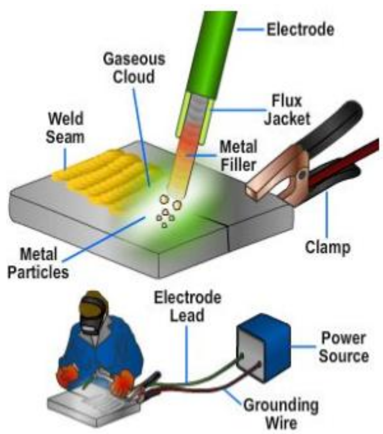
Welding Level-II

Based on March 2022, Curriculum Version I



Module Title:-Performing Fillet Shielded Metal Arc Welding (SMAW)

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Nominal duration: 100 Hours

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Acknowledgment

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Acronyms

ANSI	American National Standards Institute
AWS	American Welding Society
DCEN	Direct Current Electrode Negative
DCEP	Direct Current Electrode Positive
HAZ	Heat Affected Zone
MMAW	Manual Metal Arc Welding
MSDS	Material Safety Data Sheets
OSHA	Occupational Safety and Health Administration
SMAW	Shielded Metal Arc Welding
WPS	welding Procedure and Specification

Introduction to the Module

Manual metal arc welding (MMA or MMAW), shielded metal arc welding (SMAW) informally as stick welding, is an electric arc welding process in which an electric arc between a covered metal electrode and the work generates the heat for welding. The filler metal is deposited from the electrode, and the electrode covering provides the shielding. Some slang names for this process are "stick welding" or "stick electrode welding'.

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

It dominates other welding processes in the maintenance and repair industry, and though flux-cored arc welding is growing in popularity, SMAW continues to be used extensively in the construction of heavy steel structures and in industrial fabrication. The process is used primarily to weld iron and steels (including stainless steel) but aluminum, nickel and copper alloys can also be welded with this method.

This module is designed to meet the industry requirement under the welding occupational standard, particularly for the unit of competency: Perform shielded metal arc welding.

This module covers the units:

- SMAW Tools and Equipment
- Set-up welding machine and accessories,
- Set-up pre heating tools/ equipment,
- Tack welding,
- SMAW welds,
- Remove defects and re-welding
- Weld Quality Conformance

Learning Objective of the Module

- Prepare SMAW Tools and Equipment
- Set-up welding machine and accessories
- Set-up pre heating tools/ equipment
- Perform tack welding
- Perform SMAW welds
- Perform Remove defects and re-welding
- Assure Weld Quality Conformance

Module Instruction

1. For effective use this modules trainees are expected to follow the following module instruction:
2. Read the information written in each unit
3. Accomplish the Self-checks at the end of each unit
4. Perform Operation Sheets which were provided at the end of units
5. Do the “LAP test” given at the end of each unit and
6. Read the identified reference book for Examples and exercise

Unit one: SMAW Tools and Equipment
This unit is developed to provide you the necessary information regarding the following content coverage and topics: ❖ Weld work with industry standards ❖ Correct size, type and quantity of materials/ components ❖ Material preparation ❖ Assembling /aligning materials to specification ❖ Welding machine and its accessories ❖ Tools and equipment ❖ Safe work area for welding processes 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 Weld work with standards • Determine correct size, type and quantity of materials/ components • Prepare materials correctly • Assemble /align materials to specification • Identify welding machine and its accessories • Prepare tools and equipment appropriate to the work requirements • Ensure safe work area for welding processes

SMAW Tools and Equipment

1.1. Weld work with industry standards

Symbols for indicating welded joints on engineering drawings were originally devised by individual drawing offices to provide more useful information than a simple arrow with the instruction 'weld here'. This practice was obviously unsatisfactory, especially when drawings were passed from one company to another and, to solve this problem, the numerous symbols in existence were rationalized to some extent by countries compiling their own standard specifications for welding symbols.

The American system of symbolization is the AWS system, formulated by the American Welding Society (AWS). All AWS standards comply with the requirements of the American National Standards Institute (ANSI) and are designated ANSI/AWS. This system became widely used throughout the world, mainly because of the oil industry, and today is used by approximately half the world's welding industry. The rest of the world uses the ISO system, designed by the International Organization for Standardization (ISO). However, a number of countries, particularly those with wide trading links, may use one system in their own country but need to use the other to satisfy the requirements of an overseas customer.

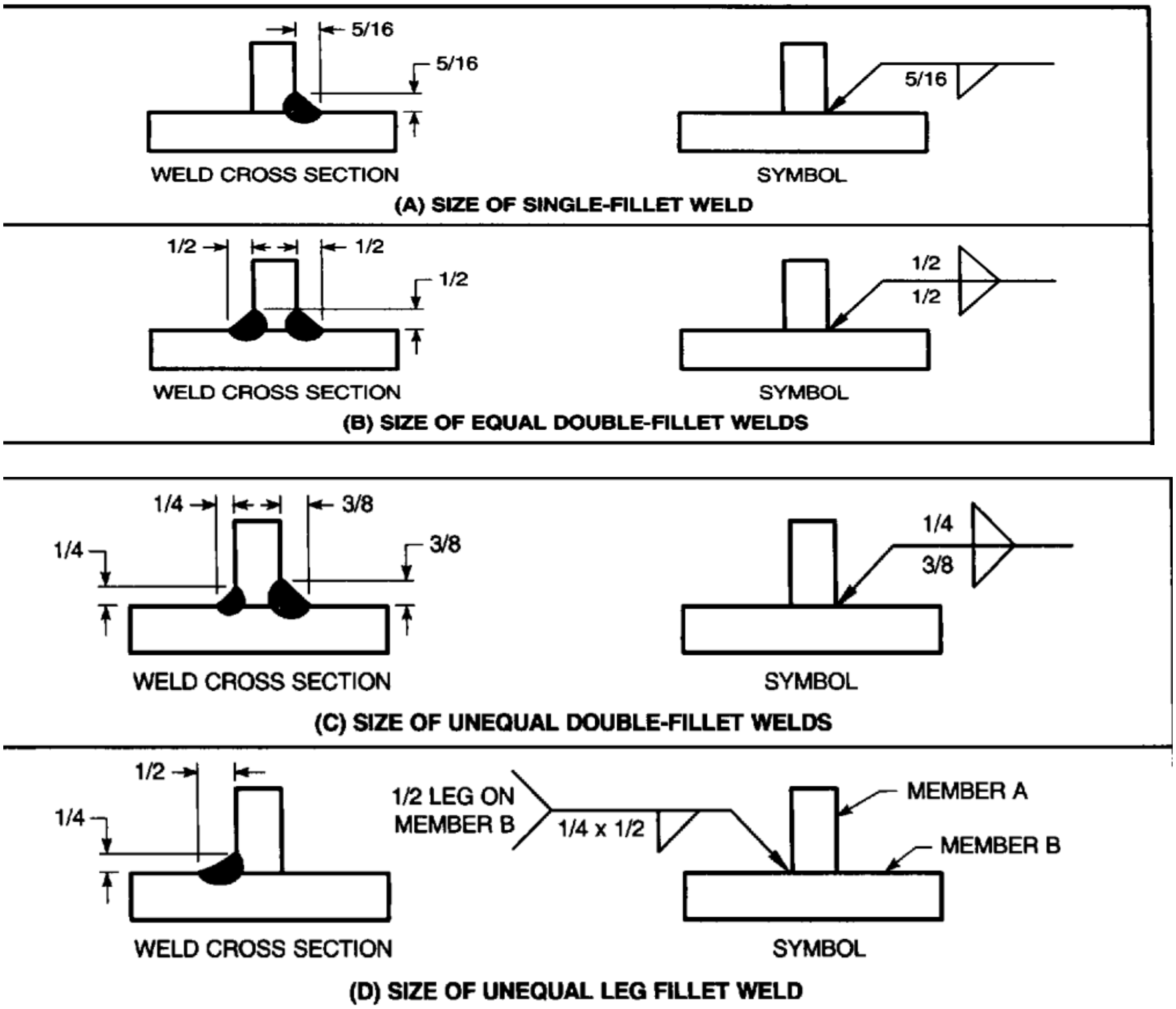
Engineering drawings are descriptions of manufactured objects in terms of shape, Surface, finish and material. In many industries it is customary to draw the shape of the component without indicating how that shape is achieved. The drawing is a description of a requirement produced by the designer for the instruction of the manufacturer.

In theory, the manufacturer knows best how to produce an object with the resources he has. In practice, of course, the designer compromises and produces designs which are capable of production by the techniques, of which he is aware. For example, a round hole can be drilled, bored or punched and can be finished by reaming, but whichever method is used, the lines on the drawing are the same and whichever method is used, the material is not changed in its characteristics.

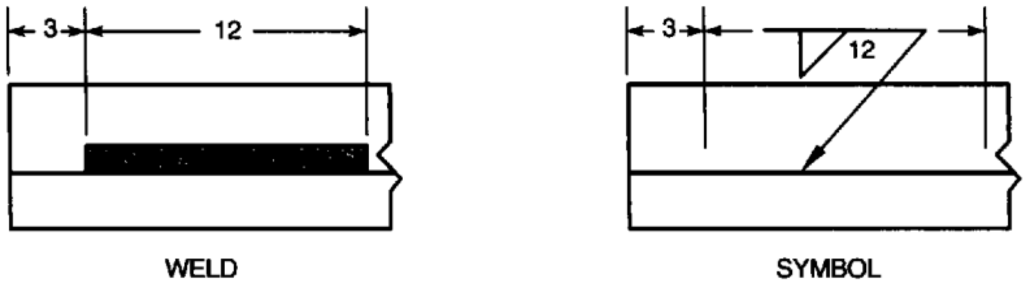
A welded joint offers a range of considerations which do not arise in other forms of manufacture. Firstly, there are far more techniques for making a welded joint than in many other manufacturing operations.

This means that the designer has far less chance of foreseeing the manufacturer's methods. Secondly, the properties and integrity of the joint will depend on the manner in which the weld is made despite this; the designer can still indicate the type of joint he requires. This provided that he is prepared to accept that he may not be able to completely define the joint in the earlier stages of a design.

In some industries it is customary for the manufacturer to produce shop drawings which contain details of weld preparations and reference to established welding procedures not shown in detail on the designer's drawings. The range of British Standard symbols which can be used on a drawing to indicate a weld detail are described here.



(E) CONTINUOUS FILLET WELD



(F) LENGTH OF FILLET WELD

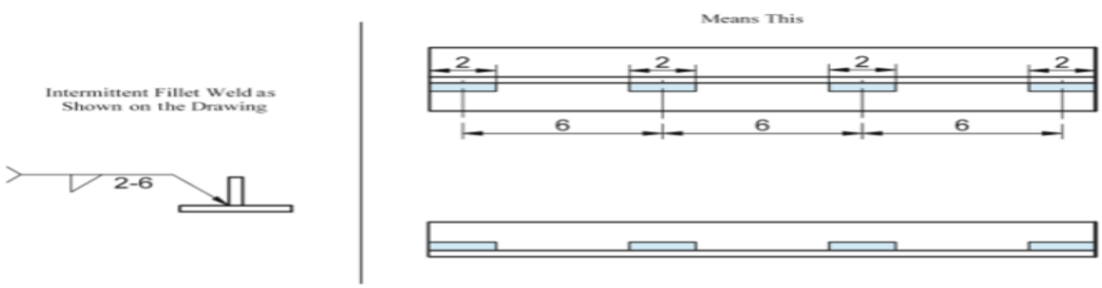


Fig Intermittent Weld

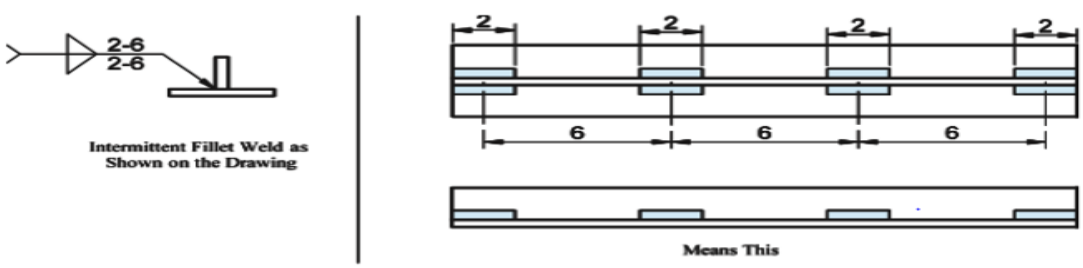
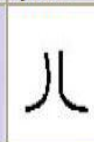
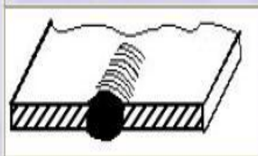
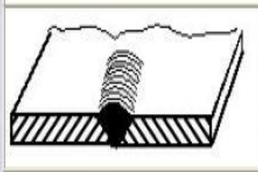
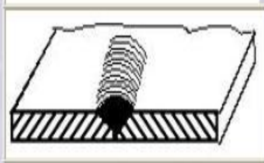
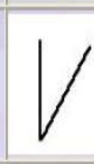
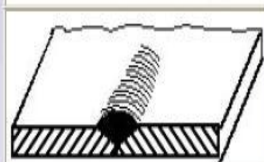
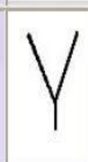
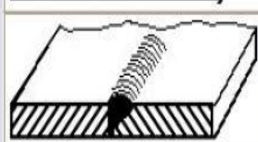
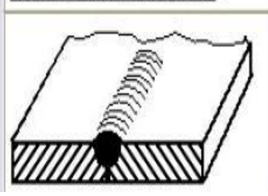
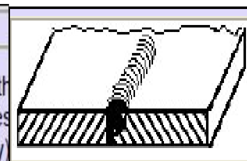
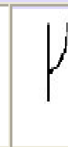
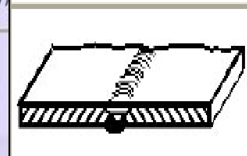
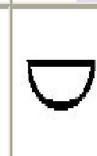
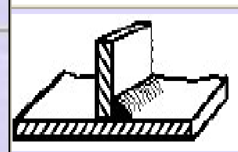
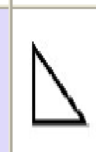
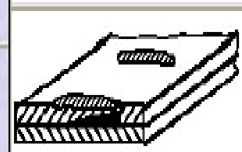
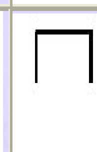
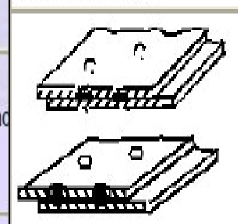
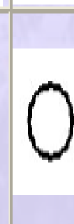
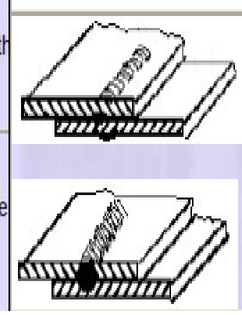
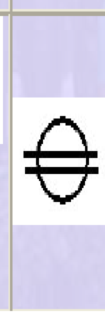
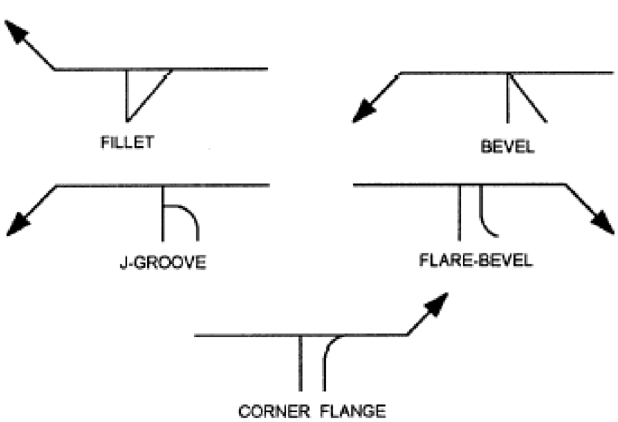


Fig Chain Intermittent Weld

Fig.1.1. Shielded metal arc welding Symbols.

Illustration (Fig)	Symbol	Description
		Butt weld between plates with raised edges*(the raised edges being melted down completely)
		Square butt weld
		Single-V butt weld
		Single-bevel butt weld
		Single – V butt weld with broad root face
		Single – bevel butt weld with broad root face
		Single – U butt weld (parallel or sloping sides)
		Single – J butt joint
		Backing run; back or backing weld
		Fillet weld
		Plug weld; plug or slot weld
		Spot weld
		Seam weld



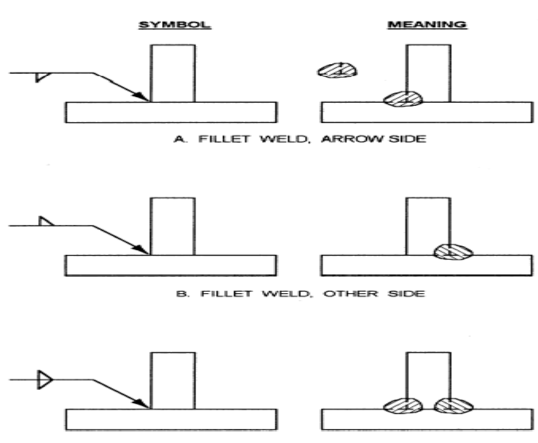


Fig.1.2. Weld symbols applied to reference line   Fig.1.3. Specifying weld locations

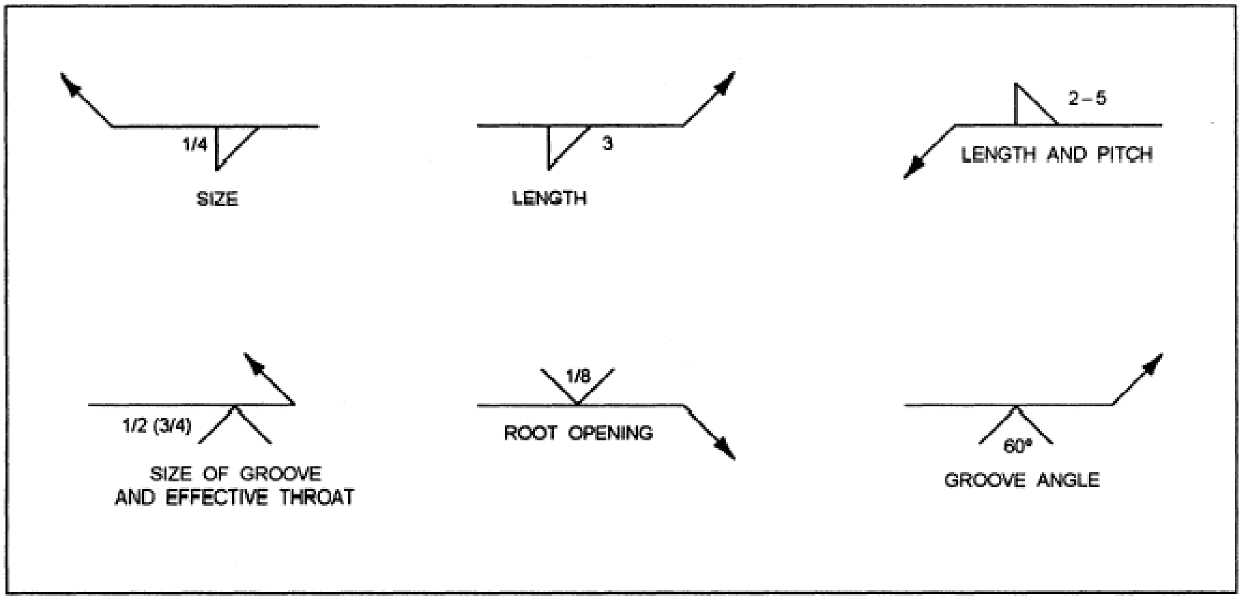


Fig.1.4. Dimensions applied to weld symbols.

Explanation for Standard Weld Symbols

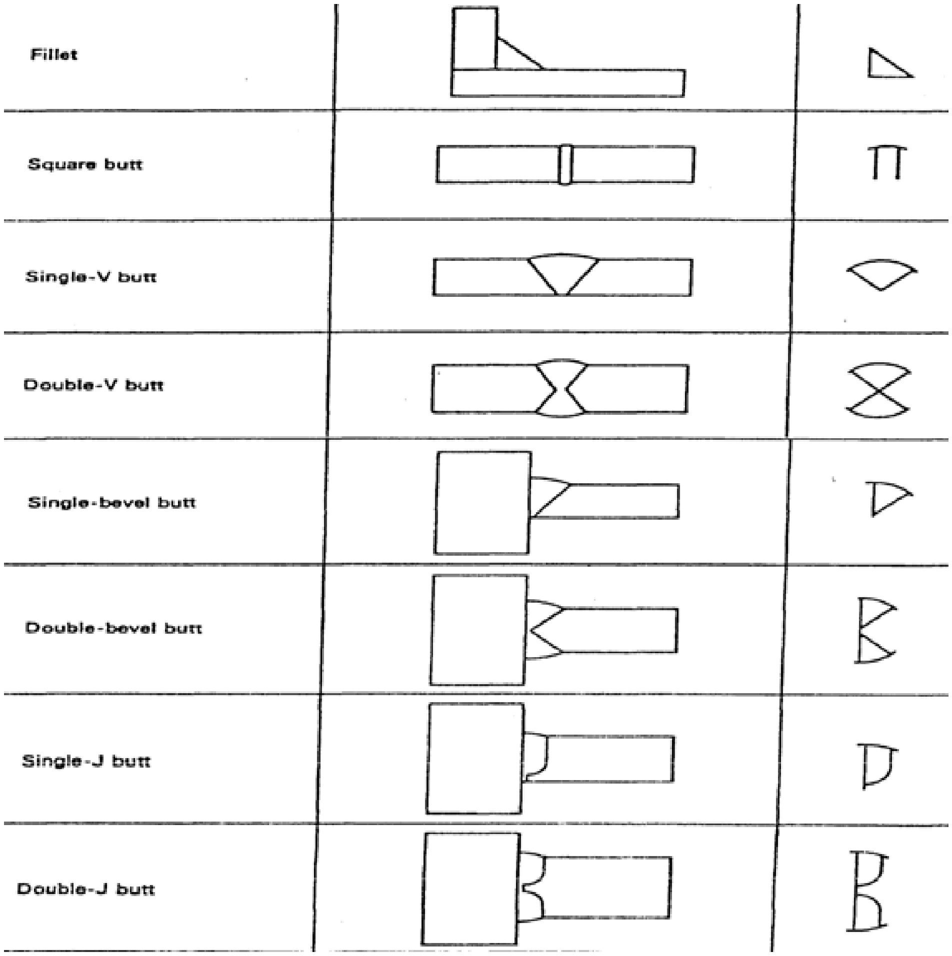


Fig .1.6. Standard Weld Symbols

1.2. Correct size, type and quantity of materials/components

- Materials for manual metal arc welding (MMAW)

Before you set up your welder and strike an arc, you'll need to first prepare your metal for welding. Sometimes you'll need to make a quick cut and other times you'll need to make a long cut through thick metal. No matter how long or thick your metal, you'll also need to clean the joint where you plan on welding.

Thermal cutting, shearing, sawing, blanking, nibbling, and machining are method used to cut blanks from stock material. The selection of the appropriate method is depending on the available material and equipments and the relative costs.

The quality of the edge needed for good fit-up and the type of edge preparation for groove welds must be kept in mind. The following points should also be considered when preparing material for welding:

1. Dimension of a blank may require a stock allowance for subsequent edge preparation,

2. The detail of the welded joints must be considered when laying out a blank with the intent to cut and prepare the edge for welding simultaneously,

3. Weld metal costs can be reduced for thick plate by specifying J- or U- groove preparations, and

4. Air carbon arc gouging, oxygen gauging, or chipping should be contemplated for back weld preparation.

Quantity Calculations

A. The *Basis of Estimates Manual* describes the method of measurement, basis of payment and required rounding accuracy for frequently used items. Calculate quantities to one additional decimal place of precision compared to input.

B. Calculate quantities by construction phase for each individual component e.g. end bents, deck, traffic and pedestrian railings, expansion joints, bearings, reinforcing steel, riprap, slope pavement, etc. For multiple adjacent bridges, whether built in phases or at the same time, include quantities and quantity breakdowns with the individual bridge they are associated with. For adjacent bridges with continuous slope treatments or other similar features, e.g. median separated bridges, clearly indicate the quantity breakdowns for each bridge in the plans. For pay items with a sub-unit measurement, calculate the sub-units, and include the quantity in the plans only if required by the *Basis of Estimates Manual*.

