Mechanics

LEVEL III

Learning Guide-18

Unit of Competence: Perform Plate and Tube Shielded Metal Arc Welding (SMAW)

Module Title: Performing Plate and Tube Shielded Metal Arc Welding (SMAW)

Module code: XXX
LG Code: XXX
TTLMCode: XXX

LO 1: Prepare welding materials

Instruction Sheet	Learning Guide #18

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

- Identifying weld requirements.
- Determining correct size, type and quantity of materials/ components.
- Alignment of materials to the specification

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

- Identify weld requirements.
- Determine correct size, type and quantity of materials/ components.
- Align materials to the specification

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 5.
3. Read the information written in the information "Sheet 1, Sheet 2 and Sheet 3
4. Accomplish the "Self-check 1, Self-check 2 and Self-check 3" **in page 12, 26, and 31 respectively**.
5. If you earned a satisfactory evaluation from the "Self-check" proceed to next **LO in page - 32.**

Information Sheet-1	Identifying weld requirements

1. Introduction

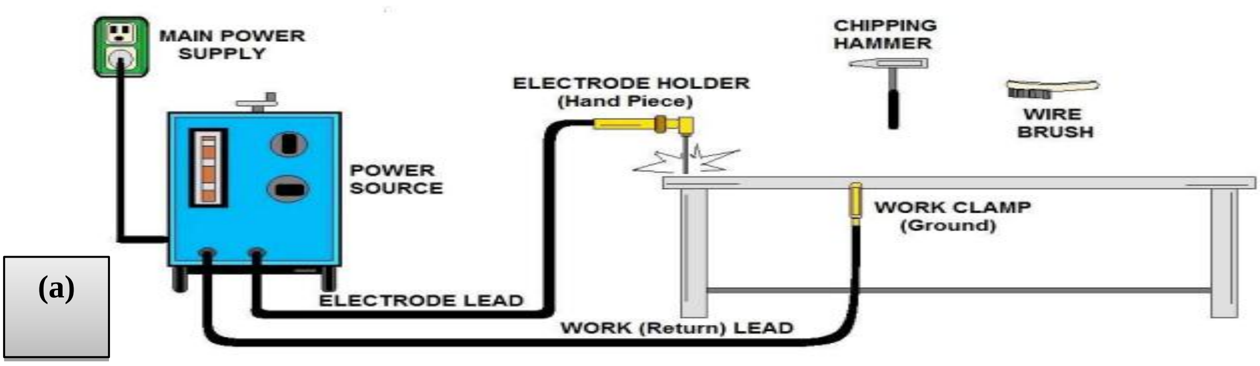
1.1 History of welding

Methods for joining metals have been known for thousands of years, but for most of this period the only form of welding was forge welding by a blacksmith. A number of totally new welding principles emerged at the end of 19th century; sufficient electrical current could then begenerated for ***resistance welding*** and ***arcwelding.*** Arc welding was initially carried out using carbon electrodes, developed by Bemados, and was shortly followed by the use of steel rods. The Swede Oskar Kjellberg made an important advance when he developed and patented the coated electrode.

1.2. Definition of welding Process

Shielded metal arc welding (SMAW) is a process that melts and joins metals by heating them with an arc established between a sticklike covered electrode and the metals, as shown in Figure 1.1. It is often called *stick welding*. The electrode holder is connected through a welding cable to one terminal of the power source and the work piece is connected through a second cable to the other terminal of the power source (Figure 1.1*a*). The core of the covered electrode, the core wire, conducts the electric current to the arc and provides filler metal for the joint. For electrical contact, the top 1.5 cm of the core wire is bare and held by the electrode holder. The electrode holder is essentially a metal clamp with an electrically insulated outside shell for the welder to hold safely.

The heat of the arc causes both the core wire and the flux covering at the electrode tip to melt off as droplets (Figure 1.1b&*c*). The molten metal collects in the weld pool and solidifies into the weld metal. The lighter molten flux, on the other hand, floats on the pool surface and solidifies into a slag layer at the top of the weld metal.



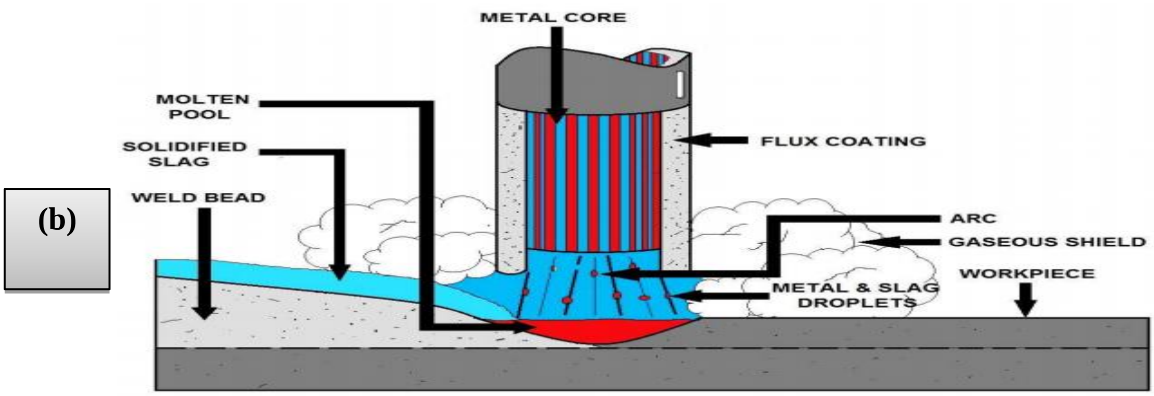


Figure 1.1 Shielded metal arc welding: (*a*) overall process; (*b*) welding area enlarged

1.3. Variables

The characteristics of the weld (size of bead and penetration) can be controlled by adjusting the following variables when welding:

- size and type of electrode
- amperage (changed on the stick welding machine)
- speed that you move the electrode along the joint being welded (called the speed of travel)
- arc length (distance between the metal and the tip of the electrode). A rule of thumb is to use an arc length equal to the diameter of the core wire inside the electrode.
- electrode angle
  - perpendicular (90 degrees) enables the most penetration
  - 45 degrees equates to less penetration
- weld width controlled by side to side motion of the electrode
- polarity control (the direction the electrical current flows) when using DC or direccurrent

1.4. Advantages and Disadvantages

Advantages

- Versatility - readily applied to a variety of applications and a wide choice of electrodes
- Relative simplicity and portability of equipment
- Low cost
- Adaptable to confined spaces and remote locations
- Suitable for out-of-position welding

Disadvantages

- Not as productive as continuous wire processes
- Likely to be costlier to deposit a given quantity of metal
- Frequent stop/starts to change electrode
- Relatively high metal wastage (electrode stubs)
- Current limits are lower than for continuous or automatic processes (reduces deposition rate)

1.5 Safety

Mishaps frequently occur in welding operations. In many instances, they result in serious injury to thewelder or other personnel working in the immediate area. In most cases, mishaps occur because of carelessness, lack of knowledge, and the misuse of available equipment. Precautions that apply to specific welding equipment are pointed out in the chapters that cover that equipment. In this section we are particularly interested in such topics as protective clothing, eye protection devices, and practices applicable to the personal safety of the operator and personnel working nearby.

1.5.1. Workshop safety

workshop is where you learn to use tools and machines to make things; It can be a dangerous place, so you must learn the safety rules for the workshop.

The safety rules tell you how to dress appropriately and how to behave whilst working with tools that may cause harm. You must never play in the workshop, run around or throw equipment to one another.

1.5.2. Personal safety:

The basic dress rules that you should always follow are:

Before you set up your welding and strike an arc, you'll first prepare your safety tools and equipment for welding. **(SMAW)**

- **Proper clothing.**

You must not wear loose clothes that can be caught in moving machinery. You must wear tight fitting overalls as shownin Figure.1.2.

Figure. 1.2: Correct dress in the workshop.

- **Proper shoes.**

You must not wear sandals or soft shoe inside the workshop as they will not protect your feet from falling objects. A safety shoes (steel-toe shoes) will protect your feet if you accidentally drop something. A safety shoe is shown inFigure.1.3.

The way you dress in the workshop is very important for your safety, always be sure to wear properly and encourage your friends to do the same.

