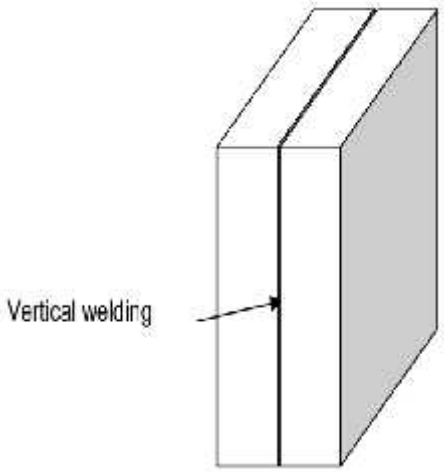


Figure 2.22. Scheme of placement of components to be welded for vertical welding

4. Overhead welding

In overhead welding, weld metal is deposited in such a way that face of the weld is largely downward and there is high tendency of falling down of weld metal during welding (Figure 2.23.). Molten weld metal is moved from the electrode (lower side) to base metal (upper side) with great care and difficulty hence, it imposes problems similar to that of vertical welding but with greater intensity. Accordingly, the selection of welding parameters, arc manipulation and welding consumable should be done after considering all factors which can decrease the fluidity of molten weld metal so as to reduce the weld metal falling tendency. This is most difficult welding position and therefore it needs great skill to place the weld metal at desired location with close control.

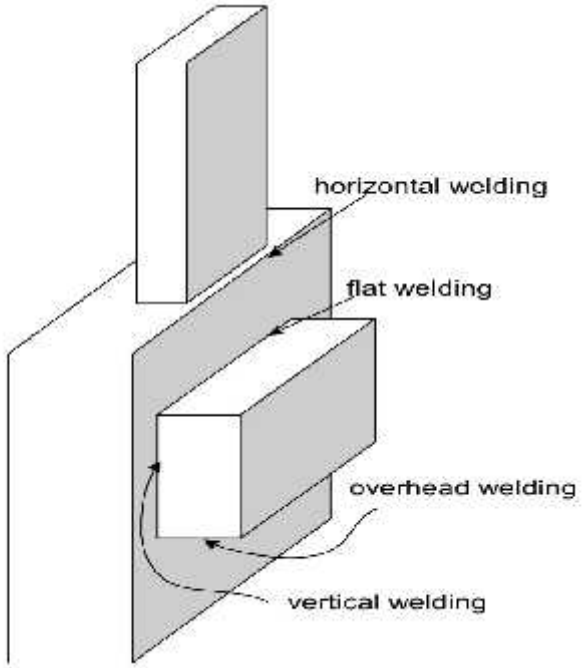


Figure 2.23. Scheme of placement of components to be welded for different types of welding positions including overhead welding

After preparing and setting the materials, the next step is welding and producing output as indicated in the following figure 2.24.

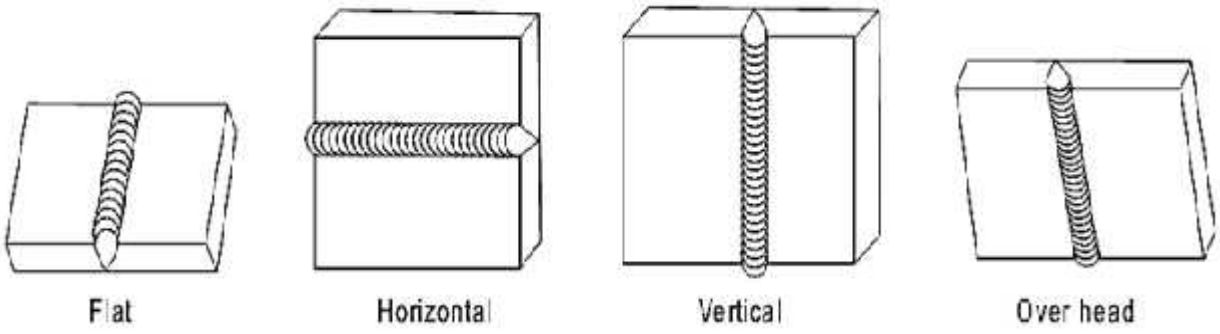


Figure 2.24. Different welding positions applied on butt joint.

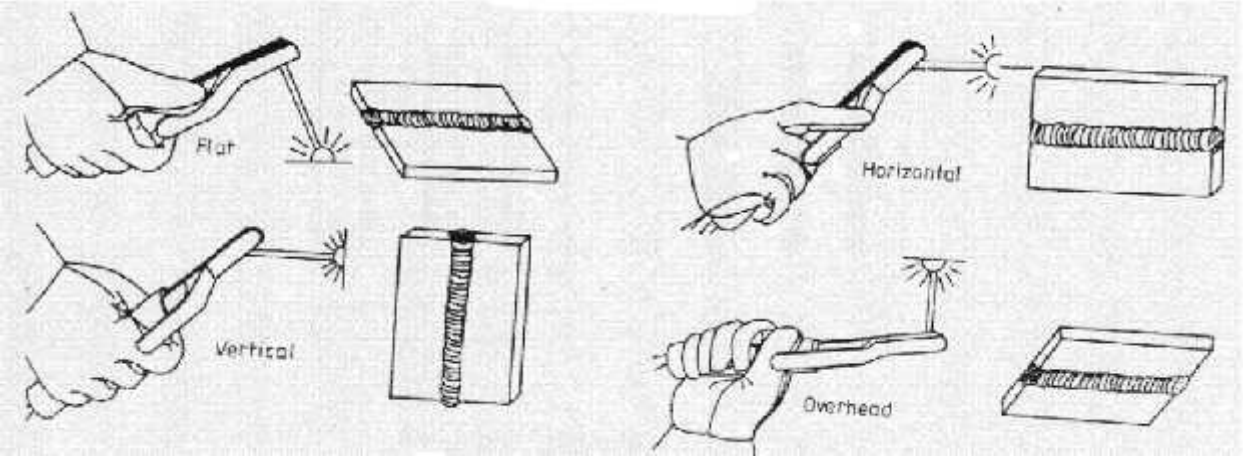


Figure 2.25.Application of butt joint welding at different positions

2.5. Clean weld seam joints

2.5.1. Clean welding seams

Cleaning is necessary before welding, during welding (inter-pass) 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 dis-colour 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.