Classification and Uses of Metals

a) Ferrous metals

Ferrous metals may be defined as those metals whose main constituent is iron such as pig iron, wrought iron, cast iron, steel and their alloys. They are usually stronger and harder and are used in daily life products.

They possess a special property that their characteristics can be altered by heat treatment processes or by addition of small quantity of alloying elements. Ferrous metals possess different physical properties according to their carbon content.

Ferrous metal ("ferrous" = containing iron and alloys)

1. Iron.

a. Rare in the pure state; pure iron is not used commercially.

2. Wrought iron.

a. Contains:

(1). Iron, alloyed (combined) with,

(2). Less than 0.03% carbon.

b. True wrought iron is scarce and expensive.

c. True wrought iron forges well, can be easily bent hot or cold and can be welded.

d. "Wrought iron" is currently used to refer to almost any malleable low carbon steel.

3. Carbon steels, or "steel".

a. Contains:

(1). Iron, alloyed (combined) with,

(2). Carbon,

(3). Less than 1.65% manganese,

(4). Less than 0.60% copper, and

(5). Smaller amounts of silicon, sulfur and phosphorous.

b. Types:

(1). Low-carbon ("mild") steels

(a). Between 0.05% and 0.30% carbon.

(b). Tough and ductile. Easily formed, machined and welded.

(c). Most commonly used of the carbon steel types.

(2). Medium-carbon steels

(a). Between 0.30% and 0.45% carbon.

(b). Strong and hard, but less ductile.

(c). Not as easily welded, due to tendency to crack after welding.

(d). Used for gears.

(3). High-carbon steels

(a). Between 0.45% and 0.75% carbon.

(b). Very hard and strong, less ductile.

(c). Special electrodes and welding procedures are required, to prevent brittleness and cracking.

(d). Used for cold chisels and hammers.

(4). Very-high-carbon steels

(a). Between 0.75% and 1.5% carbon.

(b). Super hard and strong.

(c). Seldom welded; special electrodes and procedures used.

(d). Used for tools and springs.

(e). Can be used for items that must be hardened and tempered, below for definition of these terms).

4. Rolled steels.

a. Bar, rod and structural steels produced by rolling the steel into shape, much like an old clothes wringer.

5. Galvanized steel.

a. Mild steel coated with zinc to prevent rusting.

b. Care should be taken not to inhale toxic fumes when welding this material.

b) Non-ferrous metals

Non-ferrous metals are those which do not contain significant quantity of iron or iron as base metal. These metals possess low strength at high temperatures, generally suffer from hot shortness and have more shrinkage than ferrous metals. They are utilized in industry due to following advantages:

1. High corrosion resistance
2. Easy to fabricate, i.e., machining, casting, welding, forging and rolling
3. Possess very good thermal and electrical conductivity
4. Attractive color and low density

The various non-metals used in industry are: copper, aluminum, tin, lead, zinc, and nickel, etc., and their alloys.

1.3. Material preparation

Weld Preparation

Before work pieces can be welded by means of gas fusion welding or arc welding, the weld edges must be cleaned. Oil, wax layers, paint or scale must be removed. The welding points must also Sand blasting be metallically clean, as without these preparations the welds would not last.

Lathing and other mechanical (chip removal) methods are very suitable methods for cleaning the welding points. Attention must be paid to ensuring that the tools always have sharply ground cutting edges. Avoid lubricating the metal. Therefore, no coolants or lubricants may be used.

If weld preparation is carried out on aluminum, attention must be paid to ensuring that the abrasive has been explicitly approved or recommended for aluminum by the manufacturer is also a possible method for preparing the weld. However, in this case attention must be paid to ensuring that the blasting material (grit or shot) is appropriately matched with the material to be welded. The manufacturers usually provide relevant information.

Manual cleaning is also a possible method for preparation of the weld. Only stainless steel brushes should be used for this. Other brushes can cause inclusions of carbon steel to occur in the parent metal. The diameter of the wire should be between 0.1 and 0.25mm. If the wires are too thin they smear the dirt and if they are too thick they cause deep scratches on the surface or edge to be welded.

Milling is also a very good variant of weld preparation, as very clean edges result. On request, at this stage chamfers in diverse sizes and angles can be machined on the weld edge. This makes it easier for the welder to join assemblies.

1.4. Assemble/align materials to specification

Welding is a well-known and widely-used method used to permanently join together two pieces of metal tubing or other weldable material. To accomplish a weld of high integrity, the two pieces to be joined together must be properly aligned.

Misalignment during welding creates discontinuities at the abutment junction of the two pieces of weldable material that can serve as havens for particle impurities. The existence of these particle "sites" is intolerable when the welding is being performed in connection with ultra-pure applications such as are common in the semiconductor industry.

Moreover, misalignment can result in a leaky junction that destroys the purity of the substance flowing through the tubing and creates a potentially dangerous external environment if the substance flowing through the tubing is toxic. Thus, it is highly desirable to minimize tube misalignment when welding.

Maintaining proper alignment during the conventional welding process, however, is a time-consuming and difficult task. The pieces of weldable material to be aligned and welded must be clamped tightly in alignment before and during the welding process, or the pieces will tend to slip out of alignment before the weld is completed.

The most common tools used to lay out and check joint fit-ups are straightedges, squares, levels and Hi-lo gauges.

Straightedges are used to mark straight lines and check joint alignment.

Many have calibrations along their length for measuring.

Straightedges, particularly longer ones, are typically fabricated on the job from small channel or angle iron.

Components which are to be united by butt welding are to be aligned as accurately as possible.

Sections welded to plating shall be left un-welded at the ends for this purpose. Special attention shall be paid to the alignment of (abutting) girders which are interrupted by transverse members. If necessary, such alignment shall be facilitated by drilling check holes in the transverse member which are subsequently closed by welding.

Alignment Methods

Members to be welded shall be brought into correct alignment and held in position by bolts, clamps, wedges, guy lines, struts, and other suitable devices, or by tack welds until welding has been completed. The use of jigs and fixtures is recommended where practicable. Suitable allowances shall be made for warpage and shrinkage.

General Alignment Considerations

Types of Misalignment Parallel/Bore Misalignment Parallel or bore misalignment occurs when centerlines of driven equipment and engine are parallel but not in the same plane. Refer to Figure 1.7.

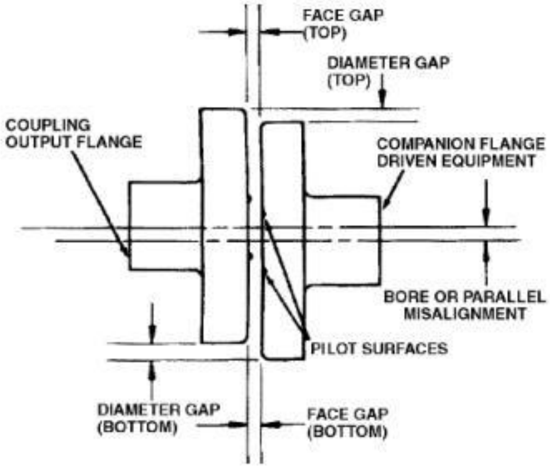


Fig.1.7. parallel misalignment

Butt Joint Alignment, Parts to be joined at butt joints shall be carefully aligned. Where the parts are effectively restrained against bending due to eccentricity in alignment, an offset not exceeding 10% of the thickness of the thinner part joined, but in no case more than 1/8 in. (3 mm), shall be permitted as a departure from the theoretical alignment. In correcting misalignment in such cases, the parts shall not be drawn in to a greater slope than 1/2 in. (13 mm) in 12 in. (305 mm). Measurement of offset shall be based upon the centerline of parts unless otherwise shown on the drawings.

Alignment Tools

Laser Alignment Tools Note: The laser alignment tools typically measure the actual offsets. The dial indicators measure a total indicator reading (TIR). Follow all the instructions that are provided by the manufacturer in order to ensure that the parallel misalignment and the angular misalignment are within the specifications.

Typically, the laser alignment tools compensate for any axial movement of the rotor shaft for the generator or the crankshaft. If the axial shaft moves during the angular measurements, consult the literature on the laser alignment tool for information.

Pipe pieces held in place for welding

The pipe pieces must be secured in a manner that keeps the root edges in alignment, while maintaining a consistent root opening. If the inside edges of the pipe are not aligned, it will be difficult to maintain complete joint penetration through the full length of the weld.

At the same time, if the root opening is narrower on one side of the pipe and wider on the other, it is difficult to control both fusions in the narrow opening and to eliminate excessive melt-through of the wider opening.

To ensure proper alignment on the job, one technique uses pipe clamps. These allow for precise alignment, fitting up the pipe for welding. Many commercial styles of both internal and external pipe clamps are available. These are often cost prohibitive in small school's shops. In this case, other alternatives exist. Angle iron or channel iron can be used for alignment, with the addition of a clamping mechanism

Fig.1.8 Channel Iron Used for alignment.

Angular/Face Misalignment

Angular or face misalignment occurs when centerlines of driven equipment and engines are not parallel. Refer to Figure 1.9.

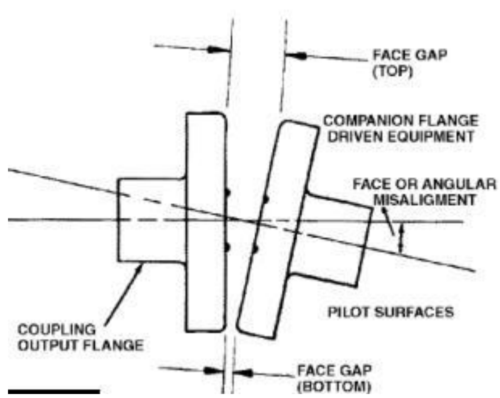


Fig.1.9. Misalignment

NDT of Weldments-Misalignment (WPG)

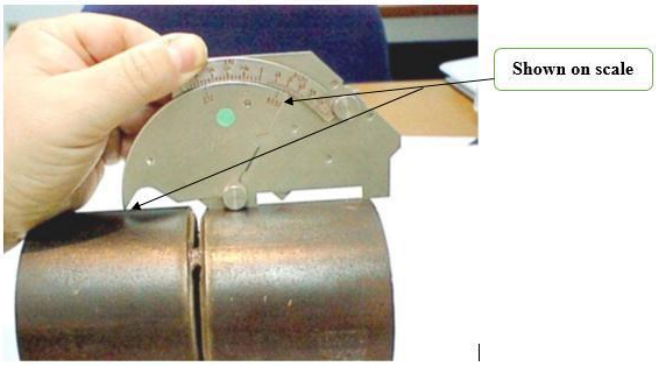


Fig.1.10. weldment Misalignment

Inaccurate Flanges

Inaccurate flanges cause apparent misalignment and make accurate alignment impossible.

Face run out refers to the distance the hub face is out of perpendicular to the shaft centerline. Refer to Figure 1.11.

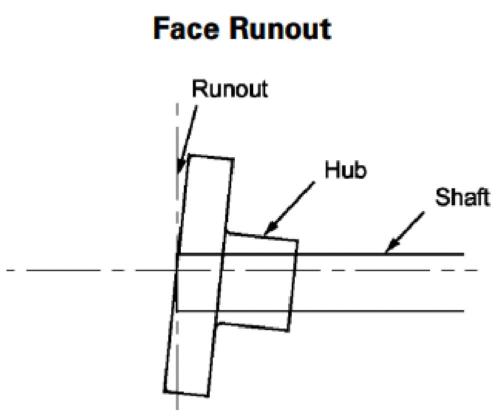


Fig.1.11. Inaccurate Flanges

- Squares

Two types of squares are used for layout: pipefitter’s square and a combination square.

Pipefitter’s square is used to measure angles and check square ness.

Combination squares are smaller with blades typically 12” or 18” long.

They have replaceable attachments that slide along the blade.

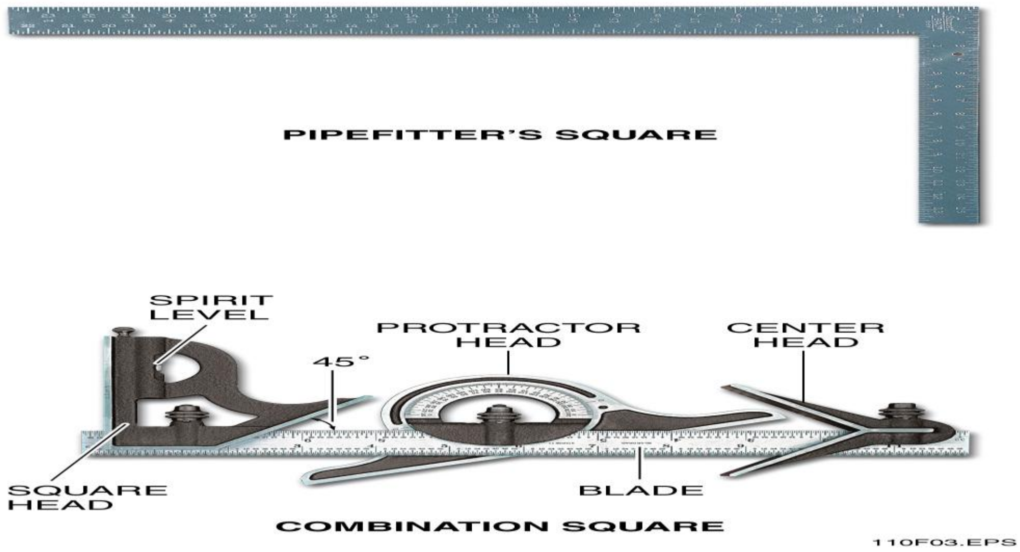


Fig1.12. Squares

- Levels

✓ Levels come in a variety of sizes and shapes.

✓ Some have magnetized bases.

✓ Levels are used to check that layouts are level (horizontal) and plumb (vertical).

✓ Levels use a bubble in a glass vial to check level and plumb.

✓ Centering the bubble between the lines marked on the vial indicates level or plumb.

✓ Some levels have a 45 degree vial.

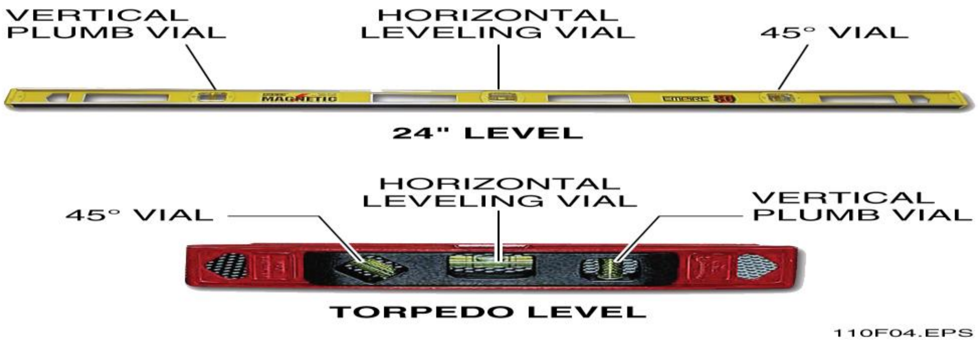


Fig.1.13. Level

- Hi-Lo Gauges

The primary purpose of a Hi-Lo gauge is to check for pipe joint misalignment.

The name of the gauge comes from the relationship between the alignments of one pipe to the other pipe, which is called high-low.

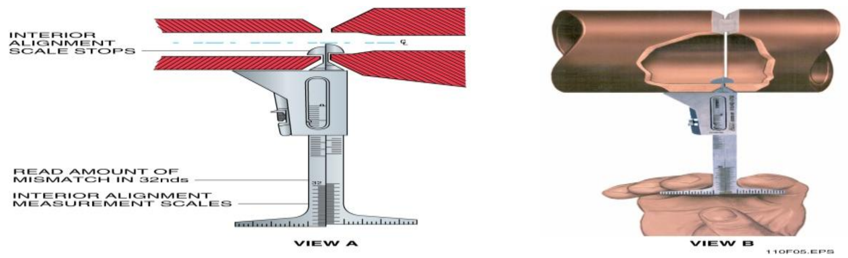


Fig.1.14. Hi-Lo Gauges

1.5. Welding machine and its accessories

- Welding machine

Arc welding machines are equipments that provide current to produce an electric arc when the electrode is struck on the work pieces.

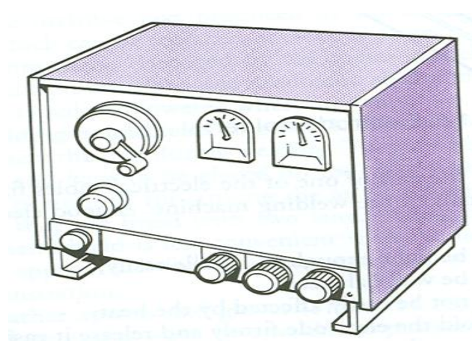


Fig.1.15. Arc welding machine

The three basic types of arc welding machines are;

Power to run these welding machines may come from regular electrical lines or from gasoline or diesel engines.

The gasoline or diesel engines are especially useful for fieldwork where electrical power is not available.

1) The motor generator welding machines
2) The transformer (AC) welding machines

3) The rectifier welding machines

1. **The motor generator (DC) welding machines:-**

Motor generators are designed to produce DC current in either straight or reverse polarity.

The polarity selected for welding depends on the kind of electrode used and the material to be welded. A switch on the machine can be turned for straight or reverse polarity.

Present day motor generators for manual stick welding are usually of the constant current, dual control type.

2. 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.

The transformer type of welding machine produces AC current and is considered to be the least expensive, lightest, and smallest machine.

It takes power directly from a power supply line and transforms it to the voltage required for welding.

3. The rectifier welding machines:-

Rectifiers are essentially transformers containing an electrical device, which changes alternating current into direct current.

Some types are designed to provide a choice of low voltage for gas metal arc welding and submerged-arc welding, and others are designed for a high open circuit with drooping voltage characteristics for gas tungsten arc welding and shielded metal-arc (stick) electrode welding.

Rectifier welding machines are also available to produce both DC and AC current.

By turning a switch the output terminals can be changed to the transformer or to the rectifier and produce either AC or DC straight or reverse polarity current.

a) Accessories

- Electrode Holder

- ✓ An electrode holder, commonly called a stinger, is a clamping device for holding the electrode securely in any position.
- ✓ To do a good welding job, a properly designed electrode holder is essential.
- ✓ The electrode holder is a handle-like tool attached to the cable that holds the electrode during welding. See Figure (1.16)

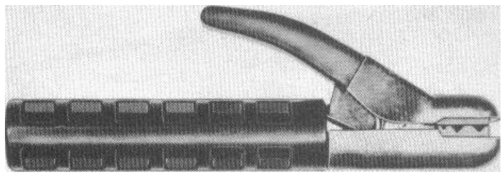


Figure.1.16. The electrode holder grips the electrode at the correct angle for welding.

- Cables

Welding the cables carry the current to and from the work piece.

One cable runs from the welding machine to the holder, and the other cable is attached to the work or bench, the cable connected to the work is called the ground cable.

Thus when the welding machine is turned on and the electrode in the holder comes in contact with the work, a circuit is formed, allowing the electricity to flow.

- Ground Connections

Ground clamps are used to complete the welding circuit. They may be a spring-loaded clamping device, a magnetic clamp, a C-clamp device or a lug welded to the work and then securely attached to the end of the work lead cable. Regardless of the type of ground clamp used, it is very important that you have a clean, tight connection.

Proper ground connections can be made in several ways.

The ground cable can be fastened to the work or bench by a C clamp, a special ground clamp, or by bolting or welding the plug on the end of the cable to the bench.

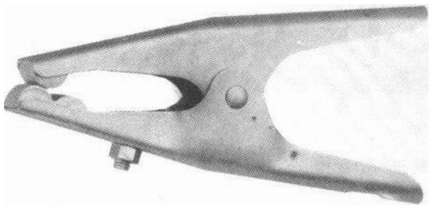



Fig.1.17. A Spring-loaded work lead clamps.

1.6. Preparation of tools and equipment

1) Chipping hammer: - is used to remove the slag from the weld. It has two striking ends, a pointed end and a flat end that runs parallel to the handle.

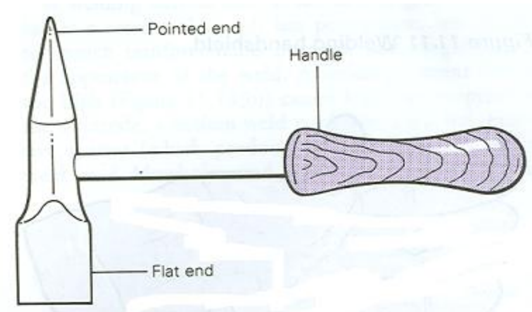


Fig.1.18 .Chipping hammer

2) 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.

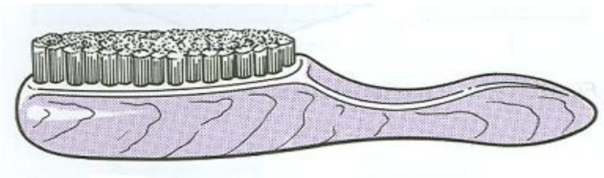


Fig.1.19. Wire brush

3) 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. It has the following parts:-

1. Handles
1. Pin and
2. Jaws

There are varieties of Tongs designed to grip different types of work pieces with various shapes.

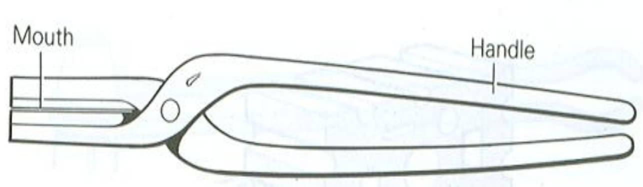


Fig.1.20. Close mouth tong

1.7. . Safe work area for welding processes

Welding can be safe when sufficient measures are taken to protect yourself and others from potential hazards

- A welder MUST always follow safe work practices:

Students should read and understand the following before welding:

- ✓ Warning Labels
- ✓ Material Safety Data Sheets (MSDS)

- Understand and follow all warning labels found:

- ✓ *On welding equipment*
- ✓ *With all consumable packaging*
- ✓ *Within instruction manuals*

- Arc Welding Safety

- Protect yourself and others from potential hazards including:

- ***Fumes and Gases***
- *Electric Shock*
- *Arc Rays*
- *Fire and Explosion Hazards*
- *Noise*
- *Hot objects*

- Fumes and Gases
- Fumes and gases can be hazardous to your health
- Keep your head out of the fumes
- Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from your breathing zone and the general area
- See product labeling and MSDS for ventilation and respirator requirements
- Electric Shock

- **Electric shock can kill**

Do not make repairs yourself, alert your instructor immediately!

- Do not touch live electrical parts
- Primary Voltage –230, 460 volt input power
- Secondary Voltage – 6 to 100 volts for welding
- Insulate yourself from work and ground
- Follow all warnings on welding equipment
- **Arc Rays**
- Arc rays can injure eyes and burn skin
- The welding arc is brighter than the sun
- Precaution must be taken to protect your eyes and skin from UV radiation
- Wear correct eye and body protection

- **Fire and Explosion Hazards**

✓ Welding sparks can cause fires and explosions

✓ Sparks and spatter from the welding arc can spray up to 35 feet from your work

✓ Flammable materials should be removed from the welding area or shielded from sparks and spatter

✓ Have a fire extinguisher ready

✓ Inspect area for fires 30 minutes after welding

- Noise

✓ Loud noises can damage your hearing

✓ Keep loud noises at a safe level by using proper hearing protection such as:

  - *Ear plugs*
  - *Ear muffs*

Self check-1

Directions: Answer all the questions listed below.

I. Say true or false

1. Milling is not good variant of weld preparation.
2. Grinding is very suitable methods for cleaning the welding points.
3. The diameter of the wire should be between 0.1 and 0.2mm.
4. The pieces of weldable material to be aligned and welded must be clamped tightly in alignment before and during the welding process.
5. The primary purpose of a Hi-Lo gauge is to check for plate joint misalignment.
6. To accomplish a weld of high integrity, the two pieces to be joined together must be properly aligned.