Figure. 1.3: Shows a safety shoe

- **Proper eye protection.**

You must always wear goggles to protect your eyes while you are working in the workshop. A safety goggles is shown in Figure.1.4

Figure. 1.4: Safety shield/ Helmet

- **Welding Hand gloves**

Gloves must always be worn when arc welding. Special welding gloves with long gauntlets are necessary. These must be of leather. Long lined welding gloves are recommended for welding withcoated electrodes show figure 1.5

Figure. 1.5hand Gloves

1.6. Arc Welding Safety Precaution

A. Do not simultaneously touch the ground clamp and the electrode.

B. Do not weld around combustibles.

C. Locate the nearest fire extinguisher before welding.

D. Do not operate in wet areas, wear wet or damp clothing, or have wet hands.

E. Use the correct size welding cables.

F. Check to be sure that cables, holder, and connections are properly insulated.

G. Do not change welding current setting while making a weld; cut off power to welderbefore making internal adjustments or cleaning.

H. Do not operate the polarity switch while welding (DC welders only).

I. Never place the electrode holder on the table top, or in contact with a grounded metalsurface.

J. Wear protective gear and clothing at all times.

K. Wear goggles with a clear lens when chipping slag.

L. Never weld on drums, barrels, or tanks until proper safety precautions have been taken toprevent explosions.

M. Do not weld in a confined space without adequate ventilation.

N. Special precautions are necessary when welding lead, zinc, beryllium, copper, orcadmium, or items coated with these metals. Never inhale the fumes. A specific andcommon example is galvanized pipe.

O. Cool or mark such hot work "HOT" so that you and others will not touch it and getburned. Be careful not to scald yourself from the steam produced when quenching.

1.7. Welding Procedures

There are many factors involved in the preparation of any welded joint. The detailed methods and practices used to prepare a particular weldment are called the **welding procedure.** A welding procedure identifies all the welding variables pertinent to a particular job or project. Generally, these variables include the welding process, type of base metal, joint design, welding position, type of shielding, preheating and post heating requirements, welding machine setting, and testingrequirements.

Welding procedures are used to produce welds that will meet the requirements of commonly used codes. The American Welding Society (AWS) produces the *Structural Welding Code* that is used for the design and construction of steel structures.

Another code that is used for the construction of steam boilers and pressure vessels is published by the American Society of Mechanical Engineers (ASME). These codes provide a standardized guide of proven welding practices andprocedures. While you are not directly responsible for developing welding procedures, you could be assigned to a welding job that requires you to follow them. For example, when a job is assigned to a Naval Construction Force unit, it is accompanied by a set of drawings and specifications.

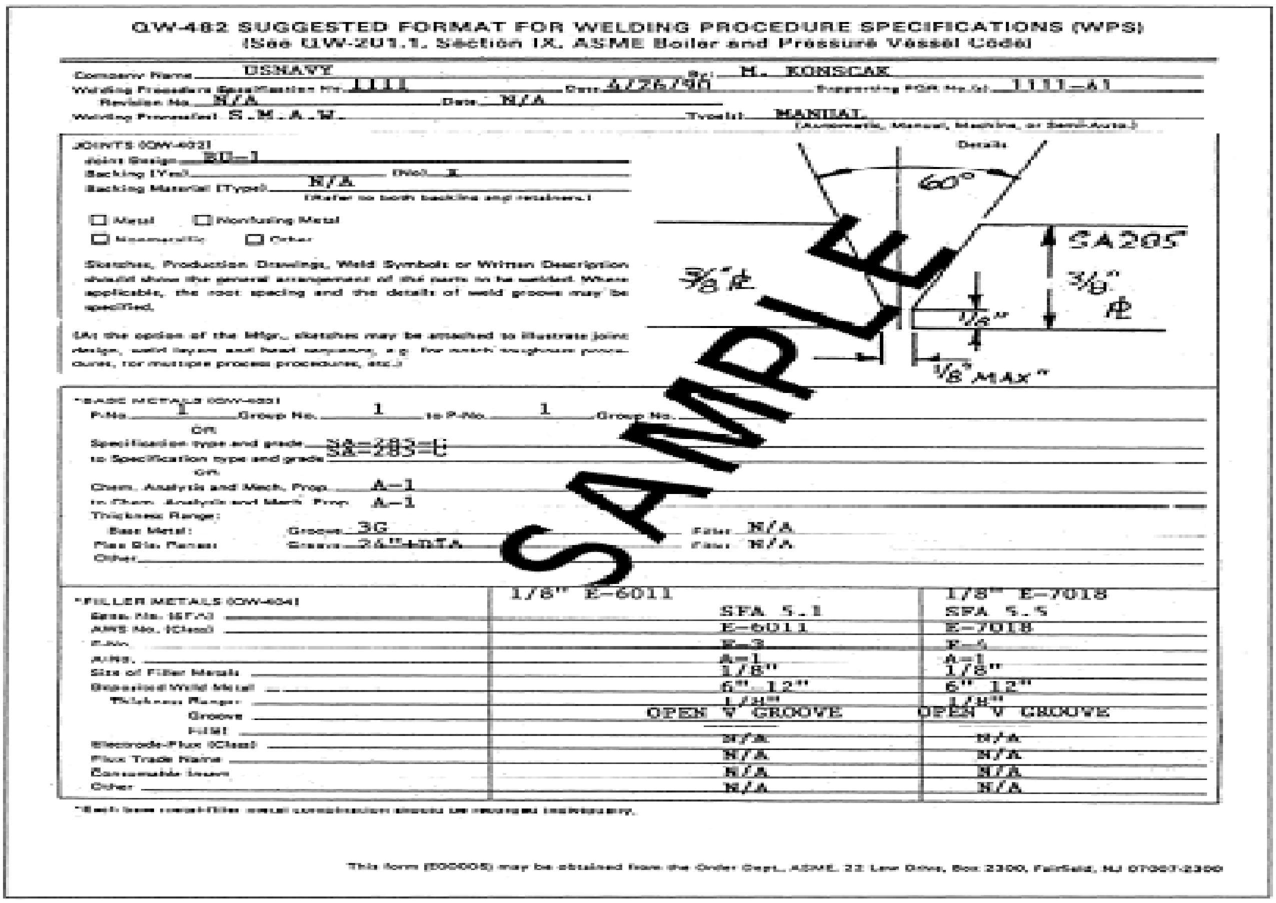
When there is welding required for the job, the specifications normally require it to be accomplished according to a specific code requirement. For instance, if your unit is tasked to fabricate a welded steel structure, the specifications may require that all welding be accomplished according to AWS D1.1 *(StructuralWelding Code).* The unit is then responsible for ensuring that the welders assigned to the job are qualified to produce the welds according to this welding procedure specification. As shown in figure 1.6, a welding procedure specification is simply a document that provides details of the required variables for a specific welding application.

1.8. Drawings

Drawings or sketches are used to convey the ideas of an engineer to the skilled craftsman working in the shop. As a welder, you must be able to work from a drawing in order to fabricate metal parts exactly as the engineer has designed them.

- **Reading Drawings**

To read a drawing, you must know how engineers use lines, dimensions, and notes to communicate their ideas on paper. In this section, we briefly discuss each of these drawing elements. For a more thorough discussion, refer to publications, such as *Blueprint Readingand Sketching,* NAVEDTRA 10077-F1, or to *EngineeringAid 3,* NAVEDTRA 10696.



QW-482 SUGGESTED FORMAT FOR WELDING PROCEDURE SPECIFICATIONS (WPS)
(See QW-201.1, Section IX, ASME Boiler and Pressure Vessel Code)

Company Name USNAVY By: M. KONSCAK
Welding Procedure Specification No. 1111 Date 4/26/90 Supporting PQR No.(s) 1111-A1
Revision No. N/A Date N/A
Welding Process(es) S.M.A.W. Type(s) MANUAL
(Automatic, Manual, Machine, or Semi-Auto.)

JOINTS (QW-402) Details
Joint Design BU-1
Backing (Yes) (No) X
Backing Material (Type) N/A
(Refer to both backing and retainers.)
☐ Metal ☐ Nonfusing Metal
☐ Nonmetallic ☐ Other

Sketches, Production Drawings, Weld Symbols or Written Description should show the general arrangement of the parts to be welded. Where applicable, the root spacing and the details of weld groove may be specified.

(At the option of the Mfgr., sketches may be attached to illustrate joint design, weld layers and bead sequence, e.g. for notch toughness procedures, for multiple process procedures, etc.)

*BASE METALS (QW-403)
P-No. 1 Group No. 1 to P-No. 1 Group No.
OR
Specification type and grade SA-285-C
to Specification type and grade SA-285-C
OR
Chem. Analysis and Mech. Prop. A-1
to Chem. Analysis and Mech. Prop. A-1
Thickness Range:
Base Metal: Groove 3G Fillet N/A
Pipe Dia. Range: Groove 24"+DIA Fillet N/A
Other

*FILLER METALS (QW-404)	1/8" E-6011	1/8" E-7018
Spec. No. (SFA)	SFA 5.1	SFA 5.5
AWS No. (Class)	E-6011	E-7018
F-No.	F-3	F-4
A-No.	A-1	A-1
Size of Filler Metals	1/8"	1/8"
Deposited Weld Metal	6"-12"	6" 12"
Thickness Range:	1/8"	1/8"
Groove	OPEN V GROOVE	OPEN V GROOVE
Fillet		
Electrode-Flux (Class)	N/A	N/A
Flux Trade Name	N/A	N/A
Consumable Insert	N/A	N/A
Other	N/A	N/A

*Each base metal-filler metal combination should be recorded individually.