2.6.OHS measures

2.6.1. Safety Considerations

A. <u>Preparation and Set-up</u>:

- ❖ The immediate area should be well marked or sectioned off in the shop prior to welding.
- ❖ This is necessary as others may be unaware the possible hazards of welding.
- ❖ The shop should contain adequate safety devices such as fire extinguishers.
- ❖ The locations of these items should be clearly marked.
- ❖ Equipment should be properly installed with all ground wires intact.
- ❖ Any loose or frayed wires should be reported immediately. The floor should be clear and dry, free from flammable materials such as oily rags or sawdust.
- ❖ The operator should wear protective clothing to include:
  - Boots – not sandals or open toed shoes;
  - Welding mask;
  - Safety glasses;
  - Jeans or heavy pants, not frayed or torn;
  - Welding apron and jacket are recommended; and
  - Welding gloves.

- It is very important that the user NOT wear contact lenses in or around the shop ANYTIME as a flash from the welder may actually burn the contacts to the eye.
- It is also important to note that while welding the operator must wear the mask, and after the weld is completed, safety glasses should be worn for chipping off the slag and splatter. After the above are complied with, the operator may proceed.

B**. <u>Operation</u>**

- Safety precautions during operation include:
  - Avoid breathing fumes, use the exhaust fan;
  - Do no weld in a confined space; and
  - Handle gas cylinders with care.

3**. Safe Machine and Tool Operating Parameters**

- Always wear gloves, as there is a significant amount of UV radiation, enough to burn skin.
- Spatter may also cause burns, not only on your skin but also inside masks and clothing. This can be avoided by wearing a welding jacket and a full welding mask.
- A welding mask is angled around the head of the operator so as to maximize coverage from flying sparks.

4**. Newer Developments and Improvements**

- An improved mask has been developed that will darken the lenses automatically.
- An electric circuit senses when the rod contacts the piece, and immediately darkens the lenses.
- This is a great improvement as the operator will no longer have to continually switch from goggles to weld mask.

5. **Environmental Concerns**

A**. <u>Disposal and Recycling</u>**

- Welding rods always leave one or two inches of stub, wire feed also leave some scrap. Scraps and slag are a part of the normal process.
- These are usually placed in scrap metal dumpsters and later sent to scrap yards for recycling.

B. **<u>Hazardous Fumes</u>**

- Fans are required to remove hazardous vapors and gases.
- Toxicity levels depend upon the chemical composition of fluxes and shield gasses. These gases also contain particulate matter, so it is very important to weld only in a well ventilated area.
- There is no difference in health between welders and non-welders when operations are carried out in an area that is adequately ventilated.

6**. Information for Design of Parts for Safe Machining**

A**. Preprocessing of Parts**

- Edges on pieces should be ground smooth and possibly machined to the correct angle for the desired weld type.
- It is important to clean joining surfaces so that they are free from anything that may weaken the weld. This includes oil, grease, oxidation or dust.

B**. Post processing of Parts**

- Parts should be cooled after the weld is completed, if possible.
- Slag and any spatter should be chipped off with a chip hammer.
- Edges should have any rough parts removed by grinding or filing.
- Arc welding is a safe occupation when sufficient measures are taken to protect the welder from potential hazards.
- When these measures are overlooked or ignored, however, welders can encounter such dangers as electric shock, overexposure to fumes and gases, arc radiation, and fire and explosion; which may result in serious, or even fatal injuries

2.6.2.Safety rules for arc welding

- Be sure the welder is properly installed and grounded.
- Never weld without adequate ventilation.
- Take proper precautions to prevent fires.
- Protect your entire body with fire retardant clothing, shoes, and gloves.
- Wear eye protection at all times.
- Weld only in a fire safe area.
- Never do any welding, cutting, or hot work on used drums, barrels, tanks, or other containers.
- Mark metal "HOT" with a soapstone.
- Keep a well stocked first aid kit handy**.**

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.

Before you start to weld, ensure that you have all the required equipment and accessories. Listed below are some additional welding rules that should be followed

- Clear the welding area of all debris and clutter.
- Do not use gloves or clothing that contains oil or grease.
- Check that all wiring and cables are installed properly.
- Ensure that the machine is grounded and dry.
- Follow all manufacturers' directions on operating the welding machine.
- Have on hand a protective screen to protect others in the welding area from FLASH bums.
- Always keep fire-fighting equipment on hand.
- Clean rust, scale, paint, or dirt from the joints that are to be welded.

WARNING

- Don't look at the welding arc without protection. Looking at the arc with the naked eye could result in permanent eye damage. If you receive flash burns, they should be treated by medical personnel.

- Another area often overlooked is ventilation. Welding produces a lot of smoke and fumes that can be injurious to the welder if they are allowed to accumulate. This is especially true if you are welding in a tank or other in closed area. Permanent welding boothsshould be equipped with an exhaust hood and fan system for removal of smoke and fume

Table 2.1 Potential health & safety hazards signs

HAZARD	TO PROTECT YOURSELF
PINCH POINTS **There are gears and exposed moving parts on machinery.** 	Use LOCK-OUT procedures when performing maintenance or conducting any work within 12" of an exposed pinch point. NEVER put your hands or feet near an exposed pinch point or gears!
ELECTRICAL HAZARD 	Ensure all electrical equipment and machines have plugs and wires that are in good condition.
EXPLOSIVE 	Make sure cylinders are stored and handled correctly. Proper grounding must be used.
HIGH SOUND LEVELS **Sound levels exceed 85 dB** 	**HEARING PROTECTION** is required when working in designated areas.

2.7.2 Application of personal protective equipment

Protective equipment is at the heart of any welding safety plan. Where there is exposure to sharp or heavy falling objects or a hazard of bumping in confined spaces, hard hats or head protectors must be used. For welding and cutting overhead or in confined spaces, steel-toed boots and ear protection must also be used.