II. Choose the best answer

1. Which of the following is the other name of shielding metal arc welding?

   A. Manual metal arc welding C. Submerged arc welding

   B. Stick welding D. A and B

2. Which one of the following is not the function of electrode coating?

   A. Provide deoxidizers and scavengers C. Produce shielding gases

   B. decrease deposit rate D. Produce a slag covering

3. E7043—H, what position is the number 4 indicates

   A. All position C. vertical position

   B. Flux type D. hydrogen

4. From the following one is the range to diameter of electrode

   A. 2 mm to 8 mm C. 200 mm to 500 mm

   B. 250 mm to 450 mm D. 3 mm to 7 mm

III. Match Column "A" with Column "B"

"A"	"B"
_____1. Welding accessories	A. Injure eyes and burn skin
____2. Damage your hearing	B. Chipping hammer
_____3. Arc rays	C. Noise
	D. Electrode holder

Operation Sheet 1

1. Operation Title: Preparing materials for welding.
2. Instruction: prepare all materials, welding tools and equipments for welding operation.
3. Purpose: Acquire knowledge and skills, how to select materials and prepare safe work area for SMAW welding operation procedures.
4. Required tools and equipment:
   - SMAW welding machine with accessories
   - Mild steel plate
   - Tong
   - Chipping hammer
   - Personal safety equipments : Like goggles, glove,apron etc
5. Precautions: Apply welding safety regulation.
6. Procedures:
   - Step1. Safety (clean work area &wear PPE)
   - Step2. Select proper tools and equipment.
   - Step3. Identify materials.
   - Step4. Prepare material based on the required
   - Step5. Align joints using d/t aligning method
   - Step6. Set up welding machine on stable position
   - Step7. Adjunct the welding machine based on the material weld
   - Step8. Clamp the ground cable
   - Step9. Preform tack welding based on standards
   - Step10. Preform root pass
   - Step11. After finishing the work cleaning the work area.
7. Quality criteria: Functionality of selected tools and equipments.

LAP Test-1 Practical Demonstration

Name: _____________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 3 hour.

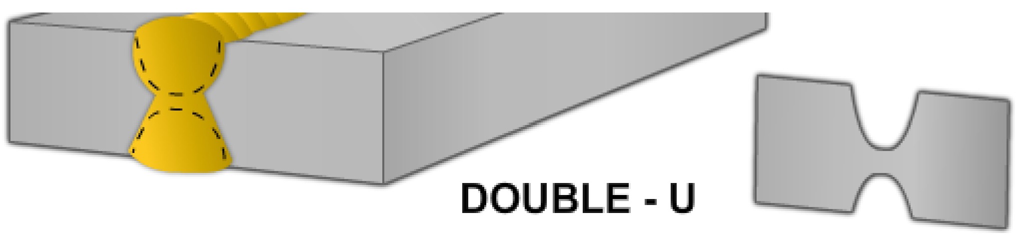
Task1. Identify materials

Task2. Prepare materials

Task3. Assemble/align welding materials.

Project

Project name: -double –u grooved butt joint



Key

The base metal is mild steel plate

W*L:-40*40mm*10mmt

Unit Two: Set-Up Welding Machine and Accessories

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

- Welding machine settings, accessories, fixtures and consumables
- welding machine connection
- current and voltage adjustment
- Braces, stiffeners, rails and other jigs
- Appropriate distortion prevention measures

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 accessories, fixtures and consumables
- Connect welding machine to an independent power supply and wired up
- Adjust current and voltage consistent with work requirements
- Provide braces, stiffeners, rails and other jigs.
- Select appropriate distortion prevention measures for weld and material type

Set-up welding machine and accessories

2.1. Accessories, fixtures and consumables

2.1.1. Welding machine settings

Before starting any welding operation welding machine should be correctly setting up. The work is connected to the source of electrical supply (welding set). The electrode holder, held by the operator, is connected to the same source. The electric arc completes the circuit. The arc will not start until the electrode touches the work. This completes the circuit.

1. Turn power supply on
2. Connect work clam
3. Select electrode
   a. Type
   b. Diameter
4. Adjust output
   a. Polarity

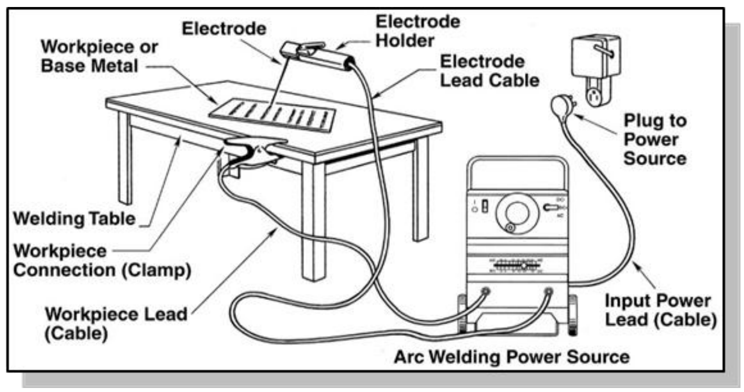


Fig.2.1.welding machine set up

5. Choose the correct polarity to match the type of electrode you are using.

   b. Amperage

6. Set the current to suit the size of electrode that you have chosen or the thickness of the metal that you are welding.

6. Insert electrode into electrode holder

7. Set the current to suit the size of electrode that you have chosen or the thickness of the metal that you are welding.

2.1.2. Fixtures and Jigs

Fixtures and jigs are devices used to hold the parts to be welded in proper relation to each other. This alignment is called fit-up. Good fit-up is required for obtaining high quality welds. Poor fit-up increases welding time and causes many poor quality welds.

The size of the root opening has an effect on the speed at which the welding of the root pass can be accomplished. Root openings are used so that full penetration welds can be made. Root passes in joints with a proper root opening can be welded much faster than joints that have excessive root opening. Fixtures and jigs are used for three major purposes:

1. To minimize distortion caused by welding heat
2. To minimize fit-up problems
3. To increase the welding efficiency of the welder.

When a welder employs a welding fixture or jig, the components of a weldment can be assembled and securely held in place while the weldment is positioned and welded. The use of those devices is dependent on the specific application. These devices are more often used when a large number of similar parts are produced. Using fixtures and jigs, when possible can greatly reduce the production time for the weldment.

2.1.3. Cconsumables

The manual metal arc welding electrode consists of a core of wire surrounded by a flux coating. The wire is generally of similar composition to the metal to be welded. The flux is applied to the wire by the process of extrusion. For welding carbon and low alloy steels (the metals most commonly fabricated using the MMAW process) electrodes will have one of four flux types, either;

- cellulose type coating
- rutile type coating
- hydrogen controlled coating (low hydrogen)
- Iron powder type coating.

a) Functions of the flux coating

In the early days of arc welding, bare wire electrodes were used. The results obtained from these electrodes left much to be desired. Over the years, electrodes have improved and flux coatings have evolved to the stage where the deposited weld metal, in many cases, has better metallurgical properties than the parent metal.

The following are functions of Electrode Coating:

- To Provide Deoxidizers & Scavengers
- To Produce Shielding Gases
- To Produce a Slag Covering
- To Provide Mechanical and Physical Properties
- To Increase Deposit Rates

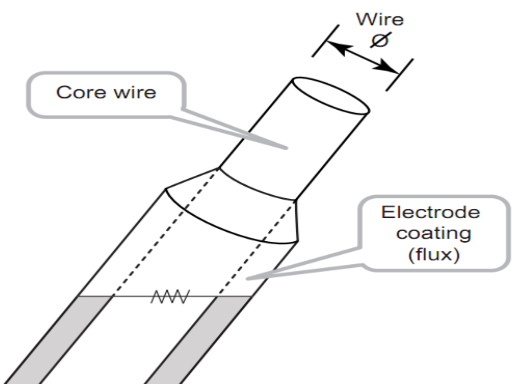
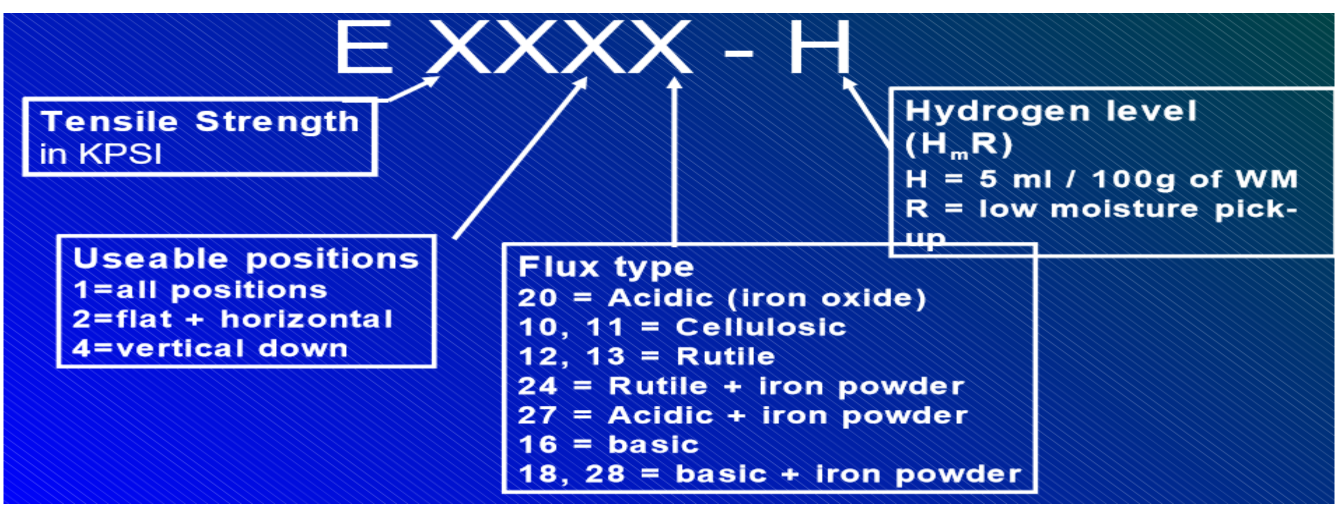


Fig. 2.2 electrode construction

Coating Core wire

- Extruded as paste, dried to strengthen
- Dipped into slurry and dried (rare)
- wound with paper or chord (obsolete

- Solid or tubular
- 2mm to 8mm diameter,
- 250 to 450mm long



Types of Flux

a. Cellulosic
b. Rutile
c. Basic

a, **Cellulosic Coatings**

As these electrode coatings are designed to operate with a definite amount of moisture in the coating, they are less sensitive to moisture pick-up and do not generally require a drying operation. However, in cases where ambient relative humidity has been very high, drying may be necessary.

b. **Rutile Coatings**

These can tolerate a limited amount of moisture and coatings may deteriorate if they are over dried. Particular brands may need to be dried before use.

c. Basic and basic/rutile Coatings

Because of the greater need for hydrogen control, moisture pick-up is rapid on exposure to air. These electrodes should be thoroughly dried in a controlled temperature drying oven. Typical drying time is one hour at a temperature of approximately 150 to 300 degrees C but instructions should be adhered to.

After controlled drying, basic and basic/rutile electrodes must be held at a temperature between 100 and 150 degrees C to help protect them from re-absorbing moisture into the coating. These conditions can be obtained by transferring the electrodes from the main drying oven to a holding oven or a heated quiver at the workplace.

a) Classification of Electrodes

Electrode: a coated metal wire having approximately the same composition as the base metal.

Electrodes are mainly classified into 5 main groups:

1) Mild steel - majority of welding
2) High carbon steel
3) Special alloy steel
4) Cast iron
5) Non ferrous - example Aluminum, Copper, & Brass

Standards are set by AWS (American Welding Society), ASTM (American Society for Testing Materials) & BIS (Bureau of Indian standards).

b) Mild steel electrodes

There are basically two kinds of mild steel electrodes:

(i) Bare: - Bare electrodes are still covered with little covering, this limits their use in the welding field.

(ii) Shielded (flux coated)

Shielded electrodes have a heavy coating on the outside of them (called flux).

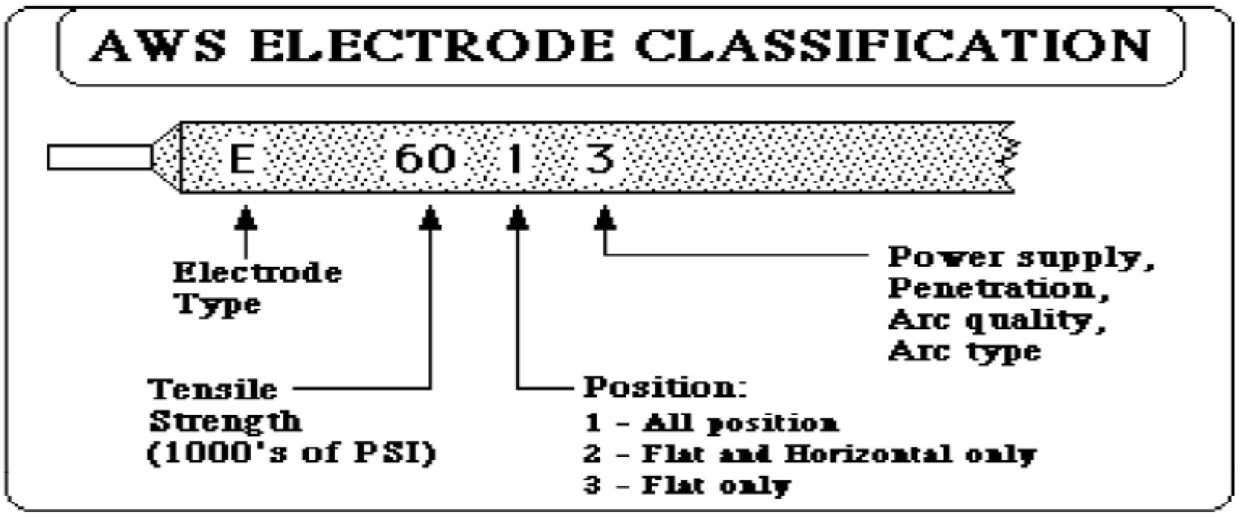


Fig. 2.3 Electrode Classification

The American Welding Society's (AWS) classification number series has been adopted by the welding industry. The electrode identification example below is for a steel arc-welding rod labeled E6010:

- "E" indicates "electrode" for electric arc welding
- The first two (or three in some cases) digits (60) indicate tensile strength in thousands of pounds per square inch.

Examples:

E60XX 60,000-psi Tensile Strength

E70XX 70,000-psi Tensile Strength

E110XX 110,000-psi Tensile Strength

- The third (or fourth in some cases) digit (1) indicates the position of the weld. An "O" indicates that this classification is not used; "1" is for all positions; "2" is for flat and horizontal positions only; 3 is for flat position only

1.8. Welding Machine Connection to an Independent Power Supply

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

Wiring Up or Setting to the Polarity

- Polarity indicates the direction of the Current in that circuit. Since the current moves in one direction only in DC welders, polarity is important because for some welding operations the flow of current must be changed.
- When the electrode holder cable is connected to the negative pole of the welding machine and the work to the positive pole, the polarity is direct current negative (DC) or more commonly referred to as straight polarity.

- If the electrode holder cable is connected to the positive pole of the welding machine and the cable leading to the work to the negative pole, the circuit is called direct current positive (DC +) or reverses polarity.

Three different Polarities in welding

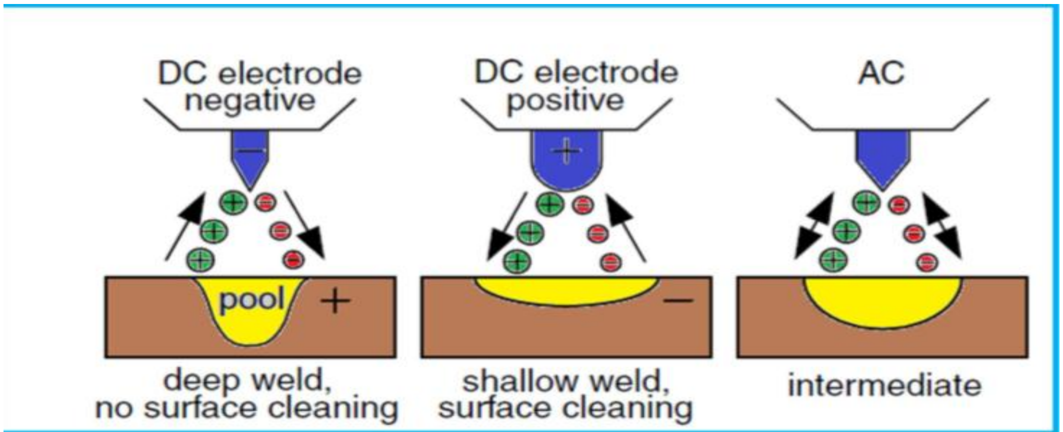


Fig. 2.4 different Polarities

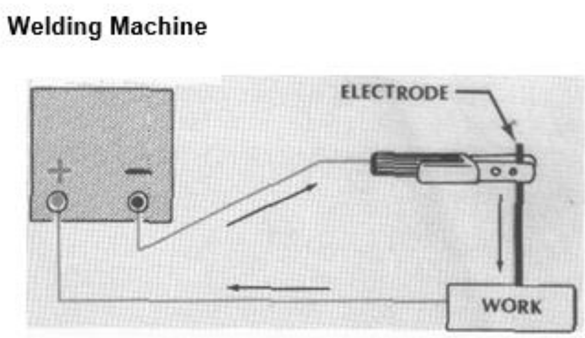


Fig 2.4 In the straight polarity circuit, current flows from the electrode to the work

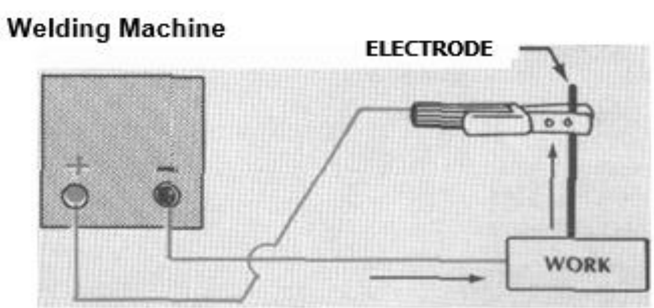


Fig.2.5. In the reverse polarity circuit, current flows from the work to the electrode.

1.9. Current and voltage adjustment

The basic operation of the SMAW process occurs when an electrical arc is established and maintained between a base material and an electrode. The molten weld pool is shielding from the atmospheric conditions by an envelope of shielding gas that is flowed continuously around both the wire filler metal feeding in the weld pool and the weld pool itself

The heat of the electrical arc serves to locally melt the base metal as well as melt the wire filler metal that is being fed into the weld. There are two entities at play in the SMAW process:

For a stable welding arc, the burn rate and feed rate need to equal each other. For instance, if the burn rate is higher than the feed rate, the wire filler metal would melt back to the contact tip and cause issues. With the exception of short circuit metal transfer, if the feed rate is higher than the burn rate, the wire filler metal would feed into the molten weld pool, again, causing issues.

There are four main variables of the SMAW process that affect both the penetration profile into the base material and weld bead profile above the base material for a given weld:

- Welding Current
- Welding Voltage
- Contact to Work Distance
- Travel Speed

The SMAW process commonly uses a constant voltage power source (SMAW-CV) that allows for a relatively constant welding voltage output over a range of welding currents. For SMAW, the wire feeder unit and an appropriate voltage on the welding power supply. The internal circuitry of the power source then supplies an appropriate amount of welding current necessary to maintain a stable arc. The SMAW process variables of current and wire feed speeds are interrelated so one cannot be independently adjusted without affecting the other by just altering the WFS selector setting on the power supply itself.

Welding Current

The variable of welding current primarily controls the amount of weld metal that is deposited during welding. As discussed earlier, the process variables of WFS and current are directly related so as one increase so does the other and vice versa.

Welds 1-5 demonstrate this relationship, holding all other variable constant, the WFS was incrementally increased from Weld 1 through Weld 5 which consequently increased the welding current. Remember, the welder sets the WFS not the current level on a SMAW-CV power supply, so the primary way of adjusting current is by adjusting the WFS

- **Current Too Low**

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

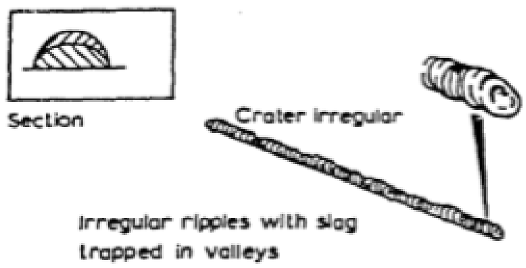


Fig 2.6 too low current

- **Current Too High**

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

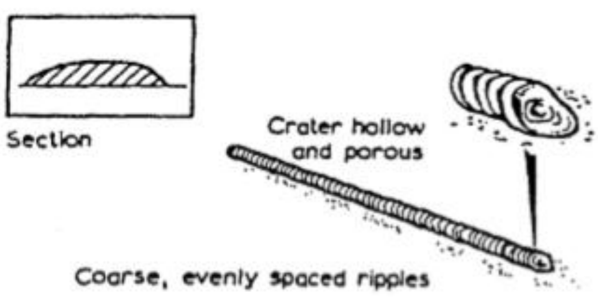


Fig 2.7 too high current

Correct Current

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

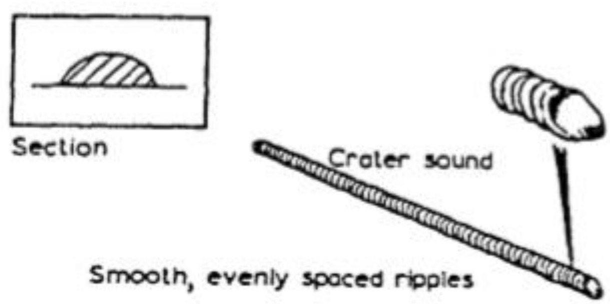


Fig 2.8 correct current

- **Alternating current (AC)**

✓ Alternating current is produced by an alternator – AC is usually taken from the mains supply which operates at 50 cycles/sec.

✓ There is a period of current flow from positive to negative followed by a period of current flow from negative to positive.

✓ The flow changes direction 50 times every second.

✓ The voltage falls to zero 100 times/sec, (therefore the arc is broken and re-established 100 times every second.

✓ Due to the even periods of current flow with AC:

✓ The heat is distributed evenly at the electrode and work piece

✓ There is no choice of polarity.

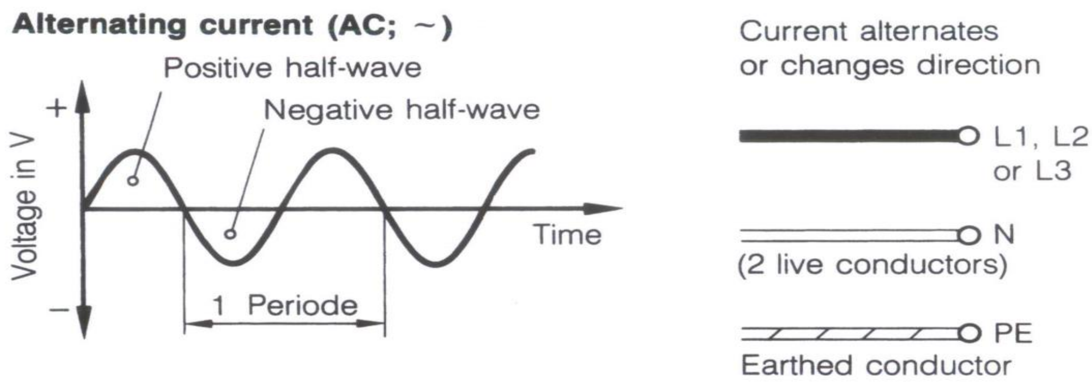


Fig 2.9 Alternating current

- **Direct current (DC)**

DC may be produced in the following ways:

- by chemical reaction as produced in a storage battery
- by a generator driven by a rotational shaft by converting AC
- by means of a rectifier or inverter.