This form (E00006) may be obtained from the Order Dept., ASME, 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300

Figure 1.6. —Welding procedure specification.

- **Weld symbols**

The information concerning type, size, position, welding process etc. of the welds in welded joints is conveyed by standard symbols in drawings. The symbolic representation includes elementary symbols along with a) supplementary symbol, b) a means of showing dimensions, or c) some complementary indications. IS: 813 “Scheme of Symbols for Welding” gives all the details of weld representation in drawings.

Elementary symbols represent the various categories of the weld and look similar to the shape of the weld to be made. Combination of elementary symbols may also be used, when required. Elementary symbols are shown in Table 1.1.

Table 1.1 Elementary 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

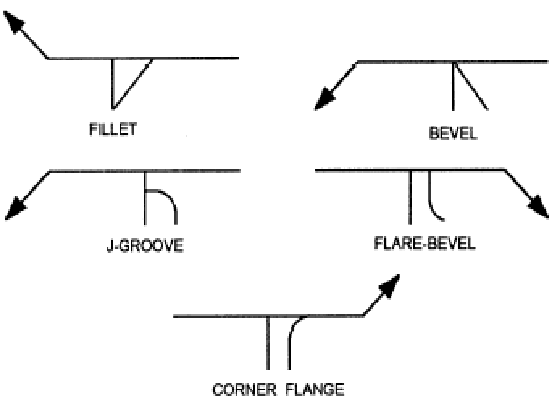


Figure1.7 Weld symbols applied to reference line

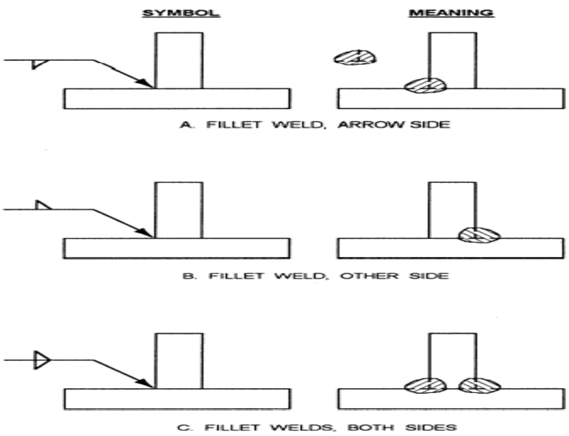


Figure1.8. Specifying weld locations

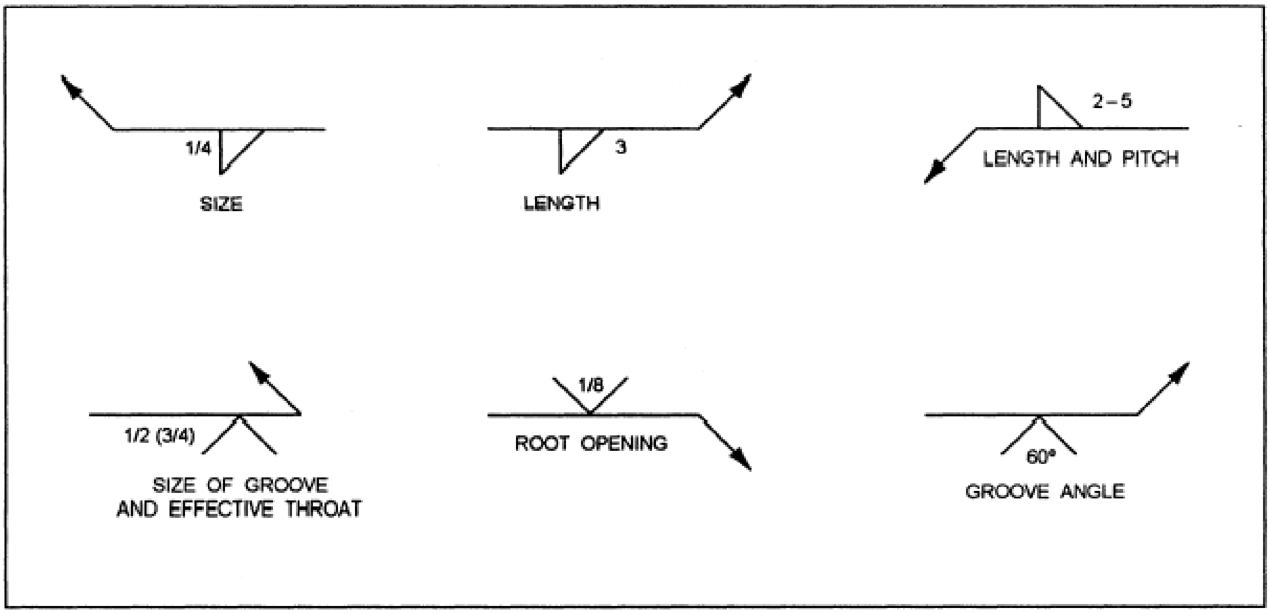


Figure1.9 Dimensions applied to weld symbols.