2.7.2. Welding Protective Clothing

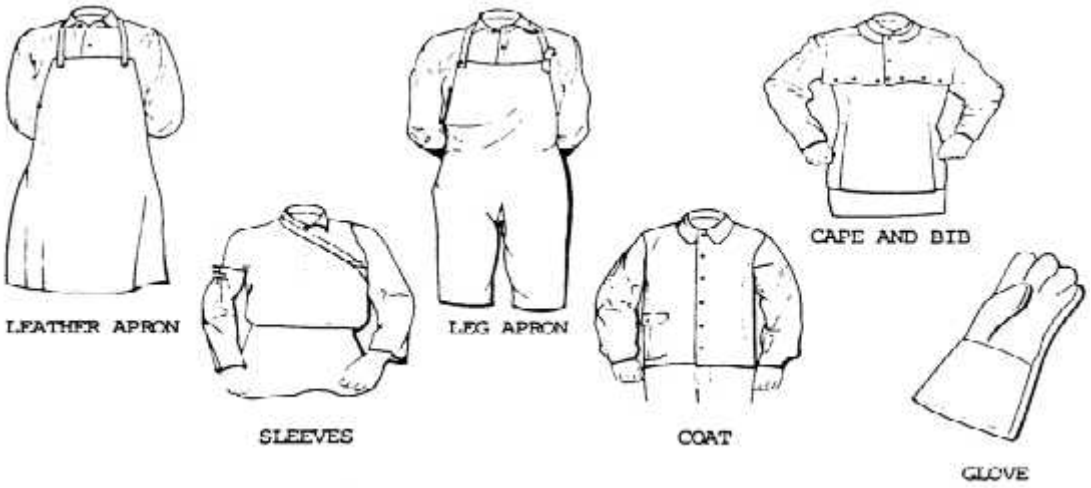


Figure 2.26.Protective close

Protective Clothing includes welding gloves, coat, sleeves, and leg protection. Personnel exposed to the hazards created by welding, cutting, or brazing operations shall be protected by personal protective equipment in accordance with OSHA standards.

2.7.2. Personal protective equipment

	Safety glasses must be worn at all times in work area!
	Respirator with HEPA filters must be worn when working with asbestos containing materials. Workers must be fit tested prior to performing any asbestos work.
	Work Boots must be worn at all times when working in an area where there is risk of serious foot injury due materials falling onto the foot.
	Welding work gloves should be worn when there is a risk of hand injury during the course of work tasks.
	Hard hats must be worn when working in an environment where there is a risk of objects falling from above or where there is a high risk of striking your head on objects.

	Welding helmets must be kept in good shape and have protective lenses meeting shade selection requirements for the task.
	Protective clothing must be worn whenever cutting, welding and grinding is done. This includes welding jacket, welding gloves, and respirator is required.

2.7.3. Welding safety tools

During welding, arc produces fumes, sparks, infrared or ultraviolet rays and slag, which are dangerous for life, so proper utilization of safety devices, can prevent the welder from those hazards. These safety devices are described.

1. Gloves: these must be made of leather and should be the gauntlet style, covering your Forearms.

Figure 2.27. Gloves

2. Aprons: are flame retardant outfits worn by a welder to protect the under clothing and the body from the sparks, the molten metal and the hot metal being welded.

Figure 2.28. Apron

3. Welding goggles: are used to protect the eyes from the rays of light emitted by the flame and the pool of molten metal, and from flying sparks.

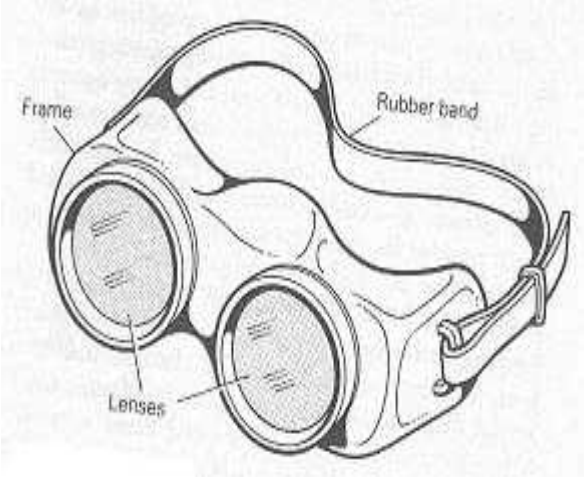


Figure 2.29. Welding goggles

4. Welding shield: these are available as a hand held shield or a head shield /helmet/, which leaves both hands free.

Figure 2.30. Helmet

a) Welding hand shields: are used to protect the face during welding.

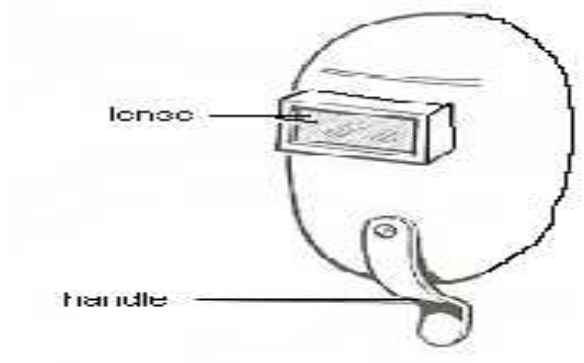


Figure 2.31. Welding hand shield

Self-check-1

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Say true or false

1. grinder is used to grind the surface of the weld to give a more uniform surface

2. Always wear safety gloves when chipping the slag after welding is completed

3. Chipping hammer is used to grind after welding to smooth the weld-meant

4. Shielded metal arc welding is often used popular for nonferrous materials.

5. SMAW is one of the world's most popular welding processes

6. Make proper joint preparation and use of multiple passes, materials of virtually unlimited thicknesses can be joined by welding

7. Square Butt is used when the thickness of the plate is from 3 to 5 mm

8 .The efficiency and quality of welded joint also not depends upon the correct preparation of the edges of the plates to be welded

9 .The cleaning of the surface should be carried out mechanically by wire brush or power wire wheel, and then chemically by carbon tetrachloride