Direct current exhibits the following characteristics:

- DC flows continuously in one direction at the preset voltage
- in DC the current always flows from negative to positive
- with DC the flow of electrons striking the positive pole (+ve) generates two thirds of the heat from the arc at the positive pole

Fig.2.10. Direct current

AC versus DC

Table 1.1 AC versus DC

	Alternating current (AC)	Direct current (DC)
portability	these machines generally consist of static step-down transformers and are considered as stationary	most modern types have features that allow portability (especially the self-contained types)
power supply	the use of these machines is restricted to the location of the nearest alternating current power point	petrol or diesel engine driven machines can be used in any location
efficiency	70–90 per cent electrically efficient	40–60 per cent efficient but some modern types compare with alternating current efficiency
polarity	no polarity	choice of polarity
arc blow	unaffected	arc blow occurs even in normal currents and is difficult to control above 300 amperes
maintenance	as there are no moving parts to be considered, maintenance costs are low	revolving and wearing parts add to maintenance
initial costs	cheaper plant as less construction is involved	more costly due to generator and motor construction
electrodes	restricted to use of electrodes that are suitable for alternating current only	suitable for all types of electrodes
running cost	cheaper running costs due to the use of an installed power supply	added costs due to the use of electric motors or internal combustion engines
voltage control	constant open circuit voltage	the open-circuit voltage can be varied by the operator
arc length	limited arc length	greater tolerance in arc length due to the characteristics of the machine

1.10. Braces, stiffeners, rails and other jigs

- **Stiffeners**

Stiffeners are typically plate welded to the web. These plate cabs are applied to either just one side of the web or both sides. By addition of these extra plates we increase the moment of inertia of plate girder which enhances the rigidity in turns it prevents buckling.

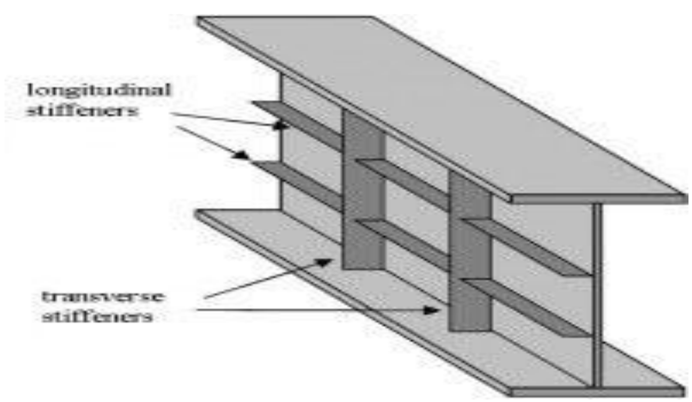


Fig 2.11 stiffener

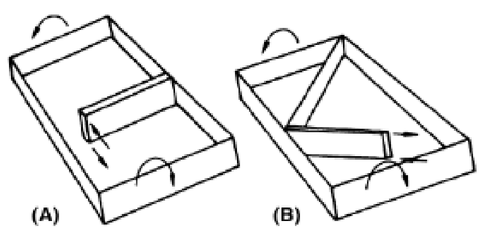
The **longitudinal stiffener** can increase shear and bending strengths of plate girder. Generally, they are not essential as transverse stiffeners.

Transverse stiffeners are provided under the outward projection of the flange. But, however there is also a chance that when the transverse stiffeners take load from the flange, they may exposed to *buckling*, as in case of a **c**olumn. So to avoid the buckling of the stiffeners

- **Braces**

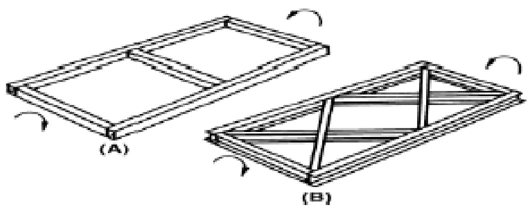
Diagonal Bracing: - Diagonal bracing is very effective in preventing the twisting of frames. A simple explanation of the effectiveness of diagonal bracing involves an understanding of the directions of the forces involved.

A flat bar of steel has little resistance to twisting, but has exceptional resistance of bending (stiffness) about its major axis. Transverse bars or open sections at 90° to the main members are not effective for increasing the torsional resistance of a frame because, as shown in Figure 2.12(A), they contribute only relatively low torsional resistance. However, if the bars are oriented diagonally at 45° across the frame, as in Figure 2.12 (B), the twisting of the frame is resisted by the stiffness of the bars. To be effective, the diagonal braces must have good bending stiffness perpendicular to the plane of the frame.



Source: Adapted from The Lincoln Electric Company, 1995, *Procedure Handbook of Arc Welding*, 13th ed., Cleveland: The Lincoln Electric Company, Figure 2-24.

Figure 2.12—Frames Subjected to Torsion with (A) Transverse Rib Bracing and (B) Diagonal Bracing



Source: Adapted from the Lincoln Electric Company, 1995, *Procedure Handbook of Arc Welding*, 13th ed., Cleveland: The Lincoln Electric Company, Figure 2-13.

Figure 2.13—Application of (A) Closed Tubular Sections or (B) Open Structures with Diagonal Bracing to Resist Torsion

- **Backing plate**

Backing strip which will provide support for a fully penetrated root pass. The backing strip may be permanent or temporary.

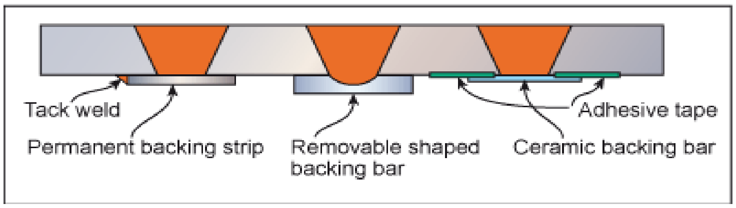


Fig 2.14.various forms of backing

The permanent backing strip weld does not have as good a performance in fatigue loading as a single sided. Whether a permanent backing strip weld is acceptable for service is therefore a design decision.

The Temporary backing bar may be used (conventionally a permanent backing is known as a 'strip', a temporary backing as a 'bar'). As the name suggests this is a backing that is easily removed at the end of the welding operation; it has not become fused to the root pass. It may be made of a ceramic or of copper, chromium plated for use on stainless steel and nickel based alloys to prevent contamination. Austenitic stainless steel has also been used. The metal backing bars may be water cooled to aid heat loss and may be grooved to provide a mould for the molten weld metal.

- **Fixtures and jigs**

Fixtures and jigs are devices used to hold the parts to be welded in proper relation to each other. This alignment is called fit-up. Good fit-up is required for obtaining high quality welds. Poor fit-up increases welding time and causes many poor quality welds. The size of the root opening has an effect on the speed at which the welding of the root pass can be accomplished. Root openings are used so that full penetration welds can be made. Root passes in joints with a proper root opening can be welded much faster than joints that have excessive root opening. Fixtures and jigs are used for three major purposes:

1. To minimize distortion caused by welding heat
2. To minimize fit-up problems
3. To increase the welding efficiency of the welder.

When a welder employs a welding fixture or jig, the components of a weldment can be assembled and securely held in place while the weldment is positioned and welded. The use of those devices is dependent on the specific application. These devices are more often used when a large number of similar parts are produced. Using fixtures and jigs, when possible can greatly reduce the production time for the weldment.

Welding Jig

A jig is a large brace that keeps a welding project stable in the face of pressure, heat, motion, and force. A quality jig will streamline welding work by keeping parts together in a vice grip. Whether the welding is entirely manual, partially automatic, or fully robotic, a jig moves the work piece while the tool remains stationary.

1.11. Appropriate distortion prevention measures

2.5.1. The Nature of welding distortion

Any unwanted physical change or departure from specifications in a fabricated structure or component is a consequence of welding.

Distortion or deformation can occur during welding as a result of the non-uniform expansion and contraction of the weld and base metal during the heating and cooling cycle.

Stresses form in the weld as a result of the changes in volume, particularly if the weld is restrained by the fixed components or other materials surrounding it. If the restraints are partly removed, these stresses can cause the base material to distort and may even result in tears or fractures. Of course, distortion can be very costly to correct, so prevention is important.

The definition of *distortion* given in the *Oxford Dictionary* states that it is 'the action or an act of distorting or twisting out of shape (permanently or temporary)'.Also, the distorted condition is 'a condition of the body ... in which it is twisted out of its natural shape'.

Distortion is a problem that exists in all industrial metalworking processes that employ heat and has been a serious problem for engineers since the early 1930s. With the introduction of welding in shipbuilding, it became necessary to control the dimensional changes of metal plates, stiffeners and assemblies that occur during welding process. The magnitude of distortion is controlled in practice within specified tolerances, not only for aesthetic purposes but also to maintain structural integrity in service.

The complex strain that develops during welding leads to internal forces that cause complex metal movement during welding and final distortion. There are three fundamental dimensional changes that occur during the welding process and in the ways in which distortion can appear (Figure 2.15) are principally:

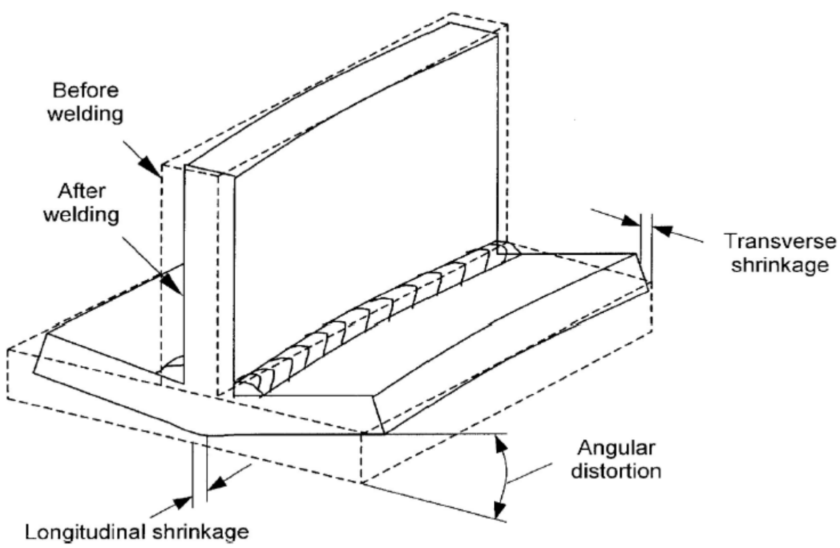
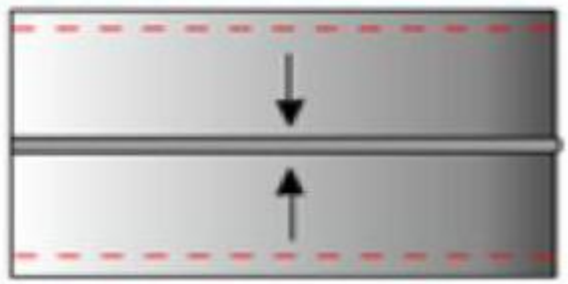


Fig 2.15 Dimensional changes occurring in a fillet weld

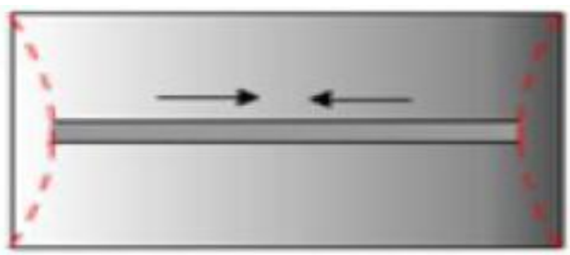
- **Types of Distortion:**

There are various types of distortion and dimensional change including longitudinal; transverse; angular; twisting and bowing. Two or more types of distortion may occur at the same time.

a) Transverse shrinkage perpendicular to the weld line,

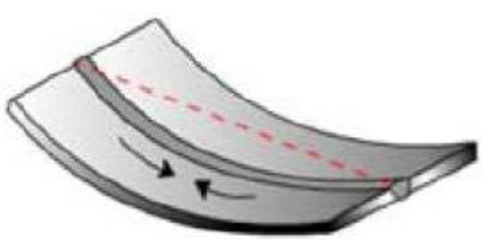


b) Longitudinal shrinkage parallel to the weld line and



c) Angular distortion around the weld line.

d) Bowing and dishing



Buckling

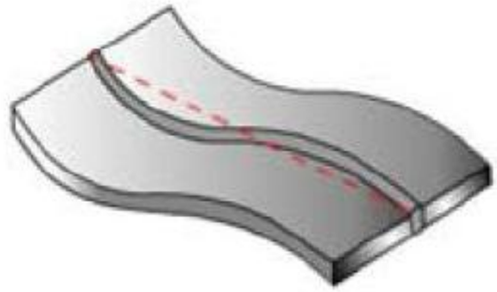


Figure 2.16 Types of Distortion

The severity of each of these will depend upon many factors. Depending on the configuration and dimensions of the structure it is possible to classify the basic types of distortion such as transverse and longitudinal shrinkage, rotational, angular, longitudinal bending, torsional and buckling distortion. The problem here is that in real structure, especially in the case of a complex structure, which has various types of joint, all these types of distortion are combined.

- **Distortion Control**

It is the process of minimizing the potential distortion in an object, such as controlling the stress distribution from welding.

The methods of distortion control in welding have been well summarized in several publications as follows.

Prevention by design of welded structures:- At the design stage, welding distortion can often be prevented, or at least reduced, by considering:

(a) Weld placement closer to the neutral axis of a fabrication;

(b) The effect of stiffener spacing and plate thickness;

(c) Reducing the size and amount of welding to the minimum required for strength, elastic stability and balanced design;

(d) Elimination of welds by forming the plate or using rolled or extruded section;

(e) joint-type design, which balances the thermal stress through the plate thickness;

(f) Use of new alternative construction materials (e.g. SPS).

Techniques based on assembly procedures and pre-welding conditions

These are:

(a) Minimization of residual stresses and initial distortion in delivered materials;

(b) Presetting method (which is mainly employed in subassemblies);

(c) restrained method entailing:

(i) Use of strong backs, jigs and fixtures,

(ii) Back-to-back assembly,

(iii) Tack welding and

(iv) Stiffening.

Techniques based on welding procedure.

These involve:

(a) The selection of a welding process, which exhibits less distortion (e.g. laser welding);

(b) Increasing the deposition rate and welding efficiency, as the weld can be deposited with the Minimum number of runs and in the shortest possible time to minimize the heat input (e.g. Using multiple wires welding, a flux or metal cored wire consumables, hot wire welding);

(c) The selection of the type of electrode that gives the lowest heat input per unit length of weld;

(d) using a sequence of runs balanced about the neutral axis of the joint;

(e) using a balanced welding sequence, such as back step and skip welding techniques, for heat dispersion;

(f) Using different types of general welding sequence of fabrications (e.g. the so-called ‘egg-box’ construction);

(g) Modifying the thermal pattern of the weldment (forced cooling, side heating, etc.).

- **Correction of distortion**

It is not always possible to control distortion within acceptable limits, especially with a new fabrication. In such circumstances, it is usually possible to remove distortion by producing adequate plastic deformation on the distorted member or section.

The required amount of plastic deformation can be obtained by thermal or mechanical methods.

- **Mechanical method**. Distorted members can be straightened with a press or jacks. When welded parts are small enough to be handled to straightening rolls or a press, it is often cheaper to straighten the parts cold after welding.
- **Thermal method.** The distorted area is straightened by heating spots or lines to 600–650 °C and quenching. This procedure will cause the material to upset during heating and then shrinkage stresses will tend to straighten the plate or beam. There are various ways in which such local heating can be applied to remove distortion, but it is only by experience that the best method can be selected for any particular job. In all cases the greatest danger is in over shrinking the area being heated, as this may cause even worse distortion.

Self-Check -2

I. Say true or false

---------1. The permanent backing strip weld does not have as good a performance in fatigue loading as a double sided.

---------2. Distortion is any wanted physical change or departure from specifications in a fabricated structure as a consequence of welding.

---------3. In alternating current there is choice of polarity.

Choose the best answer

Directions: Answer all the questions listed below.

1. Which one is used to slag cleaning purpose?
   A. Wire brush C. sand paper
   B. Ground clamp D. gloves
2. ____ indicates the direction of the current in the circuit.
   A. Voltage C. polarity
   B. Amperage D. power
3. 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
4. A device which permits current flow in one direction & can be used to convert AC to DC is ________________.
   A. Amperage C. Voltage
   B. Rectifiers D. welding machine

5. In which current adjustment the electrode becomes red hot and a large amount of spatter takes place?

   A. Current too high C. Current too low

   B. Correct current D. Current too normal

6. Which one of the following is used to support for a fully penetrated root pass?

   A. Backing plate C. jig

   B. Stiffener D. fixtures

7. ______is devices used to hold the parts to be weld in proper relation to each other.

   A. Stiffener C. backing plate

   B. Jig & fixture D. Strong back

IV. <u>Match Column "A" with Column "B"</u>

"A"	"B"
1. The current always flows from negative to positive	A. in AC
2. The resulting weld has poor penetration	B. Reverse polarity
3. Electrode positive	C. in DC
	D. current value is too low

Operation Sheet 2

Operation Title: Set-up welding machine and accessories.

1. Instruction: Properly Set-up welding and accessories according to requirements.
2. Purpose: Acquire knowledge and skills, how to set-up welding machine and accessories for SMAW welding operation procedures.
3. Required tools and equipment:
   - SMAW welding machine with accessories
   - Mild steel plate
   - Tong
   - Screw driver
   - Chipping hammer
   - Personal safety equipments : Like goggles, glove, apron etc
4. Precautions: Check an electric power off before connecting electric line.
5. Procedures:
   - Wear personal protective clothes PPE
   - Where necessary, wipe or dry any water / moisture / liquid spills around the work area.
   - **Step 3.** Remove any flammable matter from the area.
   - **Step 4**. Ensure that the area has adequate "ventilation" (fresh air).
   - **Step 5.** Where applicable, check that exhaust fans are running and that there is an adequate flow of air through the work area
   - **Step 6.** Remove all obstacles or debris that could otherwise cause you to slip, trip, snag or fall whilst you are welding.
   - **Step 7.** Position your welding machine in such a way that it is close enough for you to access during the operation
   - **Step 8.** Check where the welding cables will be laying and set them in such a way that they don't become "hazardous".
6. Quality criteria: Functionality of set-up welding machine and accessories.

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 8 hour

Task1. Identify welding machine accessories and consumable

Task2. Connect welding machine to in independent power supply

Task3. Set welding polarity

Task4. Adjust current and voltage

Unit Three: Set-Up Pre Heating Tools/ Equipment
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: ❖ Pre-heating equipment ❖ Operation of equipment ❖ Defects /functionality of tools and equipment ❖ Cleaning , lubricating and storing tools and equipment 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: • Set -up pre-heating equipment • Operate equipment in conformance with the manufacturer's instructions • Check tools and equipment for defects /functionality • Clean , lubricate and store tools and equipment

Set-Up Pre Heating Tools/ Equipment

3.1. Pre-Heating Equipment

Preheating

Depending on the type of metal, sometimes it is necessary to preheat the base metal to lessen distortion, prevent spelling or cracking, and avoid thermal shock. The preheating temperature depends on the carbon and alloy content of the base metal. In general, as carbon content increases so does the preheating temperature. However, improper heating can adversely affect a metal by reducing its resistance to wear, making it hard and brittle or more prone to oxidation and scaling.

To preheat properly, you must know the composition of the base metal. You can use a magnet to determine if you are working with carbon steel or austenitic manganese steel. Carbon steel is magnetic, but be careful because work-hardened austenitic manganese steel is also magnetic. Make sure that you check for magnetism in a non-worked part of the austenitic manganese steel. There are other ways to tell the difference between metals such as cast iron and cast steel; cast iron chips or cracks, while cast steel shaves. Also, some metals give off telltale sparks when a chisel strikes them.

In preheating, raise the surface temperature of the work piece to the desired point and soak it until the heat reaches its core. After wear facing, cool the work places slowly.

The purpose of pre-heating:

1) Reduce the risk of hydrogen cracking

Hydrogen is a very searching gas that can be liberated by oil, grease, rust etc. and water under the certain conditions. The greatest risk comes from hydrogen generated within the arc from damp or contaminated welding consumables, mainly fluxes or electrode coatings. Hydrogen will form into hydrogen porosity in the welds heat affected zone as the weld solidifies. Given the right conditions it can develop into hydrogen cracks also referred to as cold cracks.

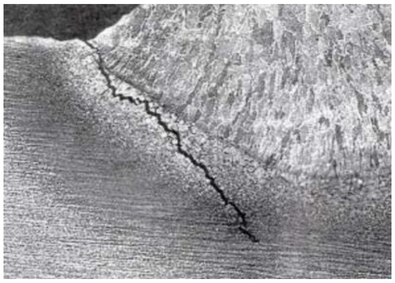


Fig.3.1. Cold cracks

2) Reduce the hardness of the weld Heat Affected Zone (HAZ)

A hydrogen crack requires a hard microstructure which is created by a harden able material subject to fast cooling from 800°C(1472°F) to 500°C(932°F). These cracks form in the coarse-grain growth zone in the Heat Affected Zone (HAZ).This is a very hard form of steel crystalline structure. Cooling can be slowed down by applying preheat. Other factors that can help, is maintaining a high inter pass temperature (base materials temperature during welding). This will normally be done by increasing welding amperage and reducing travel speed.

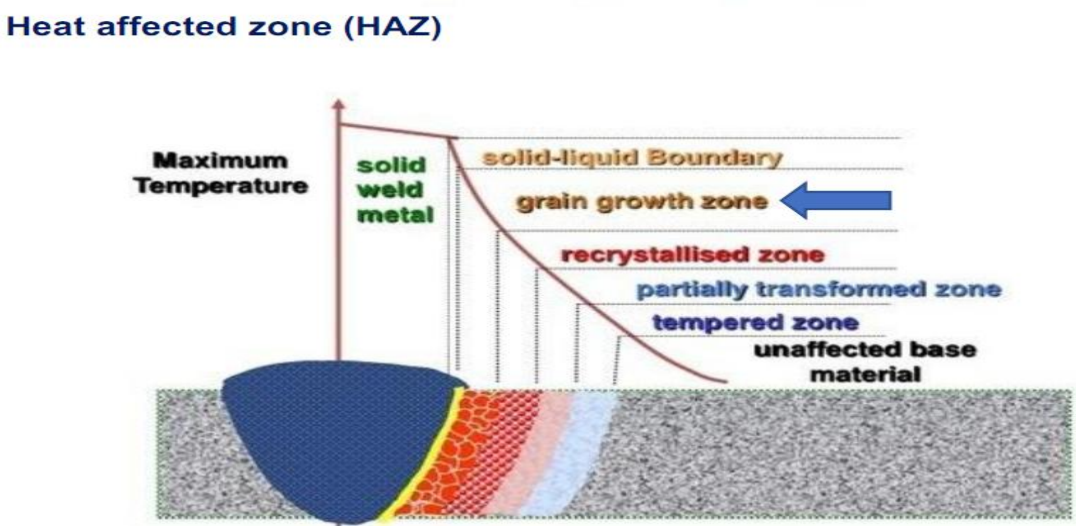


Fig.3.2. Heat affected zone

3) Reduce shrinkage stresses during cooling and improve the distribution of residual stresses.

The heat developed during welding will result in expansion and contraction. The result can be distortion or stress build-up or a combination of the two.

When a hot weld bead cools, it shrinks more than the surrounding cooler metal and thus is strained severely – sometimes so severely that the weld cracks. The more massive the joint, the more strain occurs in the weld bead. If the base metal around the joint is preheated, the base metal and the weld metal shrink more uniformly as the joint cools. This is usually helpful because less strain occurs in the weld bead and weld cracking is less likely to occur.

If all 3 factors are present there is a strong likelihood for cracking to develop after welding.