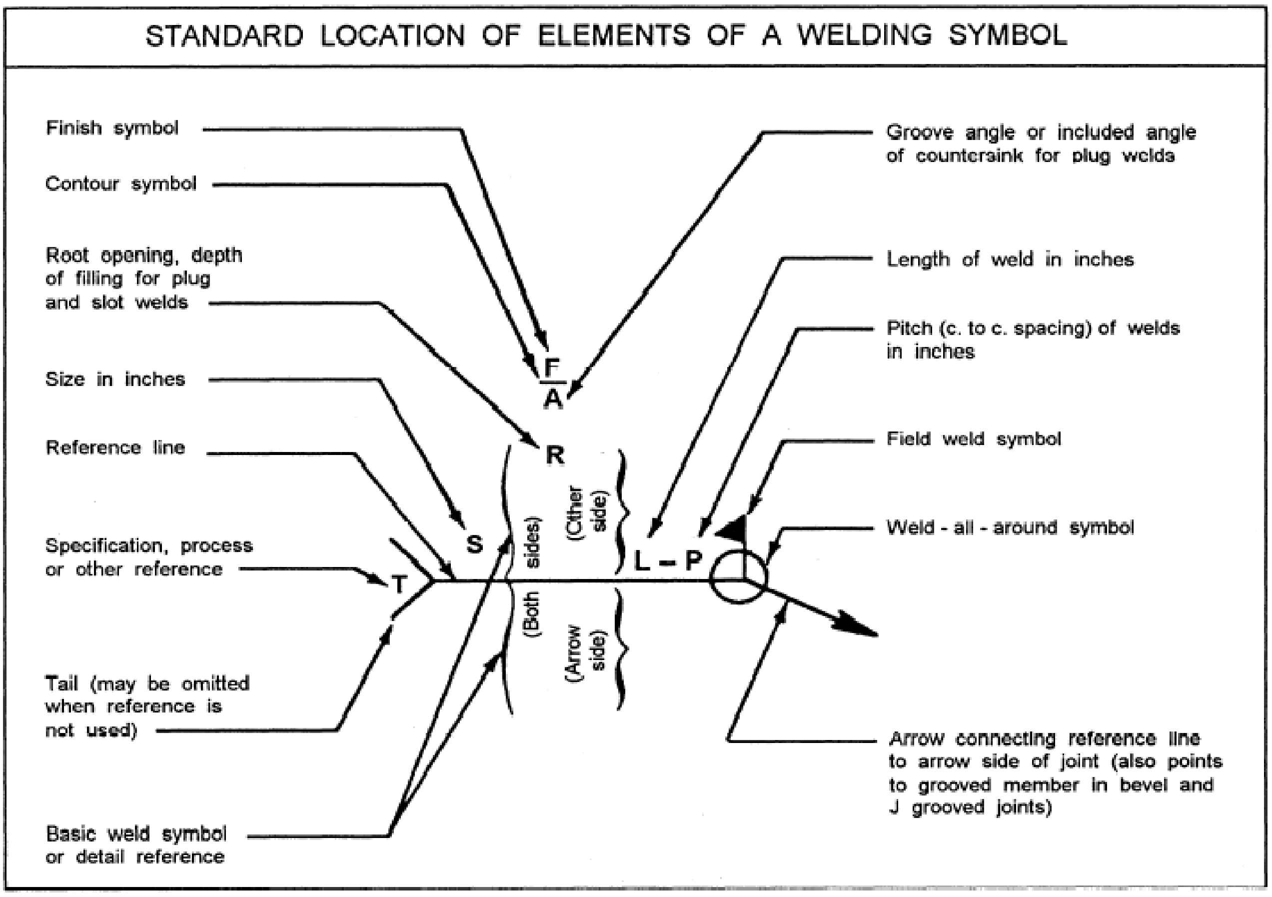


Figure1.10 Standard location of elements of a welding symbols

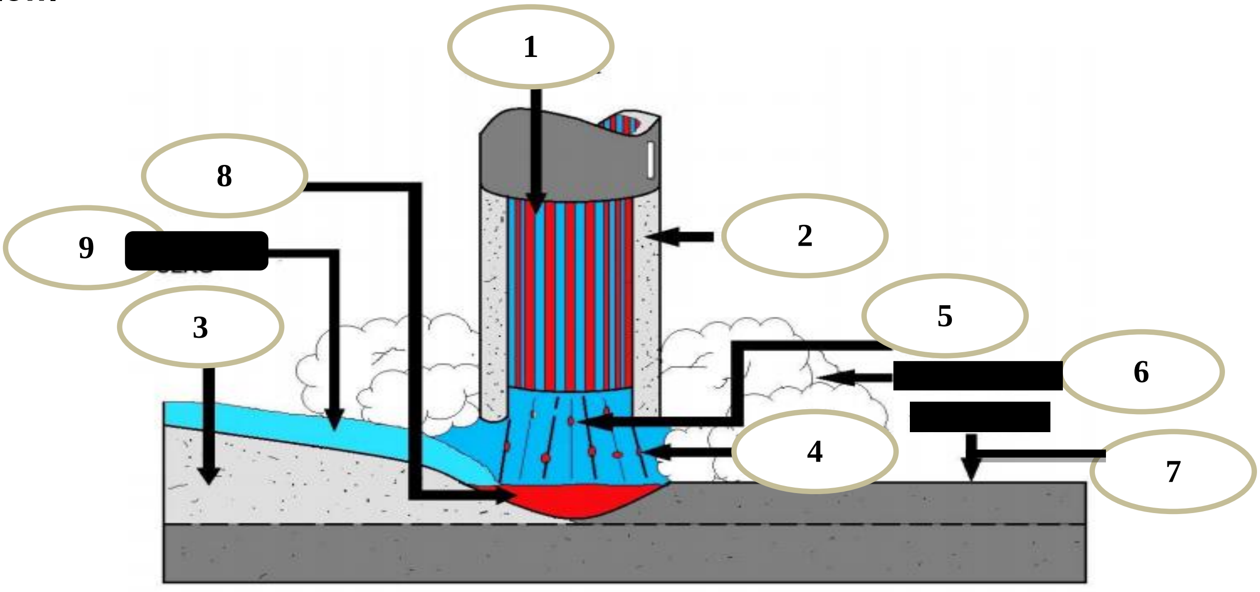
Self-Check -1	**Written Test**

Directions: Answer all the questions listed below.

PART-I: Choose the correct answer for the following

1. __________is a process that melts and joins metals by heating them with an arc established between a sticklike covered electrode and the metals
   A. Material preparation   C. Gas welding
   B. Shielded metal arc welding(SMAW).   D. None
2. Which one is not among welding ***Variables.***
   A. Materials   C. amperage
   B. size and type of electrode   D. speed of travel
3. Which one is not among welding Advantages.
   A. Low cost   C. Frequent stop/starts to change electrode
   B. Suitable for out-of-position welding   D. speed of travel

PART-II: write the name of the part that indicate by number in the process of figure below.



Note: **Satisfactory rating – 8.5 points   Unsatisfactory - below 8.5 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________   Date: _______________

Information Sheet-2	Determining correct size, type and quantity of materials/ components.

2.1. Work piece preparation

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.

2.2. 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***.

2.3. Classification and Uses of Metals

2.3.1. 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.

(1). Cold rolled steel.

(a). Steel formed when cold.

(b). Results in more accurately sized, better surface finished product.

(2). Hot rolled steel.

(a). Metal formed into shape while the metal is red hot.

(b). Produces a uniform quality, commonly used steel.

(c). Bluish scale on the surface formed when water sprayed on the steel as it passes between rollers.

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.

2.3.2. 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 colour and low density

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

2.4. Propertiesofmetals

A. *Tensile Strength*: Ability to resist being pulled apart in tension. Metal failures are often caused by forces exceeding the tensile strength of the part.

B. *Ductility*: Ability to be stretched or pulled through a die to form wire.

: Copper is a very ductile metal.

C. *Hardness*: Ability to resist penetration.

: Hardness can be increased by heat treatment or work hardening.

D. *Elasticity*: Elasticity is the ability of material to return to its original size, shape, and dimensions after being deformed.

E. *Malleability*: Malleability is the property of a metal to be deformed or compressed permanently without rupture or fracture.

F. *Plasticity*: Plasticity is the ability of a metal, such as gold, silver, or lead, to be deformed extensively without rupture.

G. *Toughness*: Toughness is the ability of a material or metal to resist fracture, plus the ability to resist failure after the damage has begun

: Toughness is a combination of high strength and medium ductility.

H.*Brittleness*: The term "brittleness" implies sudden failure.

: It is the property of breaking without warning; that is, without visible permanent deformation.

I. Corrosive Resistance: Corrosive resistance is the resistance to eating away or wearing by the atmosphere, moisture, or other agents, such as acid.

J. Abrasion Resistance: Abrasion resistance is the resistance to wearing by friction.

2.5. Identification of Metals

A. Numbering system for carbon and alloy steels.

1. Four digit (sometimes five digits) numbering system to identify carbon and alloy steels:

(a).First digit usually indicates the principle element in the steel as follows:

<u>**SERIES DESIGNATIONTYPES AND CLASSES**</u>

10XX	**Non-resulferized carbon steel grades (plain carbon steel)**
13xx	Manganese 1.75%
20xx	**Nickel steels**
23xx	Nickel 3.5%
30xx	**Nickel-chromium steels***
31xx	Nickel 1.25% - chromium 0.65 or 0.80%
40xx	**Molybdenum 0.25%**
41xx	Chromium 0.50 – 0.95% - molybdenum 0.15 or 0.20%
43xx	Nickel 1.80% - chromium 0.50 or 0.80% - molybdenum 0.25%*
50xx	**Chromium 0.28 or 0.40%**
51xx	Chromium 0.80, 0.90, 0.95, 1.00 or 1.05%
5xxxx	Carbon 1.00% - chromium 0.50, 1.00 or 1.45%
60xx	**Chrome-vanadium steels**
61xx	Chromium 0.80 or 0.95% - vanadium 0.10 or 0.15% min.
70xx	**Heat resisting casting alloys**
80xx	**Nickel – chrome – molybdenum steels***
86xx	Nickel 0.55% - chromium 0.50 or 0.65% - molybdenum 0.20%
90xx	**Silicon – manganese steels**
92xx	Manganese 0.85% - silicon 2.00%
93xx	Nickel 3.25% - chromium 1.20% - molybdenum 0.12%

*Stainless steels always have a high chromium content, often considerable amounts of nickel, and sometimes contain molybdenum and other elements. Stainless steels are identified by a three-digit number beginning with 2, 3, 4, or 5.

(b). **Second digit** (in alloy steels) represents the approximate percentage of alloy element.

(c). **Third and fourth digits** show the carbon content in points (where a point equals 100 times the percentage carbon).

(d). Examples:

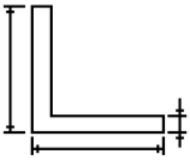
(1). 1095 steel is a carbon steel with 0.95% (95 points) carbon.

(2). 2511 steel is nickel steel with approximately 5% nickel and 0.11% carbon.