Self-check-Two

Instruction one: choose the correct answer

1. Which one of the following is PPE?

   A. gloves B, apron C, safety shoes D, all

2. Which one of the following is safety measure in welding?

   A, welding should be done in a well ventilated area

   B, avoid rolling up of sleeves

   C, welder must use eye protection equipment

   D, all

3. _____is used to handle electrode

   A. chipping hammer C. Electrode holder

   B. wire brush D, none

5. The advantage of arc welding machine is_____

   A, equipment is cheap B, versatile C, simple and portable d, all

6. one of the following is not welding equipment

   A, chipping hammer B, wire brush C anvil D, electrode holder

7. Use _____ to protect your eyes from ultraviolet rays

   A, apron B, helmet C, goggle D all

8. consumable electrodes provide

   A, gas protection B adding element to change mechanical properties

   C, A and B D, none

9. _____ is used to remove fumes

   A chipping hammer B, fume extractor C, holder D, all

10. Best metal surface should free from

A. weld B. oil &Grease

C. oxide scale D. All except A

11. Equipment used for preparing material for welding are

A. Grinder B. Sand paper

C. File D. wire brush

E. All of the above

12. Common welding joints

A. Edge & corner B. Butt &T -joint

C. Lap joint D. All of the above

13. Time take to make complete inspection during welding

A. 5 minute B. 10 minute

C. 5-10 minute D. All of the above

14. Factors to be considered during selection of electrode are

A. Properties of base metal C. Joint design &Joint up

B. Electrode diameter E. All of the above

15. In symbol E-7018 E-stand for

A. Tensile strength C. Welding position

B. Electrode D. All of the above

Operation Sheet 1	Connecting welding machine to an independent power supply

Techniques for Connect welding machine to in independent power supply

Step1. Safety (clean work area &wear PPE)

Step2. Select proper tools and equipment.

Step3. Prepare welding machine, accessories, equipment's and consumables.

Step4. Select welding machine

Step6. Select cables

Step7. Connect cables to machine

Step8. Clamp the cable

Step9. Setting up welding machine

Step10. Connect hose to the welding torch.

Step12. Select welding polarity.

Step13. Connect ground clamp to the welding machine.

Step14. Connect welding torch to the welding machine.

Step15. Connect foot pedal to the welding machine.

Step16. Cleaning the work area.

Operation Sheet 2	wiring up or setting to the polarity

Methods to setting welding polarity?

Step1. Safety (clean work area &wear PPE)

Step2. Select proper tools and equipment.

Step3. Connect welding machine to in independent power supply

Step4. Select welding polarity (DCEN, DCEP&AC)

Step5. Connect to the welding machine

Step6. Cleaning the work area.

Operation Sheet 3	Adjusting current and voltage consistent with work requirements

Methods to Adjusting current and voltage?

Step1. Safety (clean work area &wear PPE)

Step2. Select proper tools and equipment.

Step3. Connect welding machine to in independent power supply

Step4. Select welding polarity (DCEN, DCEP&AC)

Step5. Connect to the welding machine

Step6. Connect the welding machine to the power sources

Step7. Adjust current and voltage

Step8. Cleaning the work area.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **6 hour**

Task1. Identifying welding machine accessories and consumable

Task2. Connect welding machine to in independent power supply

Task3. Set welding polarity

Task4. Adjust current and voltage

Task5. Perform Prevention distortion measures

Unit Three: Assure Quality And Clean Up

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

- Clean and inspect welding seams
- Feed back on skill performance.
- measure of joints
- Welding equipment and work area

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

- Oprating Welding seams are cleaned and inspected
- Provided Feedback on performance by others in the team
- measured Joins are according to specification
- maintained Welding equipment and work welding activity

3.1.Clean and Inspect Welding Seams

3.1.1. Clean welding seams

In the welding seams the slag or flux remaining after a pass, shall be removed before applying the next covering pass. After the final pass all slag and weld spatter shall be removed. Arc strikes shall be removed by grinding or other suitable means. Cracks or blemishes caused by arc strike shall be ground to a smooth contour and examined visually to assure complete removal.

3.1.2. Welding Defects

The lack of training to the operator or careless application of welding technologies may cause discontinuities in welding. In joints obtained by fusion welding, the defects such as porosity, slag inclusion, solidification cracks etc., are observed and these defects deteriorates the weld quality and joint properties. Common weld defects found in welded joints. These defects may result in sudden failures which are unexpected as they give rise to stress intensities. The common weld defects include:

1. Porosity
2. Lack of fusion
3. Inclusions
4. Cracking
5. Undercut

1. Porosity

Occurs, when the solidifying weld metal has gases trapped in it, the presence of porosity in most of the welded joints is due to dirt on the surface of the metal to be welded or damp consumables. It is found in the shape of sphere or as elongated pockets. The region of distribution of the porosity is random and sometimes it is more concentrated in a certain region. By storing all the consumables in dry conditions and degreasing and cleaning the surface before welding, porosity can be avoided.

Porosity is best prevented by avoiding:

1. Overheating and undercutting of the weld metal.

2. Too high a current setting.
3. Too long an arc.

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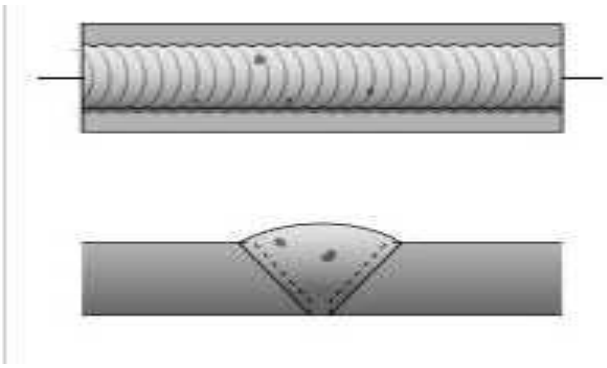


Following are a few simple steps you can take to reduce porosity in your welds:

- Make sure all your materials are clean before you begin welding.
- Work on proper manipulation of your electrode.
- Try using low-hydrogen electrodes

2. Lack of Fusion

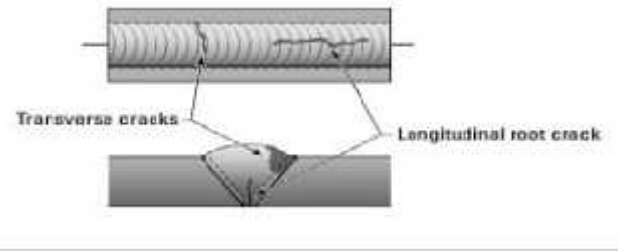
Due to too little input or too slow traverse of the welding torch, lack of fusion arises. By increasing the temperature, by properly cleaning the weld surface before welding and by selecting the appropriate joint design and electrodes, a better weld can be obtained. On extending the fusion zone to the thickness of the joints fully, a good quality joint can be obtained.

3 Inclusions

Due to the trapping of the oxides, fluxes and electrode coating materials in the weld zone the inclusions are occurred. Inclusions occur while joining thick plates in several runs using flux cored or flux coated rod sand the slag covering a run is not totally removed after every run and before the next run starts. By maintaining a clean surface before the ruins started, providing sufficient space for the molten weld metal between the pieces to be joined, the inclusions can be prevented.