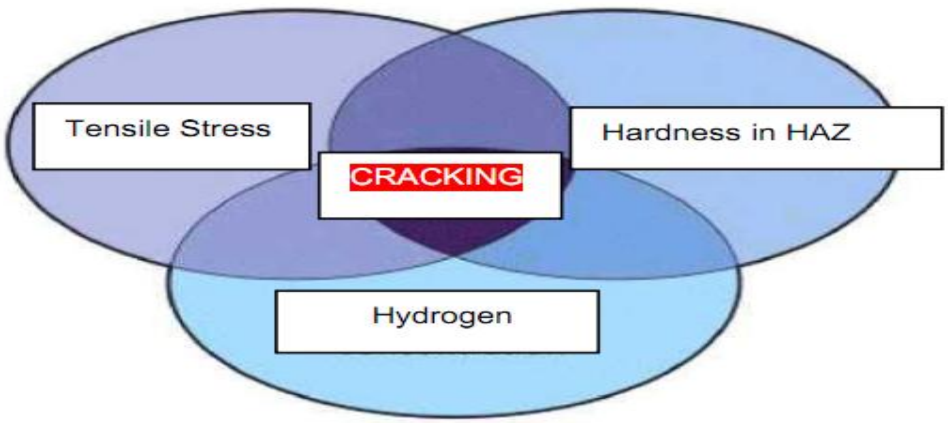


Fig.3.3. Cracking

Table 3.1.Typical Recommended Preheats for Various Steels and Cast Iron Welded by the SMAW Process

Type of Steel	Preheat
Low-Carbon Steel	Room Temperature or up to 200°F (93°C)
Medium-Carbon Steel	400-500°F (205-260°C)
High-Carbon Steel	500-600°F (260-315°C)
Low Alloy Nickel Steel -Less than ¼' (6.4 mm) thick -More than ¼' (6.4 mm) thick	Room Temperature 500°F (260°C)
Low Alloy Nickel-Chrome Steel -Carbon content below .20% -Carbon content .20% to .35% -Carbon content above .35%	200-300°F (93-150°C) 600-800°F (315-425°C) 900-1100°F (480-595°C)
Low Alloy Manganese Steel	400-600°F (205-315°C)
Low Alloy Chrome Steel	Up to 750°F (400°C)
Low Alloy Molybdenum Steel Carbon content below .150% Carbon content above .15%	Room Temperature 400-650°F (205-345°C)
Low Alloy High Tensile Steel	150-300°F (66-150°C)
Austenitic Stainless Steel	Room Temperature
Ferritic Stainless Steel	300-500°F (150-260°C)
Martensitic Stainless Steel	400-600°F (205-315°C)
Cast Irons	700-900°F (370-480°C)

Importance of Preheating

Preheating is especially important when welding:

- Highly restrained weld joints.
- Thick materials (the rule of thumb on thickness and when to preheat varies by material type).
- Base materials that tend to be more brittle, such as cast iron, and when welding dissimilar materials.
- When recommended by the base material manufacturer. This information often can be found in a table that specifies preheat temperature ranges for a given material thickness.

Preheating also can be good for materials with a high-carbon equivalency, such as AISI 4130 and 4140. High carbon levels and/or additional alloys can make the material stronger and harder, but also more brittle and less ductile, which can lead to potential cracking issues.

Parts Preheating Method

Once you have determined that the welding application requires preheating, consider the best method to use.

Fig.3.4. preheating

Induction heating is one preheat option that provides consistent heat throughout the weldment. It offers fast time-to-temperature and is considered a very safe option for preheating. *Photo courtesy of Miller Electric Mfg. Co.*

Preheating with an open flame from a torch is a common method, as it is easy to use and offers simple setup and portability. Also, the initial investment cost is low, and the process is one welders usually know. However, preheating with an open flame can be inefficient compared to other options because much of the heat is lost into the surrounding air. It also can be difficult to ensure consistent temperature levels throughout the part.

Flame preheating also poses safety hazards, including an increased burn potential, and has special storage requirements for explosive gases, usually propane or propylene.

An oven or furnace also can be used for preheating, particularly for small parts. Large models are available for large weldments.

Induction heating, another preheat option that provides more consistent heat throughout the weldment, offers fast time-to-temperature. Some equipment can document preheat temperatures via digital recording capabilities.

Considerations for Preheating

As with any welding procedure, it's important to follow the preheating guidelines from the material manufacturer, as well as some general best practices.

First, when using an open-flame method, consider the distance from the joint to achieve proper preheating. The correct distance from the joint varies based on the base material and any welding codes or procedures for the application.

Preheat a large enough area around the weld joint to ensure the proper temperature is maintained throughout welding. Preheating a wider area minimizes the risk of colder areas in the material sucking away the heat.

Other heat-measuring devices, generally, the preheat temperature should be measured at least 3 inches from the joint. The preheat temperature should be verified directly before welding begins.

Induction heating systems often feature a built-in heat controller to monitor temperatures using feedback from thermocouples mounted on the weldment. It typically works best to place the thermocouple toward the center of a coil configuration, which tends to be the warmest spot

3.2. Operation of equipment

Essentially three methods commonly are used to preheat joints:

- ✓ Torch heating.
- ✓ Induction heating.
- ✓ Electrical resistance heating.

- Torch heating

Torch heating it's just a torch and you simply monitor its temperature with temperature-indicating sticks. Once you see the sticks melt, you know you've reached the minimum preheat temperature and you start welding. While it is portability and affordability method, also notes that it is, by its very nature, not as accurate as the other technologies available.

It is very easy to overheat the steel past your maximum inter-pass temperatures. You also don't get even heating all the way around the surface. You've got to manipulate the torch a lot. Once the welder starts welding, he/she may be able to keep the weld at the minimum preheat temperature via the welding process itself; however, on thicker sections of steel, the heat tends to bleed out very quickly. In situations like that, it's important to have a more controlled preheat process.

- **Induction Heating**

The most common methods for achieving a more controlled preheat temperature are induction heating and electrical resistance heating.

The equipment used for induction is considerably more expensive than that used for electrical resistance heating. However it does get your steel hotter quicker. It still offers you much more control than what you achieve with a torch. The induction method of preheating can use either a liquid-cooled braided hose or an air-cooled premade blanket wrapped around the material to be heated to create a magnetic field. The magnetic field excites the molecules in the material, which creates heat that radiates from the center of the material outward in all directions.

With an induction heating system you attach a thermocouple to the weld. The thermocouple senses the temperature of the steel and sends a signal back to the controller on the induction machine. Once the steel reaches the preheat temperature, it will maintain that temperature until the controller is adjusted. It has its ideal applications. For instance, when a shop is heating very thick sections of pipe and rotating them, this can be a good solution. Its limitation is that an induction machine can be used to heat just one weld joint at a time, and it has only a single point of control.

Electrical Resistance Heating

A standard electrical resistance preheating machine, on the other hand, is built as a six-way unit, which means it is equipped to heat three joints at the same time, while offering six points of control.

Similar to the induction method, the pipe gets wrapped. However, the coils (flexible ceramic pads) that are used heat through conduction, and therefore heat from the outside going into the steel. The electrical resistance method (sometimes referred to as Cooperheat) also controls the preheat by using the feedback of a thermocouple.

It allows you more control, in the sense that you can add more controlling thermocouples For materials like alloy steel, where you need to tightly monitor your maximum inter pass temperature and your preheat temperature, the electrical resistance method gives you more control over that's becoming widely used in power plants and other high-temperature applications. So in circumstances where you are using this type of material, using electrical resistance allows you to control each steel. It is also your most effective method of controlling maximum interposes."

It is a little slower with respect to actually setup, but when you are welding thick sections, that speed isn't as big a concern because you can prepare for more welds at once, Preheat time could also be a half hour compared to five minutes. That depends on the power available and the setups, so it is harder to quantify.

Application of Preheat

The material thickness, size of the weldment and available heating equipment should be considered when choosing a method for applying preheat. For example, small production assemblies may be heated most effectively in a furnace. However, large structural components often require banks of heating torches, electrical strip heaters, or induction or radiant heaters.

A high level of accuracy generally is not required for preheating carbon steels. Although it is important that the work be heated to a minimum temperate, it is acceptable to exceed that temperature by approximately 100°F (40°C). However, this is not the case for quenched and tempered (Q&T) steels, since welding on overheated Q&T steels may be detrimental in the heat affected zone. Therefore, Q&T steels require that maximum and minimum preheat temperatures be established and closely followed.

When heating the joint to be welded, the WPS code requires that the minimum preheat temperature be established at a distance that is at least equal to the thickness of the thickest member, but not less than 3 in. (75 mm) in all directions from the point of welding. To ensure that the full material volume surrounding the joint is heated, it is recommended practice to heat the side opposite of that which is to be welded and to measure the surface temperature adjacent to the joint. Finally, the steel temperature should be checked to verify that the minimum preheat temperature has been established just prior to initiating the arc for each pass.

3.3. Defects /functionality of tools and equipment

- Methods of identifying non-functional tools and equipment

1. **Visual inspection**. It refers to the visual observation of an expert on the appearance of the tools and equipment.
2. **Functionality**. Vibration or extra noise from the operation means problems on parts and accessories started to develop.
3. **Performance**. When there is something wrong with the performance of either hand tools or equipment, they need immediate repair or maintenance.
4. **Power supply** (for electrically operated only). Failure to meet the required power supply, some malfunction will occur in the part of hand tools or equipment.
5. **Persons involved**. It refers to the technical person who has the knowledge and skills about technology.

3.4. Cleaning, lubricating and storing tools and equipment

The term “maintenance” means a scheduled or a planned visit of tools or equipment for inspection and from there, reports and recommendation developed and the next tasks to be decided such as cleaning, application of lubricants, dismantling and etc.

a. **Lubricating**. A task performed in the shop/production. Through the application of lubricant substance to the identified items in parts like barrels, rollers, springs, bearing, bolts and nuts, and other automotive parts.

b. **Cleaning**. Simple process applied to hand tools. The cleaning approach may differ from one another. For example, cleaning the rack corners of hand tools by using an air vacuum or by a piece of clothes. Similar process may be applied to identical cleaning situations.

c. **Storage**

Proper Storage of Hand Tools and Equipment

5S Implementation

a. **Sort** - Eliminate whatever is not needed by separating needed tools, parts, and instructions from unneeded materials.

b. **Set in order** - Organize whatever remains by neatly arranging and identifying parts and tools for ease of use.

c. **Shine -** Clean the work area by conducting a cleanup campaign.

d. **Standardize** - Schedule regular cleaning and maintenance by conducting sorting, set in order, and shine daily.

e. **Sustain** - Make 5S a way of life by forming the habit of always following the first four S's.

Self check - 3

Directions: Answer all the questions listed below.

I. Say true or false

1. Induction machine can be used to heat just one weld joint at a time and it has only a single point of control.

II. Choose the best answer

1. Which one of the following is the purpose of pre-heating?
   A. Reduce the risk of hydrogen cracking
   B. Increase the hardness of the weld heat affected zone
   C. Reduce shrinkage stresses D. All except B
2. From the following one is not the case to preheat the welding material
   A. When welding dissimilar material
   B. Base material that tend to be more ductile
   C. When the material are thick
   D. When recommended by the base material manufacturer
3. From the following which one is especially important Preheating welding:
   A. Material thickness C. When recommended by manufacturer
   B. Dissimilar material D. All
4. ________are the methods used to preheat joint.
   A. Electrical resistance heating C. Induction heating
   B. Torch heating D. All
5. In which method heat is monitor its temperature with temperature-indicating sticks?
   A. Torch heating C. Electrical resistance heating
   B. Induction heating D. All
6. From the following which one is especially important Preheating welding?
   A. Material thickness C. When recommended by manufacturer
   B. Dissimilar material D. All

Operation sheet 3

1. Operation Title: Set-up set up pre-heating machine and operating pre-heating equipment**.**
2. Instruction: Properly select and Set-up pre-heating machine according to requirements.
3. Purpose: Acquire knowledge and skills, about selecting pre-heating tools set-up pre-heating machine to protect distortion.
4. Required tools and equipment:
   - Pre-heating machine with accessories
   - Mild steel plate
   - Personal safety equipments : Like goggles, glove, apron etc
5. Precautions: Check an electric power off before connecting electric line.
6. Procedures:

- **Step2.** Select proper tools and equipment.
- **Step3.** Prepare pre-heating machine, accessories and equipment's.
- **Step4**. Select pre-heating machine
- **Step5**. Set up the machine
- Perform pre heating
- **Step6**. After finishing the work cleaning the work area.

7. Quality criteria: Functionality of set-up pre-heating machine, identification distortion and ability operating pre-heating equipment

LAP Test 3 Practical Demonstration

Name: _____________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 2 hour

Task1. Set up pre-heating machine

Task2. Operate pre-heating equipment

Unit Four: Perform Tack Welding

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

- ❖ Tack welding and make joints free from foreign materials
- ❖ Welding Procedure and Specification
- ❖ Root gap
- ❖ Alignment, code and standard
- ❖ backing plate, stiffener and running plate
- ❖ Stresses free dimensional tack weld

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:

- Perform tack welding and make joints free from foreign materials
- Identifying welding Procedure and Specification (WPS)
- Perform root gap
- Check alignment within the range of acceptability of code and standard
- Install backing plate, stiffener and running plate as required
- Make tack weld dimensionally acceptable and visually free from stresses

Perform Tack Welding

4.1. Tack Welding

The expression “Tack Welding” refers to a temporary weld used to create the initial joint between two pieces of metal being welded together.

But don’t let the ‘temporary” nature of this weld fool you, Tack Welding is an integral part of the welding process and very important to the ultimate success of your welding projects.

Let’s use a basic welding exercise to demonstrate how Tack Welding works. Say you’re going to weld two pieces of steel together in order to form a basic right-angle joint. Once you have your pieces in position (typically using a c-clamp), make two short welds, one at either end of the joint seam. These two Tack Welds hold the pieces together, and from here you can complete the joint by filling in the seam between the points of the two Tack Welds.

Even though these two Tack Welds are just the initial part of the process, the welds should be fundamentally sound, considering they provide the foundation for the entire joint. Consider the welding exercise described above: c-clamps aren’t strong enough to hold the two pieces of steel together, because the stress of the heat from the welder will separate the pieces along the seam, pulling the joint apart and compromising the strength of the weld. Therefore, your two initial Tack Welds need to be rock-solid to ensure the two pieces remains tight and the overall joint weld is secure.

Additional benefits of Tack Welding include:

Tack welding is real welding, even if the welds are deposited in separate short beads. It performs the following functions:

Holds the assembled components in place and establishes their mutual location

Ensures their alignment

Complements the function of a fixture, or permits its removal, if necessary

Controls and contrasts movement and distortion during welding

Sets and maintains the joint gap

Temporarily ensures the assembly's mechanical strength against its own weight if hoisted, moved, manipulated, or overturned

Reduces movement and distortion during the welding process

Offers temporary joint strength if an object needs to be moved or repositioned during the welding process

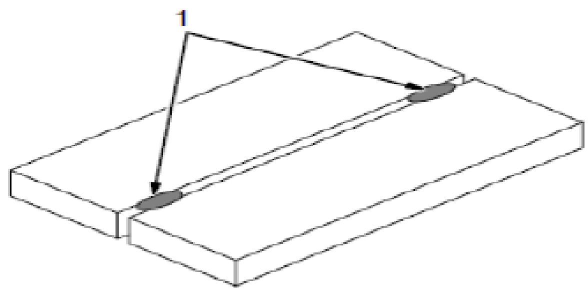


Fig.4.1. Tack Welding

Tacking and Temporary Welds

As stated by the American Welding Society (AWS):

•Tacking is defined as "welds made to hold the parts of a weldment in proper alignment until the final welds are made “

• Similar are "Temporary welds “which are defined as welds "made to attach a piece or pieces to a weldment for temporary use in handling, shipping, or working on the weldments “

• In both cases, one must remember these types of welds, if improperly made, may have negative influence on the quality of permanent welds

• It is very important to minimize the risks associated with poor tack welding as they must not interfere with or degrade the quality of the completed welded structure

• Short tack welds require limited heat input which aids in minimizing distortion therefore it is better to have more short tacks than fewer long tacks.

- **Making tack weld free from stress**
  - ✓ Weld Stress

Welding residual stresses have a negative or positive effect on the strength of the component depending on their type, sign, direction and distribution. Tri-axial tensile residual stresses in combination with crack like defects promote brittle fracture. Uniaxial or biaxial tensile residual stresses diminish corrosion resistance and enhance the stability limit; compressive residual stresses improve the fatigue strength. Components with welding residual stresses may distort during subsequent machining, storage and service loading. A particularly disturbing effect is the back-spring deformation during metal cutting. Welding distortion reduces the fatigue strength and limit load of the components. Specified manufacturing tolerances may be exceeded as a result of welding distortion. It is therefore necessary to minimize welding residual stresses and welding distortion or, as far as possible, to control them according to the respective requirements.

- **Allowable Stresses (Tubular)**

This part dealing with allowable stresses for tubular sections includes requirements for square and rectangular sections as well as circular tubes.

In commonly used types of tubular connections, the weld itself may not be the factor limiting the capacity of the joint. Such limitations as local failure (punching shear), general collapse of the main member, and lamellar tearing are discussed because they are not adequately covered in other codes.

4.2. Welding Procedures

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

Tack welding is major part of welding which are used as a temporary means to hold the components in the proper location, alignment, and distance apart, while welding. ... The tack is a very rapid quench application and a brittle, sensitive micro structure results usually at the root of the weld.

1. **Operation**

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.

2. **Welding techniques**

To start so many new welders are looking for the perfect pattern to weld with and that included myself many years ago.

The perfect welding technique is many hours of practice! Overtime your hands, eyes and body positioning automatically adjust to the weld needed and your patterns change as needed.

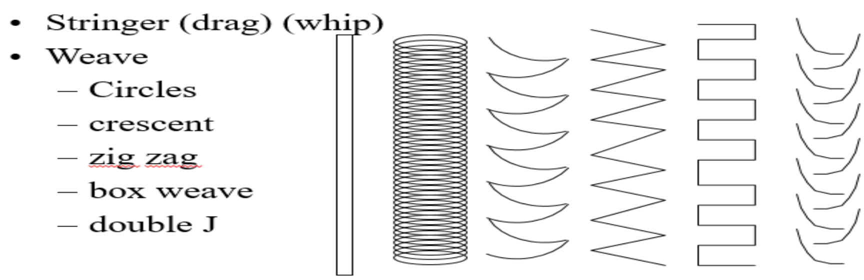


Fig 4.2.welding technique

4.3. Root gap

Root gap is fixed based on size of the welding electrode used in welding the root pass. The ideal root gap would be nearly the size of the filler metal. It can be slightly higher. But, too much root gap can cause lack of penetration which is not acceptable as per codes and concavity. A welder knows to fix the root gap.

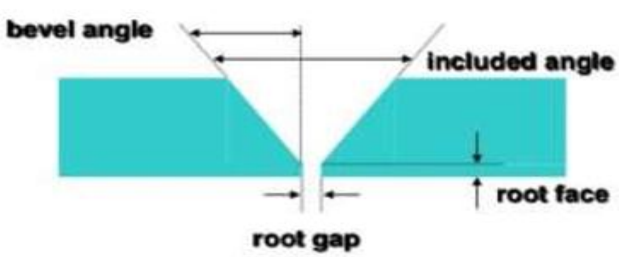


Fig 4.3.Root gap

✓ **Travel Speed**

Travel speed is another important factor in controlling the weld characteristics. The travel speed is determined by the welder, who manually controls the rate that the arc travels along the work. Increasing travel speed while the other variables remain constant reduces the width of the weld bead and increases the weld penetration. The travel speed is the speed at which the electrode moves along the base material while welding

- Too fast of a travel speed results in a ropey or convex weld
- Too slow of a travel speed results in a wide weld with an excessive metal deposit

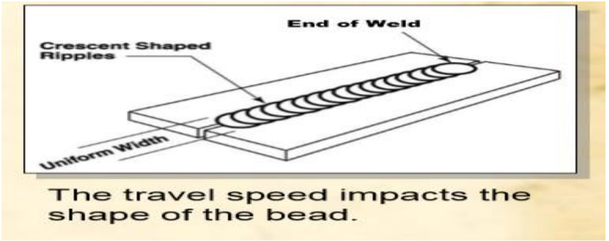


Fig4.4. Wide bead with an excessive metal deposit

- **Welding Voltage (Arc Length)**

The welding voltage is another important variable in shielded metal arc welding. The arc voltage is determined by the arc length between the end of the electrode and the base metal. The welder controls the arc voltage manually by moving the tip of the electrode close to or away from the surface of the base metal. Increasing the arc length increases the arc voltage; decreasing the arc length decreases the arc voltage. The welding voltage primarily affects the shape of weld bead cross-section and the general appearance of the weld. Increasing the welding voltage produces a wider and flatter weld bead and increases the susceptibility to arc blow.

After striking the arc, maintain a 1/8” distance between the electrode and the work piece

- If the arc length becomes too short, the electrode will get stuck to the work piece or ‘short out’
- If the arc length becomes too long; spatter, undercut, and porosity can occur Angles of the Electrode

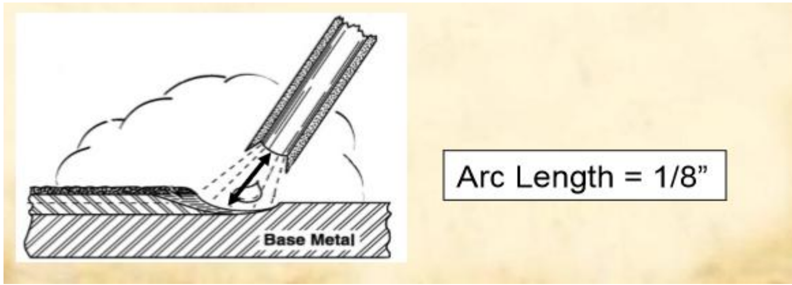


Fig4.5. Arc length

4.4. Backing plate, stiffener and running plate

- **Stiffeners**

Intermittent Fillet Welds: - Intermittent fillet welds used to connect stiffeners to beams and girders shall comply with the following requirements:

- ✓ Minimum length of each weld shall be 1-1/2 in. (40 mm).
- ✓ A weld shall be made on each side of the joint. The length of each weld shall be at least 25% of the joint length.
- ✓ Maximum end-to-end clear spacing of welds shall be twelve times the thickness of the thinner part but not more than 6 in. (150 mm).
- ✓ Each end of stiffeners, connected to a web, shall be welded on both sides of the joint arrangement. Stiffeners, if used, shall preferably be arranged in pairs on opposite sides of the web. Stiffeners may be welded to tension or compression flanges. The fatigue stress or stress ranges at the points of attachment to the tension flange or tension portions of the web shall comply with the fatigue requirements of the general specification. Transverse fillet welds may be used for welding stiffeners to flanges.

Single-Sided Welds:- If stiffeners are used on only one side of the web, they shall be welded to the compression flange.

Strong backs

Strong backs are typically made on the job site from heavy bar stock.

They are notched at the weld joint to allow access to the joint so that welds can be made without interference.

The strong back can be on the face or root side of the weldment.

When tack-welding Strong backs, place the tack welds on only one side of the strong back, so it will be easier to remove.

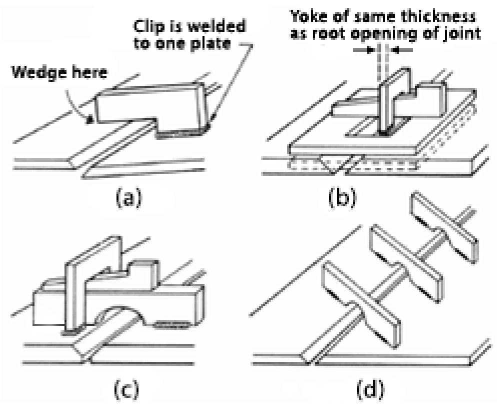


Fig. 4.7. Various strong back arrangements to control distortion during butt-welding.

4.5. Stresses free dimensional tack weld

- **Tack weld dimensional acceptably and visually free from stress**

Tack welds shall not be less than the throat thickness or leg length of the root run to be used in the joint.

The length of the tack weld shall not be less than four times the thickness of the thicker part or 50 mm whichever is the smaller.

- ✓ shall be free from all cracks and other welding defects
- ✓ Tack welds shall not be made at extreme ends of joints

- **Defective Tack Welding Risks**

When hoisted, improperly tack welded assemblies can rupture, and portions or subassemblies can fall and endanger people or damage property.

Tack welding must not interfere with or degrade the quality of final welding. It must not introduce weld defects, such as arc strikes, craters, cracks, hard spots, and slag left in place.

Many steels used in fabricating pipes and vessels are sensitive to rapid cooling or quenching, especially following short tack welds, because of the limited heat input required to tack weld. ***Note:*** Higher heat input slows the cooling rate, which minimizes the occurrence of hard and brittle microstructures.

Controlling Tack Weld Quality

To ensure quality, most codes require that tack welding be performed only according to qualified welding procedures by welders fully certified in the process used for the final weld.

The requirements are applicable for any welding process used.

Distortion Control Procedures

In all fusion welding processes, the sequence and the direction of the tack welds are important for distortion control. Besides maintaining the joint gap, tack welds must resist transverse shrinkage to ensure sufficient weld penetrations.