IV. Structural Shapesof Metals

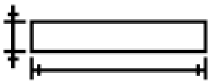
A. Angle

1. Lengths: to 40 feet (20 feet typical)
2. How measured: Leg length x leg length x thickness of legs (inches)



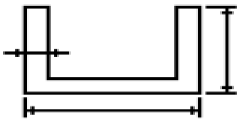
B. Band or strip

1. Lengths: 20 feet
2. How measured: Thickness (less than 1/4") x width (inches)



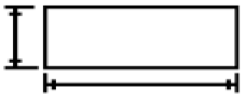
C. Channel

1. Lengths: to 60 feet (20 feet typical)
2. How measured: Depth x web thickness x flange width (inches)



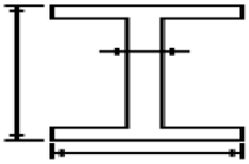
D. Flats

1. Lengths: 20 feet
2. How measured: Thickness (greater than 1/4") x width (inches)



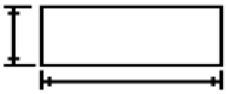
F. I-beam

1. Lengths: to 60 feet (20 feet typical)
2. How measured: Height x web thickness x flange width (inches)



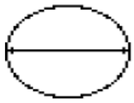
F. Plate (> 1/4")

1. How measured: Thickness x width (inches) x length (inches)
2. Typical widths: 48”, 60”, 72”, 84” and 96”
3. Typical lengths: 96”, 120”, 144”, 192”, 240” and 360”



G. Rod

1. Lengths: 12 to 20 feet
2. How measured: Diameter (inches)

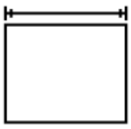


H. Sheet (< 1/4")

1. How measured: Thickness (gauge) x width (widths to 72”) x length (lengths to 240”)

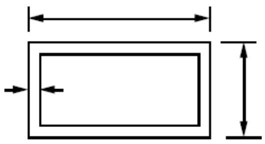
I. Square

1. Lengths: 12 to 20 feet
2. How measured: Width (inches)



J. Square or rectangular tubing

1. Lengths: 12 to 20 feet
2. How measured: Length x width x thickness (inches)



K. Pipe

1. Lengths: 21 feet
2. Types of: Unthreaded ends, threaded ends, beveled ends
3. How measured: Specified by nominal diameter (Does not refer to outside diameter of pipe - roughly equal to the inside diameter for pipes of 1” or greater nominal diameter).

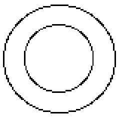
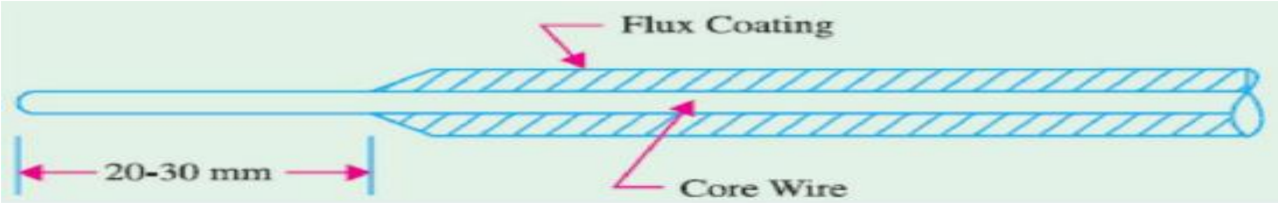


Figure 1.11 Structural shape of Metals

2.6. Type of welding consumables

An electrode is a filler metal in the form of a wire or rod which is either bare or coated uniformly with flux.

Electrode is a coated metal wire having approximately the same composition as the base metal. Standards set forth by AWS (American Welding Society) & ASTM (American Society for Testing Materials). As per IS: 814-1970, the contact end of the electrode is left bare and clean to a length of 20-30 mm. for inserting it into electrode holder (Figure. 1.12.)



- The covered electrode is a very popular type of filler metals used in arc welding.
- The selection of the covered electrode for specific work is based on the electrode usability, the composition and properties of the deposited weld metal.
- In order to properly select an electrode, it is necessary to understand the function of the coating, the basis of specifying, the usability factors, and the deposited weld metal properties.

Figure. 1.12. Consumable Electrode

Consumable Electrodes

i. Bare Electrodes
ii. Coated Electrodes

Consumable electrodes are made up of different metals and their alloys. The end of this electrode starts melting when the arc is struck between the electrode and work piece. Thus consumable electrode itself acts as a filler metal.

Bare electrodes consist of a metal or alloy wire without any flux coating on them.

Coated electrodes have flux coating which starts melting as soon as an electric arc is struck. This coating on melting performs many functions like prevention of joint from atmospheric contamination, arc stabilizers etc.

The Coating of the Electrode provides;

- **Gas** from the decomposition of certain ingredients of the coating shield the arc from the atmosphere
- The **deoxidizers** for purifying the deposited weld metal
- **Slag** formers to protect the deposited weld metal with a slag from atmospheric oxidation
- **Ionizing elements** to make the arc more stable and to operate with alternating current
- **Alloying elements** to provide special characteristics to the deposited weld metal
- **Iron powder** to improve productivity of the electrode

The Binder used for most electrode coatings is sodium silicate, which will chemically combine and harden to provide a tough and strong coating. Covered electrodes can be easily damaged. Therefore, they need special care. Electrodes may become unusable if they are exposed to moisture for an extended length of time. The coatings of some types of electrodes absorb moisture when exposed to humid atmosphere. Cellulose, rutile and acid electrodes are fairly insensitive to moisture and can tolerate quite high moisture content without the risk of porosity in the weld. The coatings of low-hydrogen electrodes pick up moisture quickly when exposed to a high humidity atmosphere. Electrodes should be stored in a special storeroom with controlled atmosphere.

Electrodes can be damaged by aging. Very old electrodes of most types will have a furry surface on the coating, usually white. This is from the crystallization of the sodium silicate.

The coatings of electrodes for welding mild and low-alloy steels may have from six to twelve ingredients, such as;

- **Cellulose:** to provide gaseous shield with reducing agent. The gas shield surrounding the arc is produced by the disintegration of cellulose.
- **Metal carbonates:** to adjust basicity of the slag and to provide a reducing atmosphere (with the aid of CO gases)
- **Titanium dioxide:** to help form a high fluid but quick-freezing slag. It will also provide ionization for the arc.
- **Ferromanganese and ferrosilicon:** to help deoxidize the molten weld metal and to supplement the manganese content and silicon content of the deposited weld metal.
- **Clays and gums:** to provide elasticity for extruding the plastic coating material and to help provide strength to the coating
- **Calcium fluoride**: to provide shielding gas to protect the arc, adjust the basicity of the slag, and provide fluidity and solubility of the metal oxides.
- **Mineral silicates:** to provide slag and give strength to the electrode covering
- **Alloying metals:** include nickel, molybdenum, chromium, and so on, to provide alloy content to the deposited weld metal.
- **Iron or manganese oxide:** to adjust the fluidity and properties of the slag. In small amounts, iron oxide helps to stabilize the arc.
- **Iron powder:** to increase the productivity by providing additional metal to be deposited in the weld.

Electrode Selection for Steels

A number of factors come into play when selecting a shielded metal arc welding (SMAW) electrode for carbon steels. SMAW electrodes are consumables that serve multiple purposes, providing both filler metal and flux. The filler metal is consumed by the weld pool while the flux functions to protect it from atmospheric gases by generating a shielding gas or protective slag when superheated during welding

- Covered electrodes are mostly used for by welding processes in construction and fabrication industries due to cheapness, basicity, flexibility, weldability of different materials etc.
- Selection of proper electrode is made while designing of the weld joint and there is no single electrode type for general purpose.
- Selection of the best electrode type mainly depends on the type of steel and its mechanical properties like:Base metal.

  : Weld position

: Flux, current and polarity

- In catalogues which are prepared by manufacturers, each type of electrode is classified as follows:
  - ✓ **Manufacturing standards**
  - ✓ **Materials to be used for**
  - ✓ **Chemical and mechanical properties**
  - ✓ **Welding positions to be used**

2.7. AWS Electrode Classification for Mild Steel and Low Alloy Electrodes

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:

E**60**XX 60,000-psi Tensile Strength

E**70**XX 70,000-psi Tensile Strength

E**110**XX 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.

Examples:

EXX1X **All positions**

EXX2X **Flat positions and horizontal fillet**

- The last two digits together (10) indicate the type of coating and the type of power supply required, 10 organic coating and DC current with reverse polarity.

✓ Therefore, a welding rod numbered E6010 indicates "E" a manual arc-welding electrode with (60) a minimum strength of 60,000 psi., that can be used (1) in all positions and (10) DC reverse polarity is required.

Common Electrode Types

Welding electrodes are classified according to whether they are to be used with DC reversed polarity (DCRP), DC straight polarity (DCSP), or alternating current (AC). The electrodes used most commonly for mild steel welding are discussed here.

E-601**0** indicates an all-position welding rod (flat, vertical, horizontal, and overhead). It performs best when used with DCRP. Deep penetration can be achieved with this electrode which has a thin coating, and which lends itself particularly well to out-of-position welding.

E-601 **1** also indicates an all-position welding rod. It is particularly suited for use with AC, but it can also be used with DCRP and DCSP. Its thin coating makes it a good electrode for out-of-position work.