4. Cracking

Cracks can occur just about everywhere in a weld: in the weld metal, the plate next to the weld metal, or in any other piece affected by the intense heat of welding. Check out the example of cracking in Figure



Here are the three major types of cracks, what causes them, and how you can prevent them.

Hot cracks:

This type of crack occurs during welding or shortly after you've deposited a weld, and its cause is simple: The metal gets hot too quickly or cools down too quickly. If you're having problems with hot cracking, try preheating your material. You can also post heat your material, which means that you apply a little heat here and there after you've finished welding in an effort to let the metal cool down more gradually.

Cold cracks:

This type of crack happens well after a weld is completed and the metal has cooled off. (It can even happen days or weeks after a weld.) It generally happens only in steel, and it's caused by

deformities in the structure of the steel. You can guard against cold cracking by increasing the thickness of your first welding pass when starting a new weld. Making sure you're manipulating your electrode properly, as well as pre- and post-heating your metal, can also help thwart cold cracking.

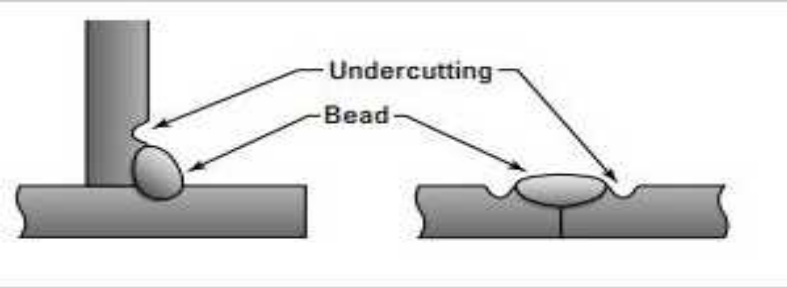
- **Prevention** : Preheat, weld toward areas of less constraint, use more ductile weld metal Repair
- Remove and re weld, correct problem first, preheat may be necessary

Crater cracks:

These little devils usually occur at the ending point of a weld, when you've stopped welding before using up the rest of an electrode. The really annoying part about crater cracks is that they can cause other cracks, and the cracking can just kind of snowball from there. You can control the problem by making sure you're using the appropriate amount of amperage and heat for each project, slowing your speed of travel, and pre- and post-heating

5. Undercutting

Undercutting is an extremely common welding defect. It happens when your base metal is burned away at one of the toes of a weld. To see what I mean, look at Figure



Here are a few common causes of undercutting

- Your electrode is too large for the base metal you're welding.
- Your arc is too long.
- You have your amperage set too high.
- You're moving your electrode around too much while you're welding

- **Prevention:** Set machine on scrap metal.
    - Clean metal before welding.
- **Repair:** Weld with smaller electrode, sometimes must be
    - low hydrogen with preheat. Sometimes must

6. Lamellar Tearing

Due to nonmetallic inclusions, the lamellar tearing occurs through the thickness direction. This is more evidently found in rolled plates. As the fusion boundary is parallel to the rolling plane in T and corner joints, the lamellar tearing occur. By redesigning the joint and by buttering the weld area with ductile material, the lamellar tearing can be minimized