For a long seam, tack welding should start at the middle and proceed along the joint length, alternating in both directions, in proper back step or skip sequence to avoid stress buildup and deformation.

Tack welds also can be placed at the joint ends and then added in the middle of each resulting distance between those already done, until the whole length is covered with the required number at the needed spacing.

Why tack weld in sequences such as these? Because if tack welds are placed progressively from one end to the other, shrinkage can close the gap at the opposite end and might even cause one sheet end to overlap the other.

Because of greater thermal expansion in austenitic stainless steels, the spacing between tack welds on these materials should be much shorter than for mild steel

Special Requirements

Tack welding is an essential step in preparing pipes for welding. Thorough attention should be given to obtain adequate alignment and consistent root opening (joint gap) that control the success of the most important root pass. Although this work could be assigned to fitters, it should be supervised closely to make sure that the workers are properly qualified.

The number and size of tack welds depend on pipe diameter and wall thickness. Tack welds with complete fusion should be the same quality as the final weld.

All tack welds must be thoroughly cleaned before proceeding with the final weld.

Both ends of each tack weld, representing start and stop (which are weak points often having unacceptable defects), must be ground to remove possible flaws and to present a very gradual slope that blends the weld's sides into the metal.

Self-check -4

Directions: Answer all the questions listed below.

I. Say true or false

1. The primary purpose of a Hi-Lo gauge is to check for pipe joint misalignment.
2. Too slow of a travel speed results in a narrow weld with an excessive metal deposit.
3. The main effect on butt welded joints is to produce poor root penetration.
4. The first step to preparing metal for welding is to remove all the impurities otherwise your weld will not be a good one.
5. Tack weld increases movement and distortion during the welding process.

II. Choose the best answer

1. What is arc length? Arc Length is
   A. The distance between electrode holder and work-pieces
   B. The distance between end of electrode and work-pieces.
   C. The distance between electrode holder and ground clamp
   D. The distance between work-pieces and ground clamp
2. _____ which one of the following is important for distortion control?
   A. Travel speed C. Tack welding
   B. Travel Angle D. Electrode angle
3. Which one of the following are the most common tools used to lay out and check joint fit-ups?
   A. Squares, C. Hi-lo gauges
   B. Straightedges D. All

Operation sheet - 4

1. Operation Title: Performing root gap.
2. Instruction: prepare root gap within the given dimensions.
3. Purpose: Acquire knowledge and skills, how to prepare root gap and tack welding.
4. Required tools and equipment:
   - SMAW welding machine with accessories
   - Mild steel plate
   - Tong
   - Chipping hammer
   - Personal safety equipments : Like goggles, glove, apron etc
5. Precautions: Follow the correct procedure and prepare the root gap.
6. Procedures:

Step1. Safety (clean work area &wear PPE)

Step2. Select proper tools and equipment..

Step3. Identify materials.

Step4. Prepare material based on the required

Step5. Align joints using different aligning method

Step6. Set up welding machine

Step7. Adjunct the welding machine

Step8. Clamp the ground cable

Step9. Perform tack welding

Step9. Perform root gap

Step10. Cleaning the work area

7. Quality criteria: Quality of alignment, Correct dimension quality tack weld and safety procedure.

Project

Prepare Root gap with the given dimensions.

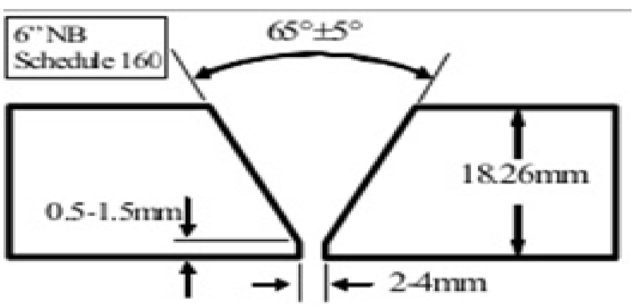
Thickness= 6 mm, joint position= flat/vertical, joint type=single side joint, process= arc welding, diameter=2.4,curret = 80-100A,volteg=12v,Travel speed mm/min=50,Types of current=DCEN &DCEP, Heat Input KJ/min=1.2,Eledrode E7013 baking or drying=NA.

Notes

Tack joint securely to prevent root closure using four bridging tacks.

Shielding flow rate 8-12L/min

Project



LAP Test 4 : Practical Demonstration

Name: _____________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 7 hour.

Task1.Perform root gap

Task2. Perform tack weld

Unit Five: Perform SMAW Welds

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

- Perform root pass
- clean root pass
- Perform subsequent filling passes
- Perform capping
- Remove defects
- Ensure weld deposit
- Clean and free joints from discontinuities

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:

- Perform root pass
- Describe Clean root pass
- Perform subsequent filling passes
- Perform capping/ the final cover pass in a welding joint/
- Remove defects with minimum loss of sound metal
- Ensure weld deposit
- Clean and free joints from discontinuities

Perform SMAW Welds

5.1. Perform root pass

- **Root Pass**

The root pass is the initial pass deposited after the pipe is fit-up and tack-welded together. Where final visual inspection is concerned, the root pass and the cover or cap-pass are the decisive factors for determining whether or not welding was successful. If the pipe has been prepared with the correct groove design, and fit-up and the tack welding have been done correctly, welding the root pass can proceed.

It is important to start the initial weld of the root pass by starting the arc at least ¼ inches back (overlapping) on the tack weld and progress forward from there. This will allow the weld pool to develop, creating enough heat to cause proper melt through and fusion with the tack weld and tie into the keyhole.

This same method must be repeated with each tie-in (restart) to complete the root pass. Remember, the goal is to finish the root pass with complete fusion, both on the root side (Figure 5.1) and the fusion face and toes of the weld (Figure 5.2).

The factors the welder controls that influence fusion are amperage, travel and work angles, arc length, and travel speed. One other factor is the position of the weld. For example, vertical down-welding requires higher travel speeds and is limited to thinner pipe thicknesses. Vertical up-welding may be done with smaller diameter electrodes to allow for both proper root fusion and weld pool control.

Fig 5.1 Fusion on the root side-both beveled pipe edges are melted.

Fig5.2. Fusion on weld face and toes

Root pass procedures vary with some alloys other than carbon steel. In the case of stainless steels, open root welding is accomplished by back purging the inside of the pipe with either argon or nitrogen gases. As an alternative, one of various types of consumable inserts (Figure 5.3), backing rings, or backing tape can be used to prevent the root from oxidizing effects of atmospheric oxygen. Consumable inserts are commercially available for most common base metal alloys.

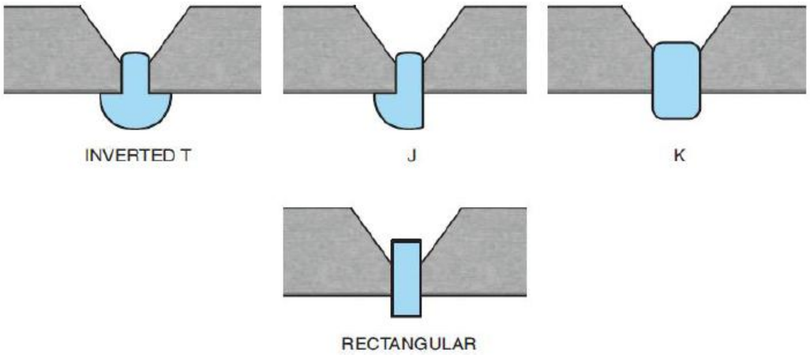


Fig 5.3 Consumable inserts for open root welding

4.6. Root pass cleaning

Cleaning root pass

After a root pass is laid in the weld joint, a 1/8 in or slightly thicker bonded wheel is typically used to grind out the area to remove excess buildup and reshape the face of the root.

This is particularly important when making multiple-pass welds. Complete removal of the slag for multiple pass welds prevents slag inclusions, porosity, and lack of fusion in the weld. After removal of the slag, a grinder is often used to grind the surface of the weld to give a more uniform surface.

A wire brush is also often used to clean up the surface of the weld.

To remove the slag, strike the weld with a chipping hammer. Hammer the bead so the chipping is directed away from the body, and away from the eyes and face as pictured in Figure.

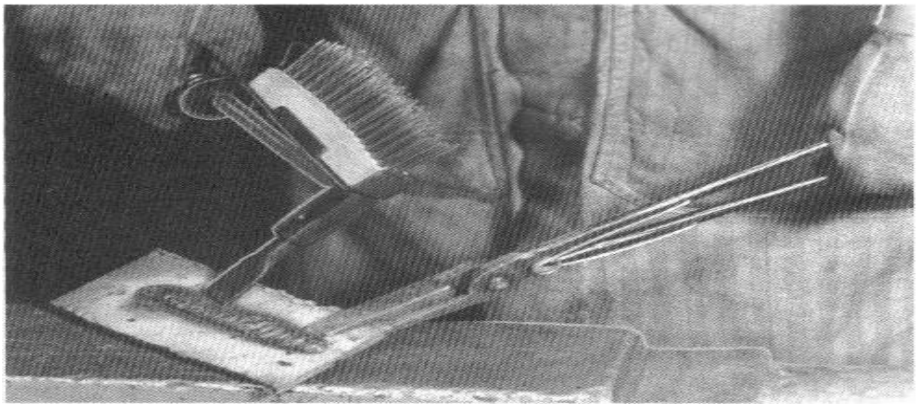


Fig.5.4 Strike the weld with a chipping hammer to remove slag.

WARNING: 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

Loosened, drag the point end of the hammer along the weld where it joins the plate.

This will remove the remaining particles of slag. Follow the chipping with a good, hard brushing, using a stiff wire brush as illustrated Figure.

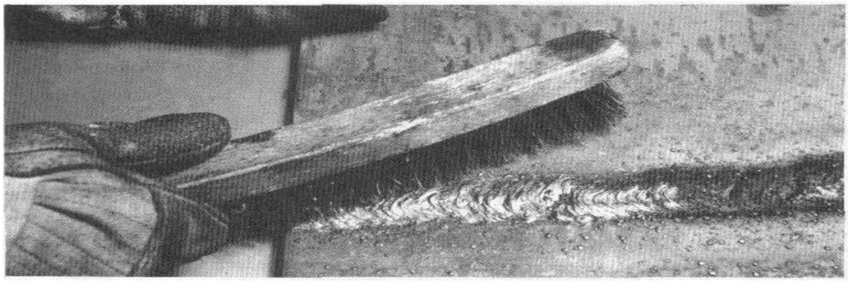


Fig.5.5. After chipping, brush the weld with a wire brush

- **Cleaning tools:-** in order to produce a strong weld joint the surface of the metal must be free from rust, oil &paint.

To clean, use the following tools:-

- ✓ **Wire brush:-** a steel wire brush is used for cleaning the work & weld
- ✓ **Chipping hammer:-**is used to remove burrs & slag from the weld deposit. Produce a strong welded joint, the surface of the metal must be free of all foreign matter such as rust, oil, and paint.
- ✓ **Grinding machine: -** used to grind after welding to smooth the weld-meant

- A steel brush is used for cleaning purposes.

- After a bead is deposited on the metal, the slag, which covers the weld, is removed with a chipping hammer.

- Additional wire brushing follows the chipping operation.

- Complete removal of slag is especially important when several passes must be made over a joint.

- Otherwise, gas holes will form in the bead, resulting in porosity, which weakens the weld.

4.7. Perform subsequent filling passes

Once the root pass is completed, it must be cleaned thoroughly to ensure that any slag, cold starts, or any other irregularity, which may reduce fusion in the next passes, are re-moved. Inter pass cleaning chipping, wire brushing, and grinding are necessary steps in producing sound welds.

When using EXX10 and EXX11 class electrodes with SMAW, a hot pass may be used after brushing and grinding. Due to the turbulent nature of the arc, electrode manipulation, and narrow groove faces of the joint root, these electrodes tend to leave a weld face that can be more difficult to clean than those of welds made with low-hydrogen-type electrodes. a hot pass is a second pass, at higher welding cur-rents, used to help eliminate and float out any difficult to remove slag particles.

After the root pass and hot pass (if needed) are completed, the groove is filled by layering with overlapping weld beads. Fill passes are used to complete the interior portion of multi pass groove welds. Fill passes are used to nearly fill the groove, leaving only enough space for the cap passes, the final weld layer. It is necessary to maintain an even layer-by-layer approach at this stage.

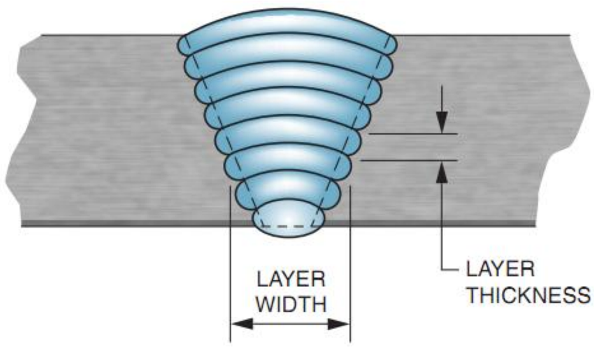


Fig5.6. Filling pass

Weld Pass

A single progression of welding along a joint is the result of a pass weld bead or layer.

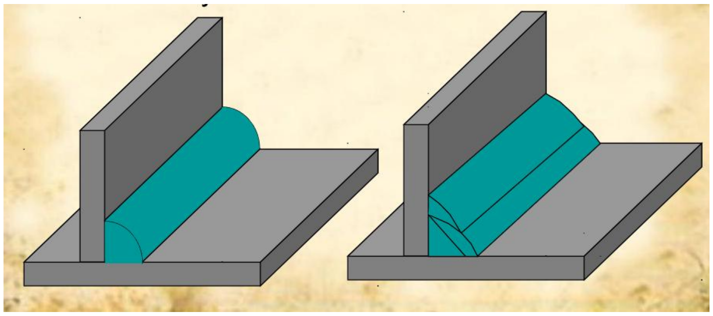


Fig 5.7 welding pass

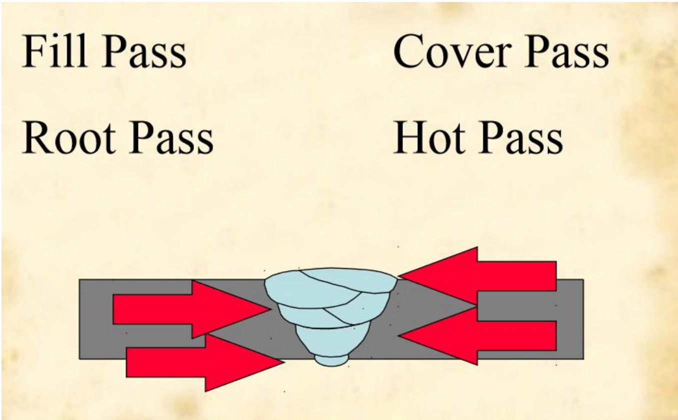


Fig 5.8 different pass

- **Reasons for Poor Weld**

✓ Machine adjustment too high or too low

✓ Electrode size too large or too small

- ✓ Improper movement of electrode
- ✓ Improper angle of electrode
- ✓ Improper base metal preparation
- ✓ Arc length too long or too short

4.8. Perform capping

- **Capping run or cosmetic pass**

This pass is completed successfully when, as its name indicates, its sole purpose is to fulfill a cosmetic role. In other words, it is essential to fill the whole of the groove without under-thickness in excess of 1 or 1.5mm during the end of f filling stage. In this situation, the oscillation pass used for the capping run provides the surplus material required to join the two diameters without creating undercuts in the uphill part.

- **Weaving Capping Weld**

It is possible to increase the fill rate of the rod by using a weaving motion. In the video a single weaving cap weld is used to complete a single v- joint. A slightly curved side to side motion is used to widen the weld and increase the fill. The direction is reversed when the arc reaches the edge of the v.

The flux covering the weld will make the weld appear wider than it really is. It can be tricky to judge the width of weave necessary. One trick is to draw two chalk lines on some scrap, try to weave between the chalk lines leaving the weld at the edge, then remove the slag and see how close you got.

- **The Completed Cap**

The cap weld is wider and lower than a single bead. Had the other side of the joint been prepared and welded in a similar manner the joint would have had close to full penetration. The advantage of welding both sides is it reduces distortion and reduces the number of passes required for complete penetration. The capping weld will shrink as it cools and pull the work into a bend. If the plate was welded from both sides the weld on the reverse would tend to straighten the work.

The cap pass is the final visible weld layer on a multi pass groove weld. Several factors must be met for the final weld and weld layer to be acceptable. First of all, the weld penetration including reinforcement has a minimum thickness equal to the base metal thickness. Second, the reinforcement height cannot exceed code requirements, and in most cases, this is 1/8” maximum. The cap pass width should be as narrow as possible while filling the groove completely. Finally, the weld must have a smooth transition to the base metal at the weld toes.

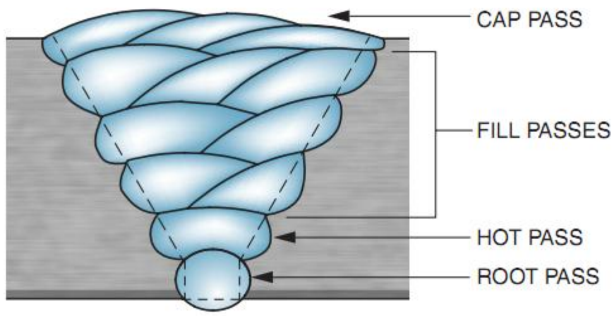


Fig 5.9 root pass, hot pass, fill passes, and cap pass.

4.9. Remove defects

Remove *defects* with minimum loss of sound metal using correct and appropriate techniques and tools.

4.9.1. General Procedure

- ✓ Surface defects shall be removed by grinding with CARBIDE BURR CUTTERS only. Abrasive-type wheels and stones are not allowed on vacuum base metal surfaces.
- ✓ Ground surface repairs shall be visually inspected to verify that the nonconformity has been removed or the indication reduced to an acceptable limit.
- ✓ The reduced material thickness shall be checked by a depth micrometer or an ultrasonic thickness gauge.

- **For Repairs Requiring Welding:**

- ✓ Remove the defect by grinding with CARBIDE BURR CUTTERS only or by chipping and grinding with CARBIDE BURR CENTERS to an acceptable level. Abrasive-type wheels and stones are not allowed on vacuum welds.
- ✓ Visually inspect the area prepared for welding.

- ✓ Re-Weld in accordance with a Buyer approved welding procedure.
- ✓ Welded repairs shall be visually inspected after welding

- . **For Fillet Weld Repairs Requiring Welding:**

- ✓ Remove the unacceptable weld metal by an approved method.
- ✓ If the full fillet weld is not completely removed, visually inspect the area prepared for welding.
- ✓ Re-Weld in accordance with a Buyer approved welding procedure
- ✓ Welded repairs shall be visually inspected after welding

4.10. Ensuring weld deposit

- **Formation of surface deposits**

Electrodes that have been kept for long periods of time in non-ideal storage conditions, usually form a white powdery deposit on the flux coating. This deposit is produced by a chemical reaction between the carbon dioxide in the atmosphere and the sodium silicate of the flux binder. This reaction forms crystals of sodium carbonate and silica powder. If there are heavy deposits on the covering it is possible that rusting of the core wire has occurred, which may lead to hydrogen-induced cracking. Heavy surface deposits indicate that re drying of the electrodes is required.

- **Deposition rate**

The deposition rate is the rate that weld metal can be deposited by a given electrode or welding wire, expressed in pounds per hour. It is based on continuous operation, not allowing time for stops and starts caused by inserting a new electrode, cleaning slag, termination of the weld or other reasons. The deposition rate will increase as the welding current is increased.

When using solid or flux cored wires, deposition rate will increase as the electricalstick-out is increased, and the same amperage is maintained. True deposition rates for each welding filler metal, whether it is a coated electrode or a solid or flux cored wire, can only be established by an actual test in which the weldment is weighed before welding and then again after welding, at the end of a measured period of time.

The deposition rate describes how much usable weld metal will be deposited in one hour of actual arc-on time.

It based on continuous operation, not allowing time for stops and starts caused by inserting a new electrode, des lagging or other reasons.

- Comparison of Deposition Rate for different Welding process

Table 6.1 Comparison of Deposition Rate for different Welding process

Welding process	Typical Deposition Rate (kgr/hr)
Shielded Metal Arc Welding (SMAW)	2 ÷ 4
Fluxed Cored Arc Welding (FCAW)	5 ÷ 7
Submerged Arc Welding (SAW) - Wire	6 ÷ 9
Submerged Arc Welding (SAW) – Strip: 60x0,5 mm	12 ÷ 14
Electro Slag Welding (ESW) – Strip: 60x0,5 mm	22 ÷ 28

4.11. Clean and free joints from discontinuities

Cleaning Joint free from discontinuity

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.

- **Edge Preparation of a Joint:**

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, reshaped, etc. The choice of various edge shapes depends upon the kind, and thickness of metal to be welded. Some different types of grooves for edges of the work are shown in Fig.5.10.

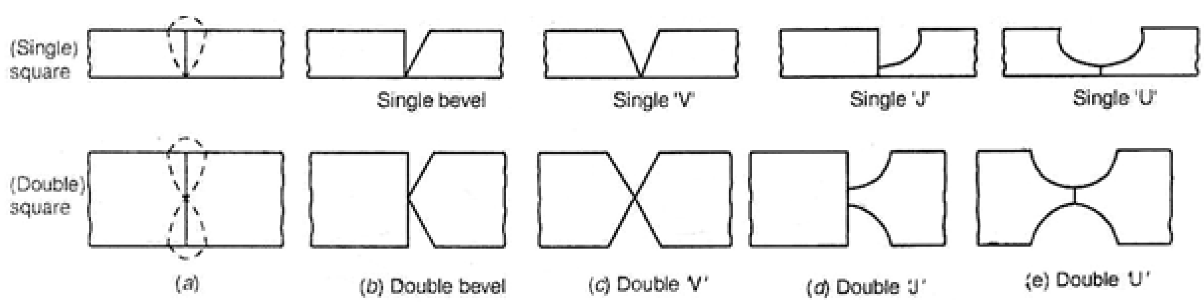


Fig5.10. Edge Preparation

(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 5.10. (a).

(ii) **Single- V-Butt:**

It is used when the thickness of the plates is from 8 to 16 mm. Both the edges are bevelled to form an angle of about 70° to 90°, as shown if Fig.5.10. (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 Fig. 5.10. (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 Fig. 5.10. (d) and (e).

4.12. Weld Joints

The weld joint is where two or more metal parts are joined by welding. The five basic types of weld joints are the butt, corner, tee, lap, and edge, as shown in figure

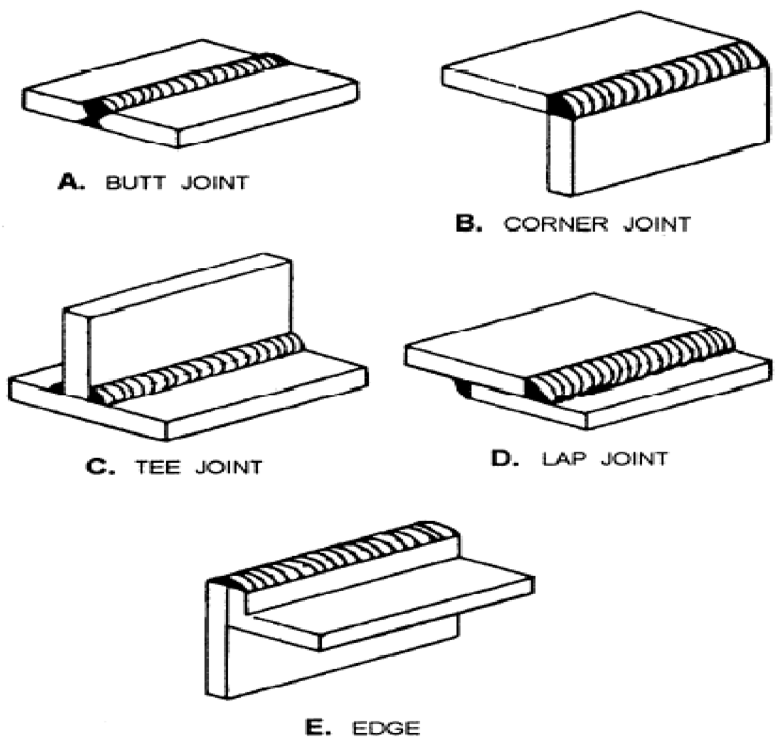


Fig5.11. Basic weld joints

Self check -5

Directions: Answer all the questions listed below.