E-601 **2** is another all-position electrode, however, because of its heavier flux coating, it is slightly more difficult to make out-of-position welds with this electrode. It is best suited for use with DCSP or AC.

E-601 **3** indicates an electrode which is especially suited for deep-penetration welds in the flat position. Because of its heavier coating it is a more difficult electrode for beginners to use than are the E-601 1 electrodes. This electrode can be used with all types of polarity.

E-60**2**0 electrodes have a heavy iron powder flux coating. They are used for flat and horizontal welding only. (Notice that the third digit is 2.) These electrodes can be used with DCRP, DCSP, or AC.

E-60**3**0 electrodes also have a heavy iron powder flux coating. As is indicated by the third digit being 3, they are for flat position welding only. These electrodes may be used with DCRP or AC.

Note: E-6020 and E-6030 electrodes are sometimes called drag rods. This is because the welder can run a bead without removing the rod from the parent metal once the arc is struck.

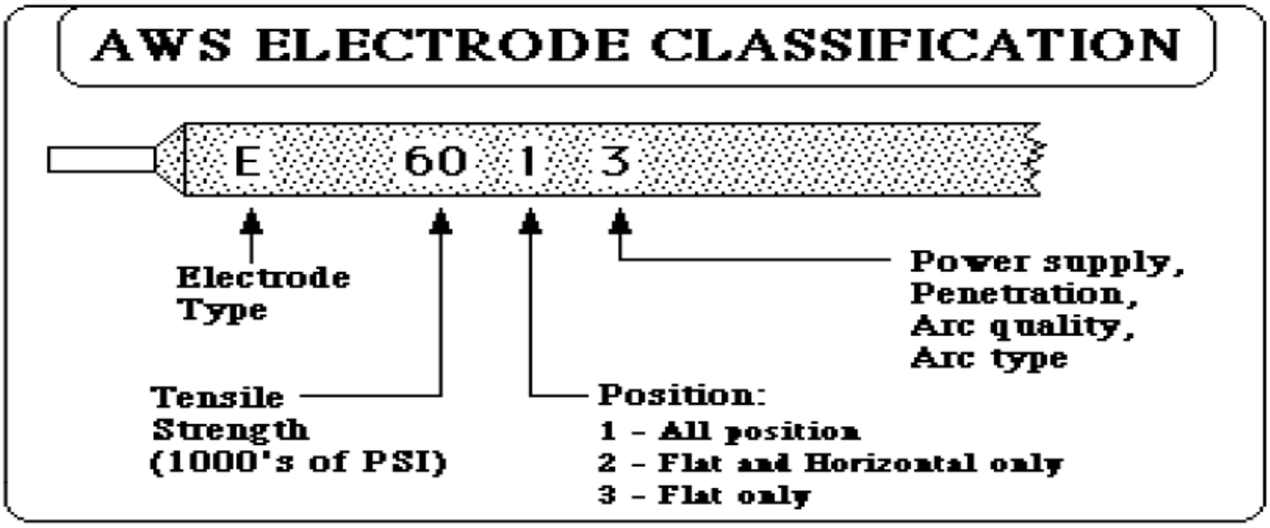


Figure 1.13 Electrode Classification

Self-Check -2	Written Test

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

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

____1. The ability of a material to resist penetration and wear by another material is named

A. Hardness C. Fatigue

B. Brittleness D. Toughness

____2. In the electrode E-**60**1 3 (“60”) is indicates.

A. position C. tensile strength of weld

B. polarity D. none

PART-II: Match the items listed under column “A” with those expressions listed under “B” (1 pt. each)

“A”“B”

_____1. Elasticity A. The property of breaking without warning

_____2. Ductility B. A combination of high strength and medium ductility

_____3. Malleability C. The capacity to be rolled or hammered into thin sheets

_____4. Toughness D. The capacity that drawn from a larger to a smaller diameter of wire

_____5. Brittleness E.The ability of material to return to its original size, shape and dimension

***Note:* Satisfactory rating – 4 points Unsatisfactory - below 4 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-3	Alignment of materials to the specification

3.1. Alignment of components

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 bepaid 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.

3.2. Alignment Methods. Members to be welded shall be brought into correct alignment and held in positionby 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.

3.3. 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 1.14

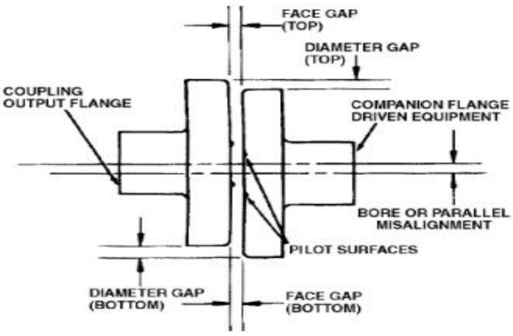


Figure 1.14parallel misalignment

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.

3.4. 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.

- **Dial Indicators**

A dial indicator measures very small changes in distance. Alignment of shafting requires measurement of small changes in distance dimensions. The indicator must be rigidly located so the specified alignment values can be measured.

- **Accuracy of Dial Indicator Readings**

There is a quick way to check the validity of dial indicator face alignment readings. As Figure 1.15 shows, readings are taken at four locations designated as A, B, C and D. When taking readings, the dial indicator should be returned to location A to be sure the indicator reading returnsto zero. Values shown in Figure 1.9 are for a unit not in alignment.

The quick check is to remember that reading of B + D should equal C. This is valid where driving and driven shafts are rotated together while checking alignment.

The quick check is useful for indicating improper procedures such as: sagging indicator brackets, dial indicator finger riding on flywheel chamfer, or indicator not properly positioned causing indicator to run out of travel.

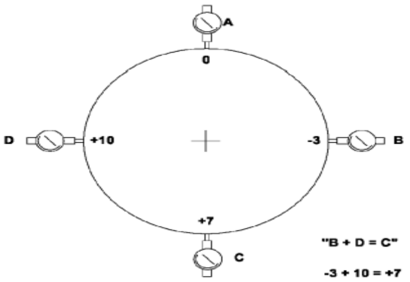


Figure 1.15 Accuracy of Dial Indicator Readings

3.5. How are pipe pieces held in place for welding?

The pipe pieces must be secured in a manner that keeps the root edges in alignment, while maintaininga 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 (Figure 1.16).

Figure 1.16 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 1.17.

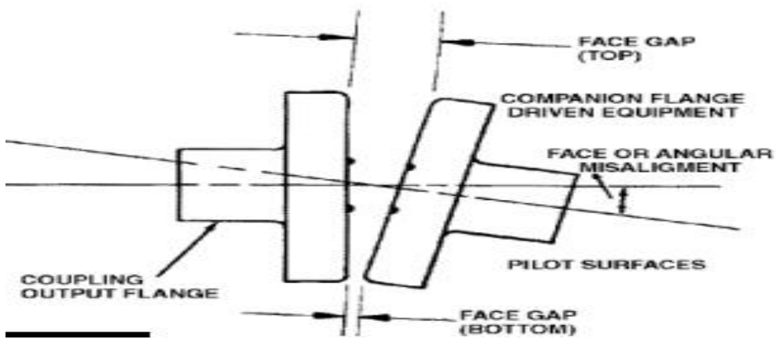


Figure 1.17 Misalignment

NDT of Weldments-Misalignment (WPG)

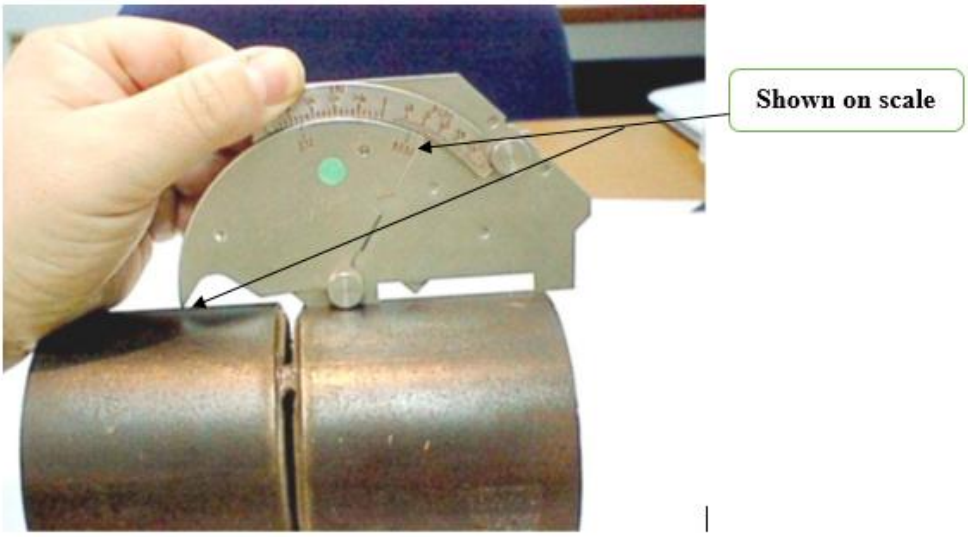


Figure 1.18weldment Misalignment

Inaccurate Flanges

Inaccurate flanges cause apparent misalignment and make accurate alignment impossible. Face runout refers to the distance the hub face is out of perpendicular to the shaft centerline. Refer to Figure 1.19.