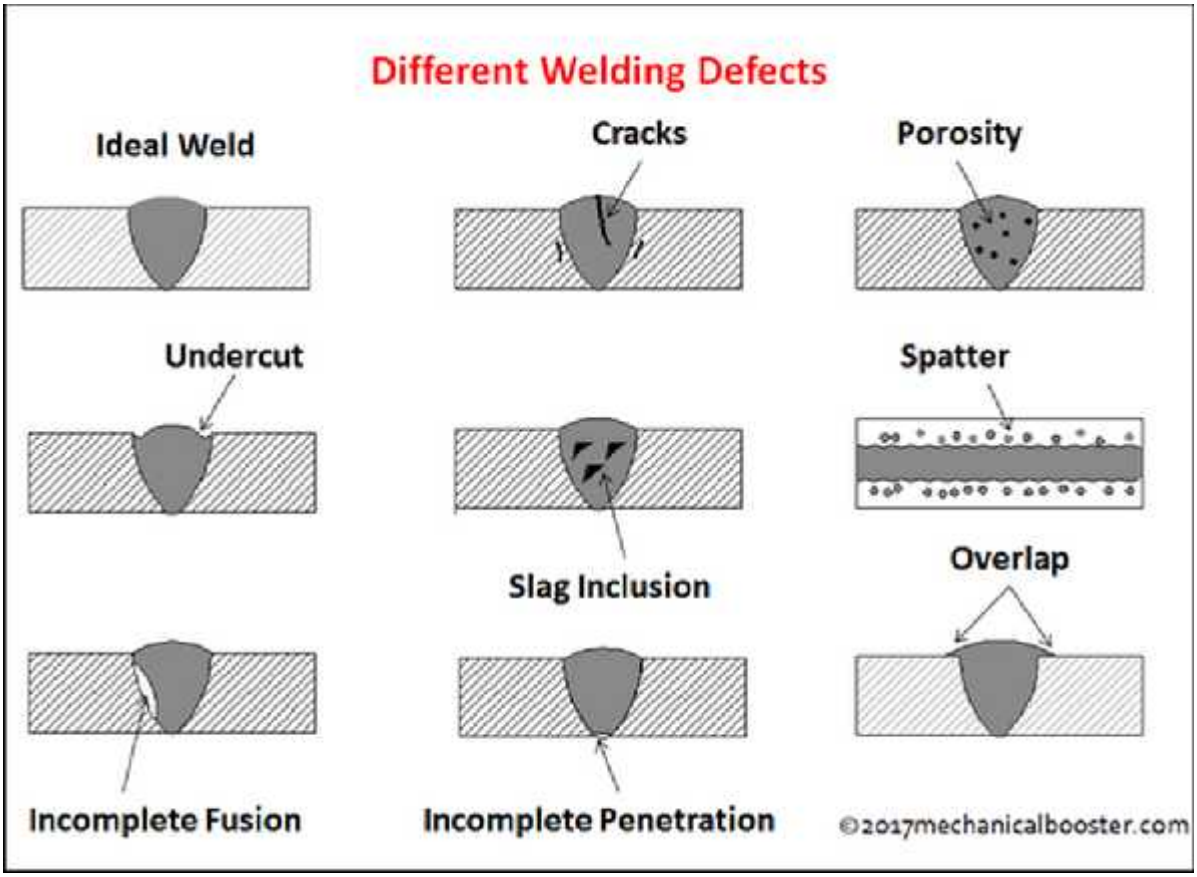


Figure : **Different welding defects**

3.1.2.Inspection and weld quality

The term **inspection** usually implies a formal inspection, prescribed by a code or by the requirements of a purchaser that is given to welds and welded structures. The minimum requirements of welding codes are inflexible, and must be met. The appearance of a weld does not necessarily indicate its quality, If discontinuities exist in a weld, they can be grouped into two broad classifications: those that are apparent to visual inspection and those that are not. Visual examination of the underside of a weld will determine whether there is complete penetration and whether there are excessive globules of metal. Inadequate joint penetration may be due to insufficient beveling of the edges, too thick a root face,-too high a welding speed, or poor torch and welding rod manipulation .Heating of the base metal, too rapid travel, or gas or dirt inclusions.

3.1.3.Destructive Testing

In destructive testing, sample portions of the welded structures are required. These samples are subjected to loads until they actually fail. The failed pieces are then studied and compared to known standards to determine the quality of the weld. The most common types of destructive testing are known as free bend, guided bend, nick-break, impact, fillet welded joint, etching, and tensile testing.

3.1.4.Free-Bend Test

The free-bend test is designed to measure the ductility of the weld deposit and the heat-affected area adjacent to the weld. Also it is used to determine the percentage of elongation of the weld metal. Ductility, you should recall, is that property of a metal that

> allows it to be drawn out or hammered thin. The first step in preparing a welded specimen for the free-bend test is to machine the welded reinforcement crown flush with the surface of the test plate. on the outside and the piece placed so all the bending occurs in the weld, bend the test piece by using a hydraulic press or similar machine.

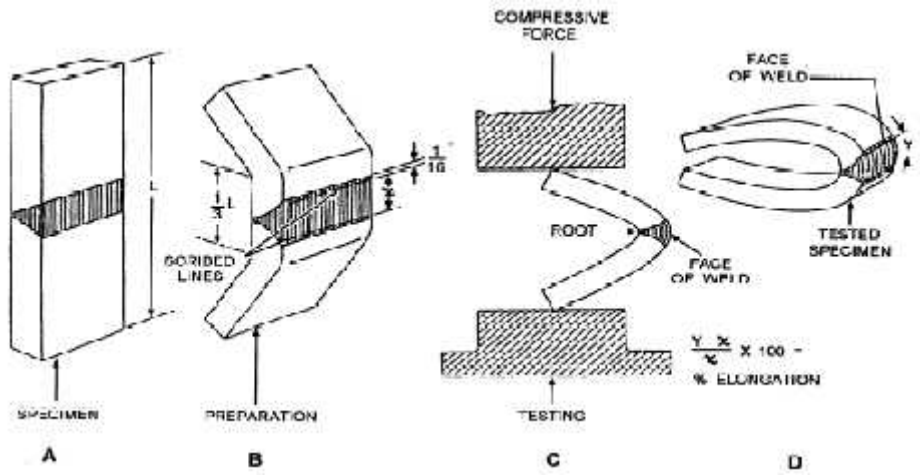


Fig. . free bend test

3.1.4.Nondestructive Testing

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

3.1 5.Visual Inspection

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

Visual inspection should be applied in the following ways.

1. During welding – check:

- Electrodes – compatibility of the electrode type to the weld metal, and joint preparation. This includes a check on the welding current, size of electrode, and speed of depositioroot run – the appearance, penetration (if required) and any external defects will give a good indication of weld quality
- slag removal – ensure that all slag is completely removed after eac
- h run – particularly watch the toes of the root run
- inter-run – each run of weld metal is going to be part of the completed weld, so check each run individually – one bad run may ruin the whole weld. It is much easier to correct defects as they occur than to wait until the weldment is completed. Watch corners, weld junctions, craters and weld toes.

2. After welding – check:

- the final appearance of the weld, and the presence of external defects such as undercut, reinforcement, weld profile, craters, misalignment, porosity, cracks and slag inclusions – the external appearance of a weld gives a good indication of its quality
- Conformity – all welds should be checked against the drawings and/or specifications to ensure that they meet the requirements laid down.

A .Visual Weld Quality Testing Steps

1. Practice and develop procedures for consistent application of approach
2. Inspect materials before welding
3. Weld quality testing when welding
4. Inspection when weld is complete
5. Mark problems and repair the weld

B. Visual Weld Equipment

Fillet Weld Gauge

Fillet Weld Gauge is an essential weld quality testing tool. It is used to check fillet leg size, checking fillet throat size dedicated weld-gap gauges and linear misalignment (high-low) gauges ,straight edges and measuring tapes ,magnifying lens (if magnification lens used it should have magnification between X2 to X5

Fig. **Fillet Weld Gauge**

Several pieces of welding equipment are required for visual weld quality testing:

- Weld handheld fillet gauge measures:
  - The flatness of the weld
  - Convexity (how the weld is welded outward)
  - Concavity (how the weld is rounded inward)
- Protective lenses with pocket viewer and shade lens for use when observing the welding process
- A magnifying glass per the code in your area
- Flashlight
- Chisel and/or welding hammer for spatter and slag removal before the weld is inspected
- Temperature device (Tempel stick, Pyrometer) to determine the preheating, inter pass and post-heating temperatures.
- Magnet to indicate the type of material being welded
- Tape measure
- Calipers

3.2.Feedback On Skill Performance

3.2. Joints Measurement

3.2.1. Inspection Tools and Measurements

Measurement and inspection of welded joint is an important step in quality control and reliability of welded constructions. External inspection allows you to detect such external defects such as undercuts, uncertified craters facing surface cracks, lack of fusion, flows, etc. Meters of welded joints and welding templates (templates welder) allow us to determine the size of joints, joint width and high, angle of bevel, depth and width of preparation, included angle, root gap, depth of root face, convexity, smoothness of transition weld to the base metal, leg length, etc.