I. Say true or false

1. Grinder is used to grind the surface of the weld to give a more uniform surface.
2. The deposition rate will increase as the welding current is increased.
3. The cap weld is wider and lower than a single bead.
4. Chipping hammer is used to grind after welding to smooth the weld-meant.
5. To remove the slag, strike the weld with a chipping hammer.

II. Choose the best answer

1._____is the initial pass deposited after the work piece is fit up.

A. Root pass C. Cap pass

B. Filling pass D. Hot pass

2. . One of the following can contaminate the weld metal and cause defects in the weld:

A. Scale B. rust C. grease D. All

3. . The choice of various edge shapes depends upon ____________

A. kind of metal to be welded C. Thickness of metal to be welded

B. Color of metal to be welded D. A and C

1. List at least four reasons for poor weld (4pts).

III. Match Column "A" with Column "B"

"A"	"B"
_____1. used to clean up the surface of the weld	A. Cap pass
____2. Second pass deposited after the root pass	B. Fill pass
_____3.The final visible weld layer	C. wire brush
	D. Root pass

Operation Sheet - 5

1. Operation Title: Perform SMAW welds
2. Instruction: Applying root and fill passes ensure SMAW deposits.
3. Purpose: By implementing Root and subsequent filling pass perform clean and free joints from discontinuities.
4. Required tools and equipment:
    - SMAW welding machine
    - Grinding machine
    - Personal safety equipments
5. Precautions: Apply all safety requirements.
6. Procedures:
    - Step1. Safety (clean work area &wear PPE)
    - Step2. Select proper tools and equipment.
    - Step3. Identify materials.
    - Step4. Prepare material based on the required
    - Step5. Align joints using d/t aligning method
    - Step6. Set up welding machine on stable position
    - Step7. Adjunct the welding machine based on the material weld
    - Step8. Clamp the ground cable
    - Step9. Perform tack welding based on standards
    - Step10. Perform root pass
    - Step11. After finishing the work cleaning the work area.

7. Quality criteria: Welding quality, dimension and safety procedure free from

Project

Prepare Root pas with the given dimension

Thickness= 5mm, joint position= 2G/horizontal, joint type=single square groove one pass, process= arc welding, diameter=2.4, current = 90-130A, voltage=12v,Travel speed mm/min=125,Types of current=DCEN &DCEP, Heat Input KJ/min=0.8,Eledrode E6013

Notes

Tack joint securely to prevent root closure

Use the appropriate electrode

LAP Test 5 : 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.Perform root pass weld

Task2. Perform subsequent filling passes weld

Unit Six: Remove Defects and Re-Welding
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: ❖ Weld defects ❖ Weld defect removal ❖ Visual test of defects ❖ verification of defect removal ❖ Re-Welding tasks 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: • Locate and mark weld defects • Identify weld defects remove • Perform visual test to verify the extent of removal of defects • Verify the extent of defect removal • Perform Re-Welding tasks

Remove Defects and Re-Welding

6.1. Weld Defects and Their Causes

1. Lack of Penetration

Lack of penetration is the failure of the filler metal to penetrate into the joint.

It is caused by:

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

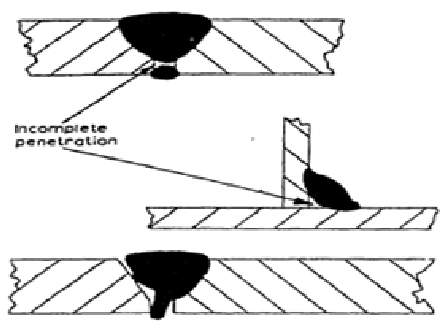


Fig.6.1. Lack of penetration

2. Lack of Fusion

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

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

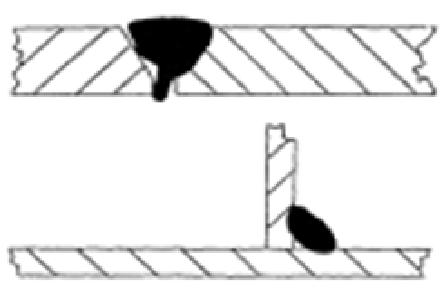


Fig.6.2. Lack of fusion

3. Porosity

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

- The welding point was not sufficiently covered with shielding gas during weld solidification.
- The welding area is damp.
- The welding area is contaminated.
- The weld is coated with paint or inorganic material that is not cleaned before welding.
- The welding electrodes/ flux are not baked or electrodes have excessive moisture.

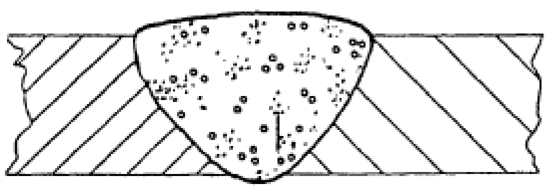


Fig.6.3. Porosity

4. Slag Inclusion

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

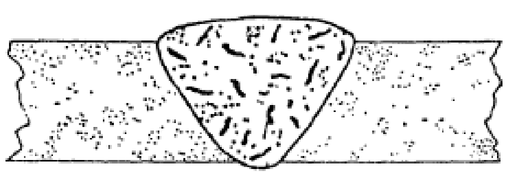


Fig.6.4. Slag inclusion

5. Undercut

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

- Too fast a travel.
- Too great a heat build-up.

- Bad welding technique

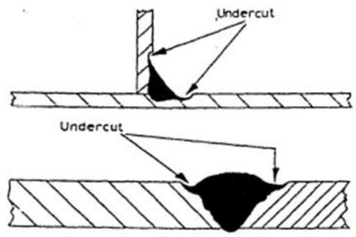


Fig.6.5. Undercut

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

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

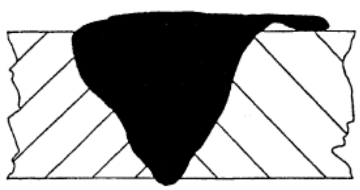


Fig.6.6. Overlay

7. Welding Crack

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

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

Fig.6.7. Crackling

8. Blowholes

- Blowholes are large holes in the weld caused by:
- Gas being trapped, due to moisture.

- Contamination of either the filler or parent metals.

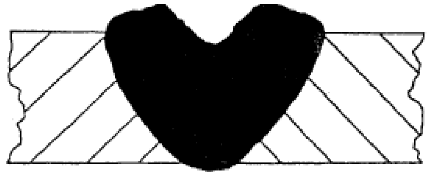


Fig.6.8. Blowholes

9. **Burn Through**

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

- Poor edge preparation
- Too great a heat concentration

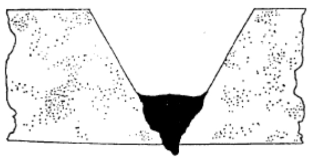


Fig.6.9. Excessive Penetration

6.2. Weld defect removal

- **Remedies to avoid Lack of Penetration**

✓ Enlarge the root opening.

✓ Increase welding heat input.

✓ Shorten the arc length.

✓ Reduce the welding speed.

✓ Use vertical uphill welding technique.

- **Remedies to avoid Lack fusion**

✓ Increase the heat input or change the mode of metal transfer.

✓ Clean the area before welding from any rust or scale.

✓ Reduce the welding speed.

✓ Weld uphill direction so the arc is ahead of the weld pool.

- ✓ Change the torch angle to ensure full fusion.

- **Remedies** to **preventive Porosity**
  - ✓ Sufficiently covered the welding point with shielding gas during weld solidification.
  - ✓ Dry the work piece before welding.
  - ✓ Make the welding area free from contamination.
  - ✓ Clean the weld coated with paint or inorganic material before welding.
  - ✓ Always keep the welding electrodes/ flux free from excessive moisture.

- Remedies to avoid **Slag Inclusion**

Sufficiently clean the base metal before welding.

- **Remedies to avoid Undercut**

Reduce the arc length or reduce the voltage.

Correct the torch angle.

Reduce the weld weaving or use stringer beads.

Change your welding technique.

- **Remedies to avoid Overlays**

Apply sufficient heat during welding.

Remove contamination of the surface of the parent metal before welding.

Use good welding technique.

- **Remedies to avoid Welding Crack**

Use a common ratio between the depth and width of the weld

Use a common ratio between the depth and width of the weld.

Tack the components without tension.

Choose a suitable filler material.

Low hydrogen electrodes must be baked prior to the use.

Use preheat to reduce the residual weld stresses

- **Remedies to avoid Blowholes**

Keep either the filler or parent metals or electrode from contamination.

6.3. Following are the preventive measures for stopping the welding porosity:

- Improve the shielding gas coverage.
- Dry the work pieces before welding.
- Clean the work piece before welding.
- Remove unwanted coatings.
- Bake the welding electrodes/ flux before use.

6.4. Visual test of defects

Visual inspection is a non-destructive testing (NDT) weld quality testing process where a weld is examined with the eye to determine surface discontinuities. It is the most common method of weld quality testing.

Advantages of nondestructive weld quality testing:

- Inexpensive (usually only labor expense)
- Low cost equipment
- No power requirement
- Quick identification of defects and downstream repair costs due to issues that weren't caught early

Disadvantages:

- Inspector training necessary
- Good eyesight required or eyesight corrected to 20/40
- Can miss internal defects
- Report must be recorded by inspector
- Open to human error

6.5. 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

6.6. Visual Weld Equipment

- **Fillet Weld Gauge**

Visual Inspection before Welding

- Check drawings
- Look at the weld position and how ti corresponds to the specification. Watch the vertical direction of travel
- Check fillet welding symbols
- Does the procedure align with local codes and the weld specification

Weld Material Inspection

- Do the materials purchased match the specification for base metal size and type? Check electrode size, gas selection and grade.
- Check materials for defects. Look for contaminants such as rust, scale, mill, lamination etc.
- Are materials prepared for correct angles

Assembly Inspection

Follow these weld quality testing steps for assembly inspection:

- Check for fit
- Alignment of fixtures and jigs. Check cleanliness (look for spatter from previous jobs)

- Check quality if tack welds are used. The tack weld must be made with the same electrode as the main weld (s).
- Check use of pre heat to slow the cooling rate and to minimize distortion

Inspection after Welding

- Check weld against code and standards
- Check size with gauges and prints
- Check finish and contour
- Check for cracks against standards
- Look for overlap
- Check undercut
- Determine if spatter is at acceptable levels
- Verification of defect removal

6.7. Verification/proof of fault elimination

In the fault elimination step several actions could be taken such as adjusting, aligning, calibrating, reworking, removing, and replacing

6.8 Re-Welding tasks

- **Repair Procedure**

When a repair welding procedure is required, the procedure shall be established and qualified to demonstrate that a weld with suitable mechanical properties and soundness can be produced. This shall be determined by destructive testing and the type and number of such tests shall be at the discretion of the company. The repair procedure, as a minimum, shall include the following:

- Method of exploration of the defect.
- Method of defect removal.
- The repair groove shall be examined to confirm complete removal of the defect.
- Requirements for preheat and inter pass heat treatment.
- Welding processes and other specification information
- Requirement for inter pass nondestructive testing.

Self check -6

Directions: Answer all the questions listed below.

I. Say true or false

1. Visual inspection is a destructive testing method.
2. Reduce the welding speed can avoid lack of penetration.

II. Choose the best answer

1._____is caused by the trapping of gas during the welding process,

A. Slag inclusions C. Lack of penetration

B. Porosity D. Weld crack

2. Which one is the fault elimination step action?

A. Replacing C. Adjusting

B. Removing D. All

1. One of the following is advantages of nondestructive weld quality testing.

A. Low cost equipment C. Open to human error

B. Can miss internal defects D. Inspector training necessary

3. Burn through is the collapse of the weld pool due to_________________.

A. Poor edge preparation C. Too great a heat concentration

B. Insufficient heat D. A and C

4. One of the following is not the preventive measures for stopping the welding porosity?

A. Remove unwanted coatings C. Wet the work pieces before welding

B. Improve the shielding gas coverage D. Clean the work piece before welding

Match Column "A" with Column "B"

"A"	"B"
_____1. Lack of Fusion	A. Blowholes
_____2. Large holes in the weld	B. Insufficient heat
_____3. Reduce the arc length or reduce the voltage	C. welding torch
	D. Remedies to avoid undercut

Operation Sheet 6

1. Operation Title: Remove Weld defects
2. Instruction: Identify welding defects visually and mark weld defects correctly.
3. Purpose: To remove weld defects and to re-weld
4. Required tools and equipment:
    - SMAW welding machine
    - Grinding machine
    - Personal safety equipments
5. Procedure

- Step1. Clean the welded work piece.
- Step2. Inspect the welded part.
- Step3. Identify defects
- Step4. Locate and mark the defect part.
- Grind defects
- Set up SMAW machine
- Step5. Clean the work area.

6. Precautions: Apply all safety requirements.
7. Quality criteria:

Unit Seven: Assure Weld Quality Conformance
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: ❖ Quality weld ❖ Material backing ❖ Weld joints Visual inspection ❖ Weld records ❖ OHS procedures and requirements ❖ Defective hand tools and equipment 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: • Make welded parts free from weld defects • Back Material according to WPS requirements • Inspect visually weld joints for conformance to specifications. • Complete and maintain weld records and completion details correctly. • Observe OHS procedures and requirements throughout this unit • Report defective hand tools and equipment for repair or replacement

Assure Weld Quality Conformance

7.1. Introduction to Quality weld

The most common quality problems associated with SMAW include weld spatter, porosity, poor fusion, shallow penetration, and cracking.

Weld spatter, while not affecting the integrity of the weld, damages its appearance and increases cleaning costs. Secondary finishing services are often required due to the aesthetic appearance caused by the occurrence of molten splatter. It can be caused by excessively high current, a long arc, or **arc blow**, a condition associated with direct current characterized by the electric arc being deflected away from the weld pool by magnetic forces. Arc blow can also cause porosity in the weld, as can joint contamination, high welding speed, and a long welding arc, especially when low-hydrogen electrodes are used.

Arc blow

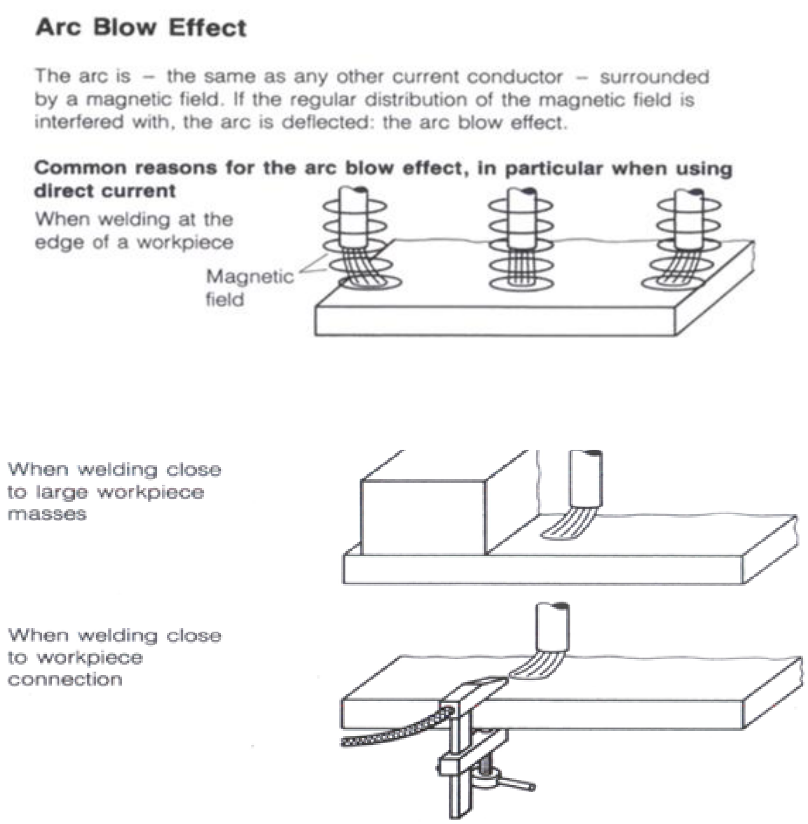


Fig.7.1. Arc blow

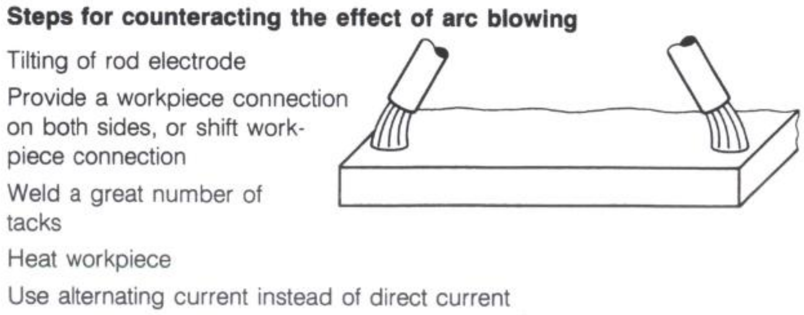


Fig.7.2. Effect of arc blowing

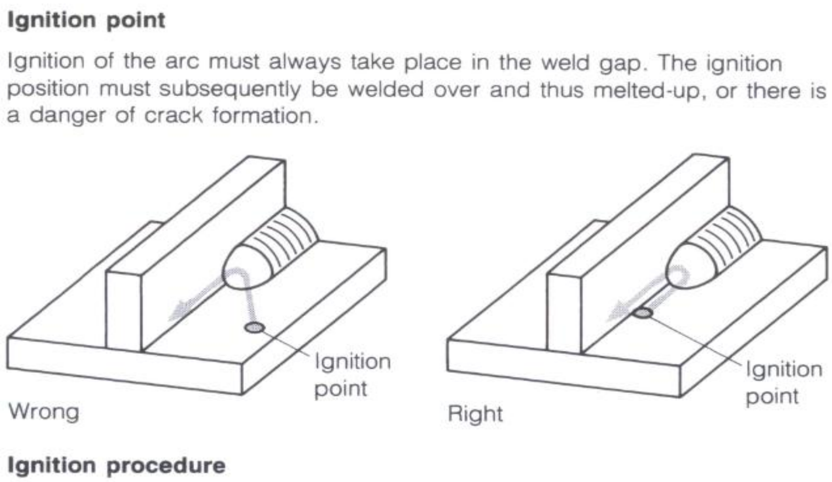


Fig.7.3. Ignition procedure

7.2. Material backing

Backing material

Permanent backing material is known as a backing strip. Temporary backing material is known as a backing bar.

Backing strips are fused into the weld and should:

- be no less than 3 mm thick and be of sufficient size to ensure they do not burn through
- have weldability not less than that of the parent metal
- Fit as close as possible with a maximum gap between the parent metal and the backing strip of 1.5 mm.

7.3. Weld joints Visual inspection

- **Inspecting Weld joint visually**

Visual examination is the most important and the most universally accepted method of inspection. This procedure covers the visual examination of welding in components such as -plates, welds, etc. by using Visual and Optical aids and Gauges.

- **Ensuring Weld Quality through**

There are two types of welding inspection

Destructive testing (DT)

(DT) is the process of breaking the material at certain distance for inspection.

- ✓ Mechanical tests
- ✓ Metallurgical tests

Nondestructive testing (NDT)

Nondestructive testing is also known as nondestructive examinations or evaluation (NDE) or inspection.

- ✓ *Visual Examination*
- ✓ X-ray fluorescence
- ✓ *Ultrasonic Examination (UT)*
- ✓ Eddy current etc.

Nondestructive testing (NDT) provides the ability to monitor various aspects of material and product quality without compromising part integrity. Many NDT technologies can be applied to ensure proper manufacturing and functionality. Three such techniques is VISUAL INSPECTION, ultrasonic, eddy current and X-ray fluorescence can be used together in manufacturing operations to ensure use of proper materials, identify near surface cracking and provide volumetric detection of critical defects.

Visual Inspection Procedure of Weld Joints

Visual inspection should be applied in the following ways:

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 deposition
- root 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 each 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.

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.

Aides to visual inspection are devices such as a torch, fillet gauges, calipers, other measuring devices, and a low powered (up to 10x) magnifying glass.

The major limitation of visual inspection is that it will disclose only surface defects, and only defects that can be seen by the naked eye. Fine surface cracks may not be readily apparent by visual inspection, but may be easily detected by some other method.

Fillet Weld Gauge is an essential weld quality testing tool. It is used to check fillet leg size, checking fillet throat size.

Fig. 7.4. **Fillet Weld Gauge**

a. Ultrasonic testing (UT) is one of the oldest and most established NDT technologies, UT utilizes pulses of high-frequency sound waves to detect hidden cracks, voids, porosity and other internal discontinuities in metals, composites, plastics and ceramics. Because sound waves travel through materials in predictable ways and reflect off defects and imperfections, like cracks, the internal condition of weldments or other test pieces can be determined by monitoring the pattern of the ultrasonic echoes that UT generates.

Ultrasonic flaw detectors are small, microprocessor-based instruments suitable for use both in the shop and the field. They typically include an ultrasonic pulser/receiver, hardware and software for signal capture and analysis, a waveform display and a data logging module. Traditional flaw detectors provide a waveform display for analysis, while advanced phased array instruments add the ability to generate cross-sectional images of the test piece, similar to medical ultrasound imaging.

Weld inspection is the single most common industrial application for ultrasonic testing. Ultrasonic flaw detection is a comparative technique. Probes, called transducers, generate high-frequency sound waves and are coupled to the test piece through a layer of liquid or gel. A trained operator uses appropriate reference standards along with knowledge of sound wave propagation and generally accepted test procedures to identify specific echo patterns and compare them to the echo patterns produced from intact areas and from representative flaws. Through this process, an operator is able to determine the test piece’s condition. In manufacturing applications, metal and plastic welds and most types of adhesive bonds can be tested.

Eddy current testing (EC) is based on principles of magnetism. It is widely used in the aerospace industry and other manufacturing applications that require inspection of thin metal for potential safety or quality problems. In addition to detecting cracks in metal sheets, tubes and manufactured parts, eddy current can be used for certain metal thickness measurements such as identifying corrosion under aircraft skin, measuring conductivity, monitoring effects of heat treatment and determining the thickness of nonconductive coatings, like paint, over conductive substrates.

Eddy current testing is based on the physics of electromagnetic induction. In an eddy current probe, an alternating current flows through a wire coil and generates an oscillating magnetic field. If the probe and its magnetic field are brought close to a conductive material, a circular flow of electrons, known as an eddy current, will begin to move through the metal like swirling water in a stream. The flowing eddy current generates its own magnetic field, which interacts with the coil and its field through mutual inductance. Changes in metal thickness or defects like near-surface cracking interrupt or alter the eddy current, resulting in changes of electrical impedance in the coil. The resultant impedance amplitude and phase angle change can be used by a trained operator to identify changes in the test piece.

Since eddy current is best used for detecting surface-breaking cracks, one of its most practical applications is inspecting welded structures that are subject to cyclical loading, which can lead to fatigue crack propagation in critical welded areas. Eddy current inspection of conductive materials offers several benefits over competing inspection techniques. Traditionally, a suspect weld is stripped and cleaned, then a magnetic particle or liquid penetrate inspection is performed to detect any surface-breaking cracks. These techniques have high consumables cost and require pre- and post-inspection cleanup. Magnetic particle testing is not an option for non-ferritic materials like aluminum and stainless steel. Eddy current uses specially designed weld inspection probes incorporating differential coil probes and dual frequency techniques to test rough weld beads through paint or another coating if necessary. Eddy current NDT enables quick inspection of large areas without the use of coupling liquids.

X-ray fluorescence (XRF) is based on the interaction of matter with X-rays, which are short-wavelength, high-energy beams of electromagnetic radiation. When a primary X-ray beam strikes a substance, it excites elements at the atomic level, causing electron movement. Each element has characteristic emissions of secondary (fluorescent) X-rays when these movements occur, making it possible to identify the elemental composition of the substance. XRF can identify elements with an atomic number of 12 and up (magnesium through uranium). Unlike other technologies, XRF provides qualitative and quantitative material characterization of metals and alloys. XRF is used for material identification, alloy grading, process control and regulatory compliance, such as ROHS. XRF is used in industries like mining and geology, scrap and recycling, precious metals screening, environmental safety, consumer safety and general manufacturing. XRF operates on a material's surface with very little penetration.