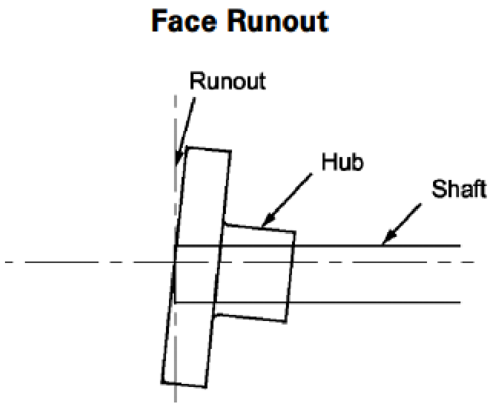


Figure 1.19 Inaccurate Flanges

Self-Check -3	Written Test

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

1. List threemethods that used to Align and positioned the parts. (3pts)
2. List the two alignment tools. (2pts)
3. How Angular or face misalignment occurs? (1pts)

Note: **Satisfactory rating – 4 points** **Unsatisfactory - below 4 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Mechanics
Level-III

Learning Guide-19

Unit of Competence: Perform Plate and Tube Shielded Metal Arc Welding (SMAW)

Module Title: Performing Plate and Tube Shielded Metal Arc Welding (SMAW)

Module Code: XXX

LG Code: XXX

TTLM Code: XXX

LO 2: Set-up welding machine/equipment, accessories and fixtures

Instruction Sheet	Learning Guide #19

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

- Positioning and setting welding machine to the polarity indicated.
- Adjusting current and voltage consistent.
- Providing braces, stiffeners, rails and other jigs
- Selecting appropriate distortion prevention measures.
- Installing electrode and oven/heaters.

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

- Position and sett welding machine to the polarity indicated.
- Adjust current and voltage consistent.
- Provide braces, stiffeners, rails and other jigs
- Select appropriate distortion prevention measures.
- Install electrode and oven/heaters.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 5.
3. Read the information written in the information "Sheet 1, Sheet 2, Sheet 3 Sheet 4, and Sheet 5,".
4. Accomplish the "Self-check 1, Self-check 2, Self-check 3, Self-check 4 and Self-check 5 **in page -41, 45, 49,54and 57**respectively.
5. If you earned a satisfactory evaluation from the "Self-check" proceed to the next **LO** in page 58

Information Sheet-1	**Positioning and setting welding machine to the polarity indicated.**

2.1. Arc Welding Equipment

Arc welding equipment, setup, related tools, and accessories are shown in Figure. 2.1

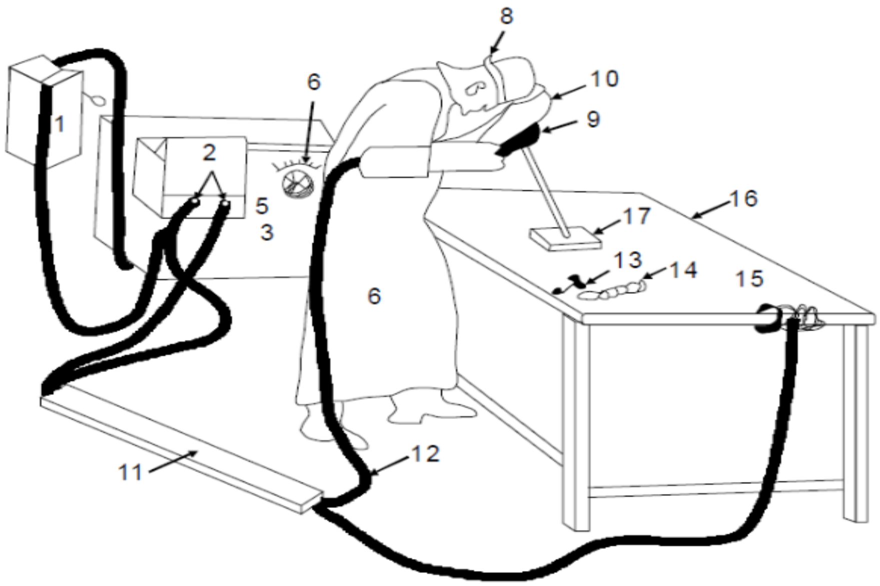


Figure 2.1: Arc welding equipment, accessories and fixtures

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

2.1.1. Arc welding power source

Both direct current (DC) and alternating current (AC) are used for electric arc welding process, each having its particular applications. DC welding supply is usually obtained from generators driven by electric motor or if no electricity is available by internal combustion engines. For AC welding supply, transformers are predominantly used for almost all arc welding where mains electricity supply is available. They have to step down the usual supply voltage (200-400 volts) to the normally open circuit welding voltage (50-90 volts). The following factors influence the selection of a power source:

1. Type of electrodes to be used and metals to be welded

2. Available power source (AC or DC)
3. Required output
4. Duty cycle
5. Initial costs and running costs
6. Efficiency
7. Available floor space area and
8. Versatility of equipment

Figure 2.2. Welding power supply/Machine

2.1.2. Welding cables

Welding cables are required for conduction of current from the power source through the electrode holder, the arc, the work piece and back to the welding power source. These are insulated copper or aluminum cables.

Table 2.1
Recommended Copper Welding Cable Sizes

Power Source		Awg Cable Size for Combines Length Of Electrode and Ground Cables				
Sizes in Amperes	**Duty Cycle %**	**0 to 50 ft. (0 to 15m)**	**50 to 100 ft. (15 to 30m)**	**100 to 150 ft. (0 to 15m)**	**150 to 200 ft. (46 to 61m)**	**200 to 250 ft. (61 to 78m)**
100	20	6	4	3	2	1
180	20-30	4	4	3	2	1
200	60	2	2	2	1	1/0
200	50	3	3	2	1	1/0
250	30	3	3	2	1	1/0
300	60	1/0	1/0	1/0	2/0	3/0
400	60	2/0	2/0	2/0	3/0	4/0
500	60	2/0	2/0	3/0	3/0	4/0
600	60	2/0	2/0	3/0	4/0	*

Courtesy of American Welding Society

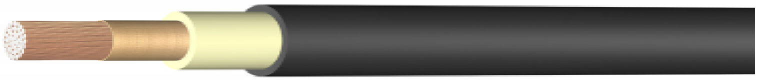


Figure 2.3 Welding Cable

3. Electrode holder

Electrode holder is used for holding the electrode manually and conducting current to it. These are usually matched to the size of the lead, which in turn matched to the amperage output of the arc welder. Electrode holders are available in sizes that range from 150 to 500 Amps.

Figure 2.4 Electrode holder

4. Clamps

Clamp**s**are used to fasten the cables to work piece or table where the work piece is positioned so the welding circuit will be completed, and some operate with spring pressure while others are magnetic.

Figure 2.5 Clamps

5. Wire Brush

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

Figure 2.6 Wire Brush

6. Chipping Hammer

A chipping hammer is a tool used to remove welding slag from a weld and welding spatter from alongside welds. Used by carefully swinging and hitting the weld to shatter the slag. The chipping hammer is used for the removal of slag after arc welding. The hammer is of robust construction and well balanced. When working on stainless steel, a chipping hammer made of stainless steel must always be used.

Figure 2.7 Chipping Hammer

2.2. SMAW Installation Instruction

The machine is equipment with power voltage compensation equipment. When power voltage movesbetween±15% of rated voltage, it still can work normally.

When use long cable, in order to prevent voltage form going down, bigger section cable is suggested. Ifcable is too long; it may affect the performance of the power system. So we suggest you to use configured length.