3.2.2. Joints Measurement and other defects

A. Fillet welds

The leg length of the largest right isosceles triangle that can be inscribed within the fillet weld cross section is the size of the fillet weld. There are two types of fillet welds: concave and convex. The fillet weld type is determined by the shape of the fillet weld. Fillet weld gauges such as the ones in figure below are for specific size fillet welds and are two-sided in order to measure both concave and convex fillet welds. Be sure to use the proper side of the gauge for the fillet weld type being measured.

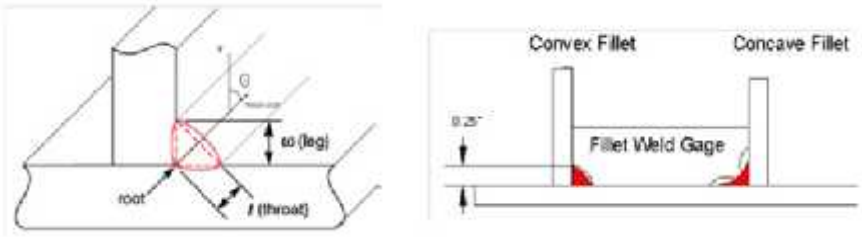


Figure 3.8. Fillet welds

Fillet welds can be measured using a gauge set as shown in Figure 3.10-3.12 below. The gauges can be used on both concave and convex fillet welds as long as the user understands show a fillet is measured. Whether measuring fillet welds or other weld features, the key tousling these gauges is to make sure they are sitting flat against the surface.

Figure 3.10. V-WAC gauge

Figure 3.11.Throat measurement with cam gauge

Figure 3.12.Bridge cam gauge

Note: Fillet welds are designed based on their cross-sectional area, which is calculated by the throat times the length. Drawing callouts for fillet sizes are given as the leg size. It is important for the inspector to understand that concave fillet welds cannot be measured by their leg size. Concave tools measure the throat and convert this size to the equivalent leg.

A. Undercut

Undercut is measured from the surface of the base metal to the deepest point of the undercut. Undercut can be quickly identified by running a flashlight along the edge of weld parallel to the surface of the base metal.

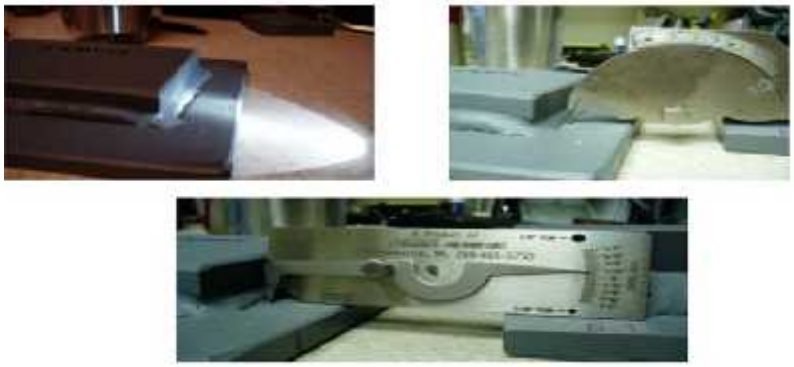


Figure 3.13. Measuring Undercut

B. Reinforcement

Face reinforcement is measured from the top surface of the base metal to the top of the face of the weld. Root reinforcement is measured from the bottom surface of the weld to the root surface of the weld.

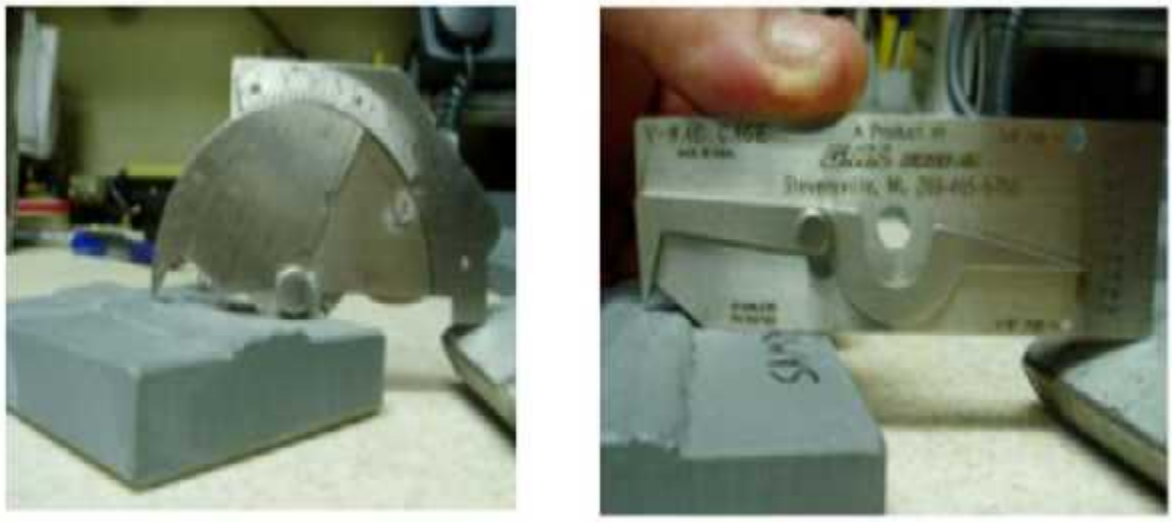


Figure 3.14.Measuring weld Reinforcement

Note: There are many other welding inspection tools available. Selection of these tools should be based on an evaluation of the attributes you are trying to verify. Practice with each selected tool is essential.

3.4. Clean and maintain welding equipment and work area

Tool housekeeping is very important, whether in the tool room, on the rack, in the yard, or on the bench all ways after completing operations. Tools require suitable fixtures with marked locations to provide an orderly arrangement. Returning tools promptly after use reduces the chance of it being misplaced or lost. Workers should regularly inspect, clean and repair all tools and take any damaged or worn tools out of service.

- Ensure sufficient time for materials to cool before handling.
- Switch off machine and fume extraction (if relevant).
- Hang up electrode holder and welding cables.

- Practice good housekeeping and ensure the area is clean and tidy.

3.4.1. Housekeeping in the Welding Shop Environment

Housekeeping in the welding shop environment is a key feature that all shops should possess. Without an organized shop many things we don't want to happen could occur. Cleaning up our shop area is just as important as making a good weld. Someone who takes pride in their work also takes pride in their work environment. Many shops have a lot of stuff stored in and around the shop, it's been there for years and is rarely used. Some shops have so much stuff in it you can barely move around or find anything. Other shops or well-organized and everything has a place and everything is in its place. Which one of these descriptions describes the shop or work environment you populate?