For weld inspection, handheld XRF instruments have three applications. They can be used for quality assurance of incoming weld material to ensure compliance with ordering specifications. Since weld rods often have a coating of flux, the proper procedure is to make a weld puddle spot and then analyze the spot with XRF. After welding, XRF can perform compositional analysis of the weld and surrounding base metal as a process check, and also to identify deposited weld material after surface treatment like grinding or machining.

Nondestructive testing of welds is an important part of any quality control program. While each of the three technologies described has both strengths and weaknesses, when used together, they provide the most complete assessment of material and weld quality.

7.4. Weld records

Completing and maintaining Weld records and completion details

The weld number and the welder's identification number are also recorded on beside the actual weld. Other information such as the serial numbers of the weld head and power supply may be entered into some orbital welding plants and printed out along with the weld program which identifies the parameters of the welding sequence, these are then file with the weld coupons to form part of the overall welding handover package.

These weld records are combined with the Material Test Reports (MTRs or materials certificates) which list the chemical composition and test data of the heats of materials used. Surface finish test reports, and results of pressure testing, passivation, and other documentation required by the Design Specification must be presented to and retained by the owner/user for a required period of time.

Weld record Sheets Information

A weld record sheet is used to track the critical information for each specific weld completed in a system. Figure 1 below illustrates a typical weld record sheet which is sub divided into 4 main sections these being:

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

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

Once complete the project engineer reviews it and verifies that all welds are completed, tested and accepted it can then be signed approved and included in the overall handover documentation package.

Header Section

Client: The company name who the work is being completed for.

Client project No.: A unique number assigned by the client for the work being completed.

Approved by: Signature of the person approving the weld record sheet

Project No.: A unique number assigned by the contractor for the work being completed. It is usually used to track costs and progress on a particular project.

Machine Serial No.: The serial number of the welding machine used to carry out the welding. It is unique to each machine and if faults are discovered and linked back to this machine, it makes it easier for all welds completed by this machine to be tracked and re-inspected after the fact.

Machine model No.: The type of model of welding machine used to complete the welding.

System: *The name of the system being welded, e.g. Pure steam, product etc.*

Line/Iso No.: *This is the isometric drawing number or the line number for which the welds that are being recorded are on.*

Sheet No.: Sometimes there may be 3 or 4 isometrics for one line therefore they are grouped together as sheet 1 of 5, 2 of 5 etc.

Weld Information Section:

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

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

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

Weld date: The date the weld was completed.

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

Process: Automatic or manual, most welds should be automatic which are more consistent and therefore more likely to pass inspection.

Manual welds are only used where the fitting to fitting distance is reduced to a point where the automatic weld heads will not fit and therefore a manual weld is required. These are only usually allowed by prior approval of the client and usually require 100% inspection.

Material Information Section:

Component / Component: This identifies the different components either side of a weld, e.g. Pipe/elbow or elbow/tee etc..

Cast No. / Cast No.: Also known as the heat number it identifies the batch of material that the component was manufactured from. It was once a requirement that the cast number had to be the same each side of the weld to ensure consistent welding, however due to improved manufacturing techniques it is now possible for mills to repeatedly produce material which is consistent and which has tightly tolerance ingredient amounts. This consistency in the materials of the components ensures that the finished welds are of a high quality.

Testing Information Section

NDT Report No.: Non Destructive Test report No., this allows the weld record sheet to be cross referenced to the independent test report.

NDT type: Usually baroscopic (optic fibre with a camera on the end that is pushed down the tube and rotated to record the internal profile of each weld. The baroscopic is non hazardous, quick, can be carried out during normal working hours and gives instant feedback and there is generally used for 90% of the welds on a system. The other option is to X-ray the weld to get a radiographic picture of the weld, this is usually done on closing welds where it is not possible to gain access for the baroscopic. X-rays are usually done at night out of hours to reduce the risk of exposure to radiation sources and the films have to be developed therefore the results are slower.

NDT date: The date the weld was inspected.

Accept or Reject: The result of the NDT inspection. See Phase 4, module 2 Unit 8 for accept / reject criteria.

FAS

Client : ________________ FAS Project No.: ________________ System: ________________

Client Project No.: ________________ Machine Serial No.: ________________ Line / Iso. No. : ________________

Approved By : ________________ Machine Model No.: ________________ Sheet : ________ of ________

Weld Information								Material Information				Test Information				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Weld No.	Welders No.	Weld Size	Weld Date	Location		Process		Component /	Component	Cast No. /	Cast No.	NDT Report No.	NDT Type	NDT Date	Accept or Reject	Inspectors Initials
				Shop	F.W.	Auto	Man.									
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																

Inspector initials: Proof from the welding inspector that each of the individual welds was inspected and that the result is valid

7.5. OHS procedures and requirements

- **Welding Safety Procedures**

Welding safety starts with an understanding of what could go wrong, and preparation for when it does. Risks include electric shock, injuries related in inhalation of toxic fumes, eye injury and skin burns. To start, protective clothing and equipment must be worn during all welding operation including helmets and shields.

For arc welding, the electric arc is a very powerful source of light, including visible, ultraviolet, and infrared. During all electric welding processes, operators must use safety goggles and a hand shield or helmet equipped with a suitable filter glass to protect against the intense ultraviolet and infrared rays. When others are in the vicinity of the electric welding processes, the area must be screened so the arc cannot be seen either directly or by reflection from glass or metal.

During all SMAW processes, the operators must use safety goggles to protect the eyes from heat, glare, and flying fragments of hot metals.

Also be sure to keep MSDS sheets (Material Safety Data Sheets) for all hazardous materials. Every manufacturer provides MSDS sheets to keep you informed regarding any potential hazards, such as if a respirator is needed when working on a project.

Welding safety starts with having the right protective gear. This includes:

Respirator/Welders Mask: There are multiple types of respirators. Buy the one that is made for welders and the type of projects you will be performing. If purchasing a mask with a filter, match the filter to the types of metals and coatings used.

Keep the area clean and check any gasses for signs of leaks.

Ventilation: All welding areas should have proper ventilation. Check with OSHA for the up to date standards. Poor ventilation leads to "plume poisoning". If you suspect that be inhaled a toxic plume seek medical help immediately.

Storage: All flammables should be stored in a flammable liquids locker.

Eye protection: welding eye protection protects against injuries from debris and from

the effects of the ultraviolet light. Different types of helmets are made to protect you

when performing different types of welding. These vary by shade number, having a passive or auto-darkening lens (automatically adjusts to welding rays) and comfort/fit.

Fire protection: Sparks created during the welding process can start fires. For welding Class C extinguishers are often used since these are for electrical fires. Sand and water can also help to extinguish fires.

Protective Clothing: All skin areas need to be protected to protect against molten metal and sparks.

This includes:

- Long sleeve shirts
- Pants that cover the tops of shoes
- Gloves
- shoes or boots
- Hair is protected with something called a welder's beanie
- Leather jackets are also effective for protection from slag and sparks
- Leather aprons provide some protection when sitting down
- Shoe covers called spats protect shoes, something helpful if you are working on a project that produces sparks and slag (molten metal)

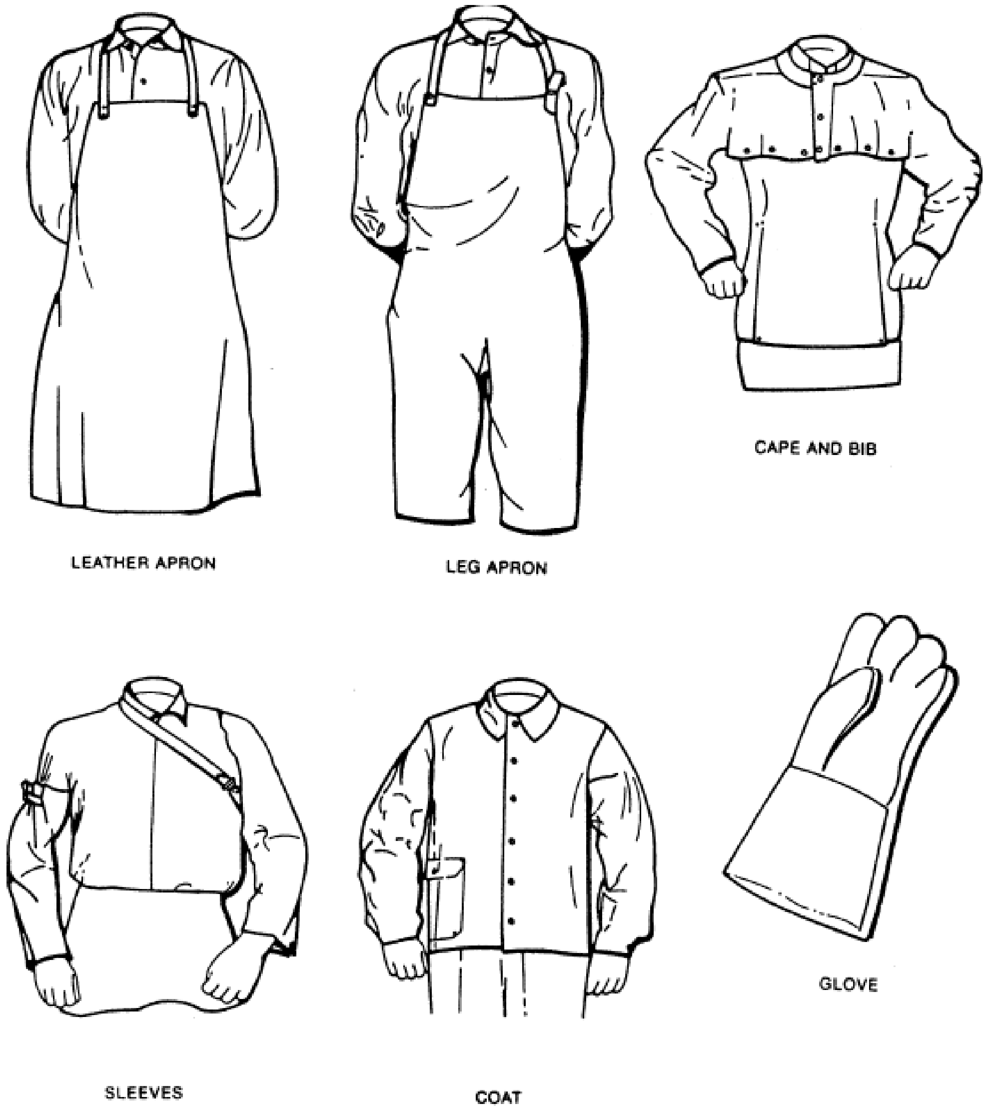


Figure7.5. Welder’s protective clothing

Welding Safety Tip:- Use pliers when handling metals. If you believe a metal is cool, use the back of the hand and slowing bring it closer to the metal. You'll feel the heat as you get closer if it is too hot to handle.

Prepare for Accidents: Keep a first aid kit on hand that includes bandages and burn spray. Consider an option that exceeds ANSI (American National Standards Institute) and OSHA guidelines such as this first aid kit.

7.5.2. **The Primary hazards associated with ARC welding processes are:**

- ✓ Electric Shock.

- ✓ Eye Flash or "Retinal Burn".
- ✓ Flash or Arc-Burn.
- ✓ Toxic fumes and gas.

- **Electric Shock.**

- ✓ To avoid electric shock you should be observe the following "rules":
- ✓ Switch off a machine when it is not in use.
- ✓ Place electrode-holders off the work when not in use. Do not leave them lying on the ground, or on top of the welding machine. An electrode-holder stand is ideal for storing the holder.
- ✓ Keep all equipment dry. Damp (wet) equipment is a "killer". Dry all equipment if it is wet, but only do this with the machine ISOLATED from the input power supply.
- ✓ Do not stand on wet ground or floors when welding. Stand on wooden "duck-boards" or a rubber mat, especially if the workbench is made of metal.

- **Eye Flash or "Retinal Burn".**

The electric "arc" from the electrode tip produces intense "visible light" as well as heat. Both "Infra-red" and "ultra-violet" light rays are generated in the arc. Looking directly into an arc with "unprotected eyes" will almost certainly result in "permanent eye damage"

To prevent eye injury, follow these procedures:

- ✓ Always wear a "welders helmet' when welding.
- ✓ Wear anti-flash goggles when you are in the vicinity of arc welding operations.
- ✓ Erect suitable "flash screens" around your work area to shield other workers from the arc.
- ✓ Do not "lift your visor" when striking an arc. Even the short duration of a flash can result in "arc-eye

- **Flash or Arc-Burn.**

This is by far the commonest injury reported (and not reported) by welders. Flash burn is basically the same as "sun burn" and it affects any part of the body that is not covered. Flash burn can affect anyone within a 5 - 6 meter radius of the arc.

To avoid flash burn practice the following:

- Roll down the overall sleeves in order to cover the arms.
- Always wear "chrome-leather welding gloves".
- Keep the shirt or the overall fully buttoned during the welding process. Alternatively wear a "welder's cape" that covers the upper chest and shoulders.
- Always wear your "welder's helmet", or use a "welders mask". These not only protect your eyes but they also shield your face from arc rays.

7.5.1.3. **Toxic fumes and gas.**

During the welding process, flux burns of the electrode and "fumes" are generated. Some fumes, depending on the type of flux used on the rods, can be "toxic" therefore adequate "ventilation" must be applied to the welding area. The use of "extraction units" (exhaust ducts) to carry off fumes is essential in some applications.

Note that toxic fumes will be generated when welding "galvanized (zinc coated) steel", or materials containing lead, copper and cadmium.

Follow these precautions when welding:

- Make sure that there is plenty of "fresh air" surrounding your work area. Never weld in a "confined space" where there is no fresh air entering or flowing.
- Use a "fume extractor" (exhaust vent) when welding at a "welding bay" (indoors).
- Read the safety / health warnings provided on the packaging of electrodes and follow the advice and warnings given regarding fumes.

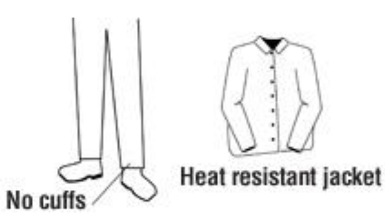
7.5.3. **Measures to protect skin from welding radiation**

- Wear tightly woven work-weight fabrics to keep UV radiation from reaching your skin.
- Button up your shirt to protect the skin on the throat and neck.
- Wear long sleeves and pant legs.
- Cover your head with a fabric cap to protect the scalp from UV radiation.
- Protect the back of your head by using a hood.

- Protect your face from UV radiation by wearing a tight-fitting, opaque welder's helmet.
- Make sure that all fabric garments are resistant to spark, heat and flame. Keep the fabrics clean and free of combustible materials that could be ignited by a spark

Welding - Personal Protective Equipment and Clothing

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

Welding - Personal Protective Equipment			
Body Part	Equipment	Illustration	Reason
Eyes and face	Welding helmet, hand shield, or goggles		Protects from: radiation flying particles, debris hot slag, sparks intense light irritation and chemical burns Wear fire resistant head coverings under the helmet where appropriate
Lungs (breathing)	Respirators		Protects against: fumes and oxides
Exposed skin (other than feet, hands, and head)	Fire/Flame resistant clothing and aprons		Protects against: heat, fires burns radiation Notes: pants should not have cuffs, shirts should

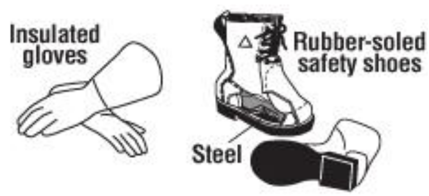
			have flaps over pockets or be taped closed
Ears – hearing	Ear muffs, ear plugs		Protects against: noise Use fire resistant ear muffs where sparks or splatter may enter the ear, rather than plugs.
Feet and hands	Boots, gloves		Protects against: electric shock heat burns fires

Fig7.6. Personal Protective Equipment

Tips to know when using protective clothing

DO

- Wear clothing made from heavyweight, tightly woven, 100% wool or cotton to protect from UV radiation, hot metal, sparks and open flames. Flame retardant treatments become less effective with repeated laundering.
- Keep clothing clean and free of oils, greases and combustible contaminants.
- Wear long-sleeved shirts with buttoned cuffs and a collar to protect the neck. Dark colors prevent light reflection.

- Tape shirt pockets closed to avoid collecting sparks or hot metal or keep them covered with flaps.
- Pant legs must not have cuffs and must cover the tops of the boots. Cuffs can collect sparks.
- Repair all frayed edges, tears or holes in clothing.
- Wear high top boots fully laced to prevent sparks from entering into the boots.
- Use fire-resistant boot protectors or spats strapped around the pant legs and boot tops, to prevent sparks from bouncing in the top of the boots.
- Remove all ignition sources such as matches and butane lighters from pockets. Hot welding sparks may light the matches or ignite leaking lighter fuel.
- Wear gauntlet-type cuff leather gloves or protective sleeves of similar material, to protect wrists and forearms. Leather is a good electrical insulator if kept dry.
- Using a shield can help keep any sparks spray away from your clothing.
- Wear leather aprons to protect your chest and lap from sparks when standing or sitting.
- Wear layers of clothing. To prevent sweating, avoid overdressing in cold weather. Sweaty clothes cause rapid heat loss. Leather welding jackets are not very breathable and can make you sweat if you are overdressed.
- Wear a fire-resistant skull cap or balaclava hood under your helmet to protect your head from burns and UV radiation.
- Wear a welder's face shield to protect your face from radiation and flying particles.

DO NOT

- Do not wear rings or other jewelry.
- Do not wear clothing made from synthetic or synthetic blends. The synthetic fabric can burn vigorously, melt and produce bad skin burns.
- Procedures and steps in handling fire extinguisher
- Remove safety pin

Remove the hose from the clip.

Hold the hose and directly aim to the base of the fire.

Position yourself approximately 2.0 to 2.5 meters away from the fire and press the release lever

While pressing the release lever, move it side to side with the nozzle aimed at the base of the fire.

Fig7.7. Procedures and steps in handling fire extinguisher

7.6. Identify defective hand tools and equipment

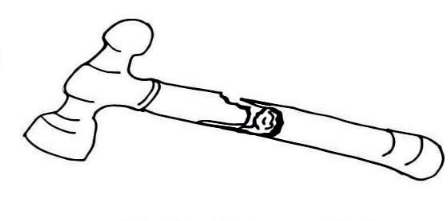
Tools are very useful to us in our homes, especially to our job. It can help us make our work easy as it aids us to be more effective, and work faster. But tools that are no longer functional may cause harm.

There are many ways of identifying hand tools. One of these is to identify them according to their function. However, awareness of defective and non-defective hand tools is the earliest concern of workers/welders to be effective in their jobs.

- **Functional tools and equipment -** refer to the tools and equipment that are in good condition and can effectively complete its regular functions. This can be noticed first by its appearance as it is the most obvious thing to be seen. A functional tool and equipment can help you work faster and make your task much easier than usual.
    - **Non-functional tools and equipment** - refer to the tools and equipment that are no longer capable of performing its regular function because of some damaged parts. A non-functional tool can also cause harm if it is still used in its current defective state. That is why it is important for us to label correctly a tool that is no longer functional and defective to avoid harm.

Given below are some examples of non-functional and defective tools and equipment.

Broken Ball-peen hammer handle



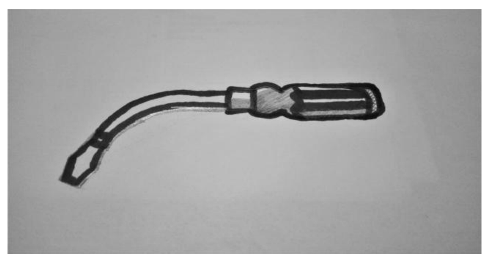
Causes:

Mishandling

The material used (wood) for the handle is substandard

Worn-out handle (due to the amount of time of it being used)

Bent Screwdriver



Causes:

Mishandling

Substandard material was used in making the tool

Chipped Flat screwdriver head

Broken side cutting pliers handle

Causes:

Mishandling

Brittle metal material

Accumulation of rust on the screwdriver head.

Worn-out

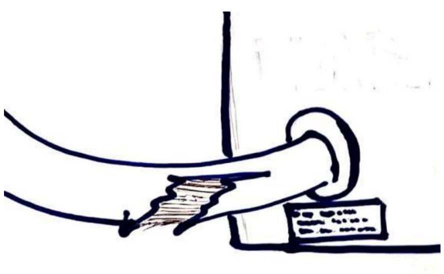
Causes:

Mishandling

Substandard material was used in making the tool.

Worn-out

Damaged welding cable



Causes:

Mishandling

Brittle cable

Accidentally cut by a sharp object

Worn out

Broken grinder blade

Causes:

Mishandling

Chipping on the brittle surface

Worn out

Self-Check 7

Directions: Answer all the questions listed below.

I. Say true or false

1. A weld record sheet is used to track the critical information for each specific weld completed in a system.
2. Non-functional tools and equipment are tools and equipment that are in good condition.
3. Machine model number isthe type of model of welding machine used to complete the

II. Choose the best answer

1. Defective hand tools are kept and ___________.
   A. marked as defective.
   B. mixed together with non-defective tools.
   C. put anywhere in the shop.
   D. sold in the junk shop.
2. From the following one is destructive testing method
   A. Mechanical tests C. X-ray fluorescence
   B. Visual examination D. Eddy current
3. Which one of the following is section of welding record sheet?
   A. Test information C. Weld information
   B. Material information D. Header E. All
4. __________nondestructive testing method is based on principles of magnetism
   A. Ultrasonic examination C. Eddy current testing
   B. X-ray fluorescence D. Visual examination
5. Which personal protective equipment is used to protect against noise?
   A. Gloves C. Respirators
   B. Ear plugs D. Helmets

Operation Sheet -7

1. Operation Title: Observe OHS procedures and requirements
2. Instruction: Identify weld hazards and their causes correctly in the SMAW welding.
3. Purpose: To identify and minimize weld in SMAW welding.
4. Required tools and equipment:
    - Respirator/Welders Mask
    - Protective Clothing
        - Long sleeve shirts
        - Pants that cover the tops of shoes
        - Gloves
        - shoes or boots
    - Ventilation
5. Procedure

- Step1. Clean the welded work area.
- Step2. Inspect the welded Work shop.
- Step3. Identify hazards
- Step4: Identify Cause
- Step5. Take corrective action

6. Precautions: Turn off breaker before checking electric cables connection
7. Quality criteria: Safe work area.

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.

Operation Sheet 2	safety (OHS) procedures

Procedures for to clean work area free from accident

Step 1. Remove any flammable matter from the area.

Step 2. Ensure that the area has adequate "ventilation" (fresh air).

Step 3.Check that exhaust fans are running

Step 4. Remove all obstacles or debris

Step 5.Wear the appropriate personal protective equipment.

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

List of Reference Materials

Basic Welding and Fabrication W. Kenyon, ISBN 0-582-00536

Fundamentals of Fabrication and Welding Engineering . FJM, Smith ISBN 0-582-09799

Workshop processes, practices and materials, 3rd edition, ElsevierScience & Technology. Black, Bruce J 2004, ISBN-13: 9780750660730

Book on Welding Engineering Technology by Dr.R.S.Parmar.

Book on Welder Trade Theory published by National Instructional Media

Institute, Chennai (under Directorate General of Employment and Training,

Ministry of Labour and Employment, Govt. of India).

Book "Welding notes for Artisans" issued by Basic Training Centre (C&W), Nagpur Division, Central Railway.

Suggestions received during seminar held on 14th November, 2011 at CAMTECH

Gwalior on "Welding process for good quality weld"

http://www.M2_U3_Manual%20Metal%20Arc%20Welding.pdf

http://www.distortioninweld.pdf

http://www.weldingdefects-150304091946-conversion-gate01.pdf

hppt:%20%2012/6013%20Welding%20Rod,%20Settings,%20Polarity%20and%20Amps%20-%20MechanicWiz.Com.htm

http://www./Ensuring%20Weld%20Quality%20through%20Nondestructive%20Techniques%20%20%202016-04-01%20%20%20Quality%20Magazine.htm

http://www./Preheating%20can%20be%20critical%20to%20welding%20success.htm

http://www./Welding%20Preheat%20With%20Induction%20Improves%20Consistency%20and%20Saves%20Time%20%20%20MillerWelds.htm

http://www./Ensuring%20Weld%20Quality%20through%20Nondestructive%20Techniques%20%20%202016-04-01%20%20%20Quality%20Magazine.htm

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