A well-organized shop saves time money and effort in many different ways. First, if the materials for fabrication are stored properly, it easy and quick to locate the proper material that we need to fabricate any project that we might want to build. Also if the shops material is well-organized it makes it very easy for the shop supervisor, project manager or plant manager to inventory the materials and see what's present. Understanding what is there what is available and in what sizes and thicknesses will help eliminate duplicate material orders for something we already have in stock. Also when it comes time to build the project the layout person, fitter or welder can easily and rapidly find the material required by the blueprint or technical drawing. Since labor is the most expensive component of fabricating most projects this savings of labor could amount to a large savings for the shop, possibly hundreds or thousands of dollars.

Since safety is a key component of everything we do in the welding world, housekeeping is just as critical to safety as wearing safety glasses, the proper clothing, boots, face and eye protection. Having our tools, equipment, hoses, cords, welding leads and our material well-organized in and around where we're going to do our fabrication, eliminates many of the tripping hazards and other safety issues associated with our welding shop environment. Having an injured shop employee does not help meet deadlines or get work done, its only a setback to the company. Just one injured employee can result in thousands of dollars of cost to the shop or fabricator. If we would just keep our area clean and organized we could use those thousands of dollars of cost on

new equipment, more materials, employee benefits or other things that our shop really needs. Just as important as having a well-organized shop at the beginning of the project, cleaning up our mess, returning everything to its proper location and returning the materials to where they belong at the end of the project is just as important in the preparation for the next project is as finishing up the present project.

The best way to organize our welding shop is to think about the flow of work through it and place the materials, machines and equipment in a logical place and manner that meets your requirements and keeps the operation efficient. Look around your shop open up your eyes and think about what you could do to improve your area. In all our shops we can easily find something that we could do better and if we focus on those single items and continue to improve bit by bit, item by item, over the long haul we will see the benefits of having a well-organized shop, improved safety and cost savings

3.4.2. Maintenance of equipment

You must ensure that any equipment used in welding is adequately maintained. Electrical equipment such as power sources, generators and welding machines and devices like ventilation systems and equipment must be properly installed, maintained, repaired and tested. Equipment used with compressed gases, including regulators, must be properly maintained to prevent hazards such as gas leaks. Persons with management or control of workplaces must ensure that gas cylinders are regularly inspected by a competent person. They should frequently check whether cylinders and regulators are visibly damaged or corroded, and whether they are within test date. Gas pipes, hoses and tubing can easily become damaged over time so these should also be inspected regularly. PPE must be maintained to be in good working order and kept clean and hygienic. Some types of personal protective equipment have a limited life span and need to be replaced periodically, while other types of personal protective equipment may become damaged or ineffective if stored incorrectly. For example, some respirators and filters can absorb toxins and contaminants in the air when stored between uses. PPE should be stored in a clean environment to avoid contamination or damage or according to instructions provided by the manufacturer.

Clean up work area

After operations, the shop should be cleaned. Electrode stubs should be disposed of, any scrap metal should be placed in the scrap metal container, the floor should be swept, and any water or other liquids spilled should be wiped up. Keeping the area around your work neat is as important as maintain your equipment.

- Clean your work area after completing your task (activity)
- Clean all tool , equipment and machines after practical work
- Cleaning your work area, Not only help to protect yourself from accident, but also much easier for you to work efficiently.
- Turn off all machines and power supply after work
- Keep all your equipment, cable, hoses etc out of any traffic routes. Such as
    - ✓ Door
    - ✓ Hallways
    - ✓ Ladder
- Inspect your equipment and found to be ok, but all your caution won't matter, when for example , a co-worker trip over your cable, causing you, or other people around you , to be injured by shock, hot metal , or from falling , there for your work area should always neat.
- Clean, collect and return all hand tool and safety equipment to supply room or to its original position.
- Dispose waste are Waste can be classified: Decomposed, Reuse, Waste.
- All class of wastes are selected , classified and disposed safely

Clean check and Maintain tools and Equipment: Should handle carefully while using, Check the functionality of tools and equipment before start welding and after complete welding, if there is damaged tool and equipment, you should maintain if you are skilled, report to responsible person location. Tools and equipment include

- Hand and power tools
- Measuring equipment

- Arc welding equipment
- Safety device etc.

All tools and equipment should be

- Cleaned
- Chided
- Maintained
- Stored at their proper location

Self-Check – 1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Which one of the following is not the causes of undercut?
   A. Your electrode is too large for the base metal
   B. Your arc length is too long
   C. Your speed of travel too fast
   D. You have amperage set too high
2. _____is the welding defect in which the base metal is burned away at toes of weld
   A. Under cutting C. Cracks
   B. Porosity D. Incomplete fusion
3. In which type of crack happens well after a weld is completed and the metal has cooled off.
   A. Hot crack C Crater cracks.
   B. Cold crack D. All
4. From the following one is destructive testing method
   A. Mechanical tests C. X-ray fluorescence
   B. Visual examination D. Eddy current
5. _____nondestructive testing method is based on principles of magnetism
   A. Eddy current testing C. Ultrasonic examination
   B. X-ray fluorescence D. Visual examination
6. Why do you clean your work area
   A. To protect your self from accident
   B. To protect others from
   C. To make much easier to work efficiently
   D. All of the above

Self-Check – 2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Say true or false

1. Square Butt is used when the thickness of the plate is from 3 to 5 mm
2. The efficiency and quality of welded joint also not depends upon the correct preparation of the edges of the plates to be welded
3. The cleaning of the surface should be carried out mechanically by wire brush or power wire wheel, and then chemically by carbon tetrachloride.

Operation Sheet 1	Inspecting and maintaining Weld records

Techniques for Inspecting and maintaining Weld records

Step1. Safety (clean work area &wear PPE)

Step2. Prepare tools and equipment.

Step3. Select inspection method.

Step4. Check the weld

Step5. If the weld does not correct.

Step6. Re-weld the joint

Step9. Record the document.

Step10. Clean the work area.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 4 hour.

Task 1. Inspecting, maintaining, and recording Weld joint.

Task 2. Clean work area.

Task 3. Clean work area free from accident

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