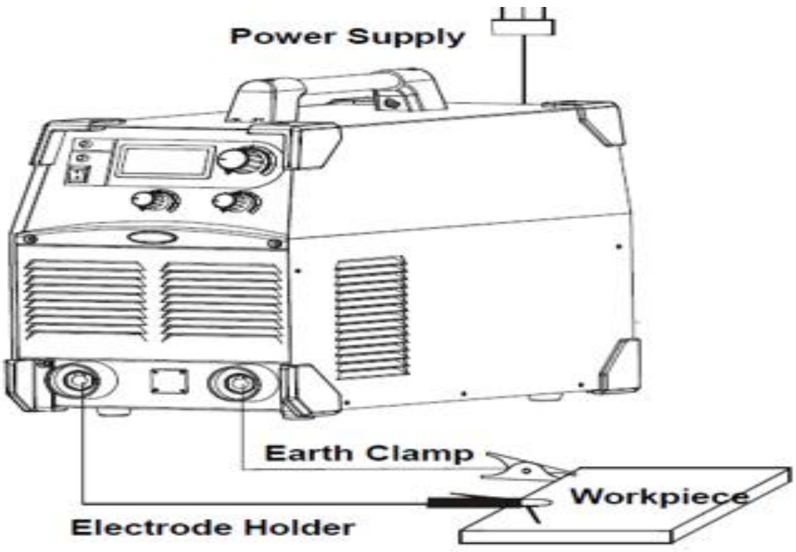
1. Make sure intake of the machine not blocked or covered, lest cooling system could not work.
2. Make sure the earth end of power interface has been reliably and independently grounded.
3. Correctly connect the arc torch or holder according to the sketch. Make sure the cable, holder and fastening plug have been connected with the ground. Put the fastening plug into the fastening socket at the "-" polarity and fasten it clockwise.
4. Put the fastening plug of the cable to fastening socket of "+" polarity at the front panel, fasten it clockwise, and the earth clamp at the other terminal clamps the work piece.
5. Please pay attention to the connecting polarity, DC welding machine has two connecting ways:

   positive connection and negative connection.

   - ***Positive connection***: holder connects with "-" polarity, while work piece with the "+" polarity.

- ***Negative connection***: work piece with the “-” polarity, holder with the “+” polarity. Choose suitable way according to working demands. If unsuitable choice, it will cause unstable arc, more spatters and conglutination. If such problems occur, please change the polarity of the fastening plug.

6. According to input voltage grade, connect power cable with power supply box of relevant voltage grade. Make sure there is no mistake and make sure the voltage difference among permission range. After the above job, installment is finished and welding is available.



. **Figure 2.8 Installation Diagram**

2.3. Polarity in DC Welding

Arc welding with the electrode connected to the positive end of the D.C. supply is called reverse polarity. *Obviously, the work piece is connected to the negative end. A better name for D.C. reverse polarity (DCRP) is electrode-positive as shown in Figure. 2.9 (a). As stated earlier in Art. 48.4, two-third of the arc heat is developed at the anode. Hence, in DCRP welding, electrode is the hottest whereas work piece is comparatively cooler. Consequently, electrode burns much faster but weld bead is relatively shallow and wide. That is why thick and heavily coated electrodes are used in DCRP welding because they require more heat for melting. Arc welding with the electrode connected to the negative end of the D.C. supply is called straight polarity. **Obviously, the work piece is connected to the positive end as shown in Figure. 2.9 (b). A better name for D.C. straight polarity (DCSP) is electrode-negative.

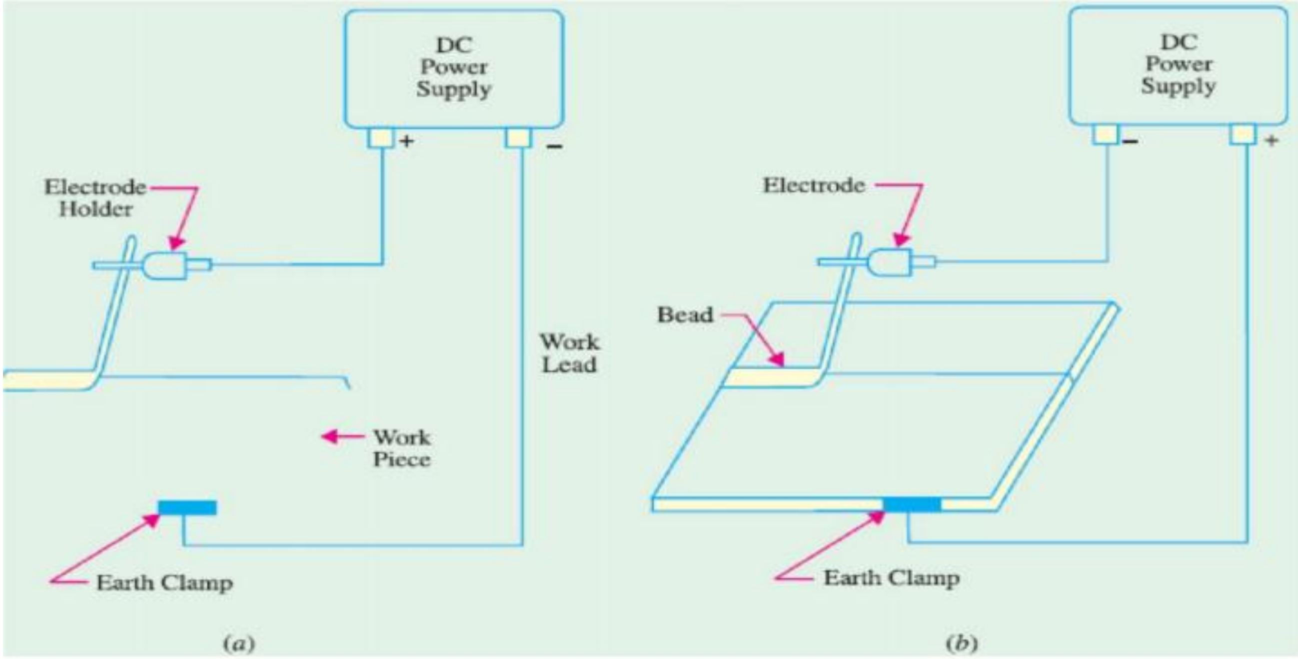


Figure2.9 Polarity in Welding

In DCSP welding, work piece is the hottest, hence base metal penetration is narrow and deep. Moreover, bare and medium-coated electrodes can be used in this welding as they require less amount of heat for melting. It is seen from the above discussion that polarity necessary for the welding operation is determined by the type of electrode used. It is also worth noting that in A.C. welding, there is no choice of polarity because the circuit becomes alternately positive, first on one side and then on the other. In fact, it is a combination of DCSP and D CRP.

A *Polarity of Welding Current.*

(1) The electrode polarity recommendations established by the manufacturer should be followed when a specific type of electrode is being used. The polarity recommended may be either "straight" or "reverse." In straight polarity, the electrode is in the negative side of the circuit. With reverse polarity, the electrode is in the positive side of the circuit.

(2) In general, straight polarity is used for all mild-steel, bare, or lightly coated electrodes. With electrodes of this type, the greater heat is developed at the work piece being welded which is the positive side of the current. However, when heavy coated electrodes are used, the gases given off in the arc may that the opposite is true and the greater heat is produced on the negative side. Electrode coatings affect the heat conditions differently, depending on their composition. One type of heavy coating may provide the most desirable heat balance

with straight polarity, while another type of coating on the same electrode may provide a more desirable heat balance with reverse polarity.

(3) Reverse polarity is used in the welding of nonferrous metals such as aluminum, bronze, Monel, and nickel. Reverse polarity is also used with some types of electrodes for making vertical and overhead welds.

(4) The proper polarity for a given electrode can be recognized when attempting a weld by the sharp, cracking sound of the arc. The wrong polarity will cause the arc to emit a hissing sound and the welding bead will be difficult to control.

B. *Direct Current Arc-welding Electrodes*.

(1) In general, direct current (dc), shielded-arc electrodes are designed either for reverse polarity (electrode positive) or for straight polarity (electrode negative) and are not interchangeable. Many, but not all, of the direct current electrodes, both reverse and straight polarity, also can be used with alternating current. Direct current is preferred for many types of bare and covered nonferrous and alloy steel electrodes. These electrodes are used when ferrous welds are to be made in horizontal, vertical, or overhead positions. Recommendations from electrode manufacturers include the type of base metal for which given electrodes are suitable.

(2) In most cases, straight polarity electrodes (electrode negative) will provide less penetration than the reverse polarity electrodes (electrode positive) and, for this reason, will permit greater welding speed. Good penetration can be obtained with either type under proper welding conditions and arc manipulation.

C. *Alternating Current Arc-welding Electrodes*.

(1) Coated electrodes that can be used with either direct or alternating current are available. Alternating current is more desirable under certain operating conditions. Alternating current reduces arc blow (an unstable arc condition) that is particularly harmful when welding in corners or restricted places and when high currents, as required in thick sections, are used. Arc blow, in these cases, causes blowholes and slag inclusions in the weld as well as a lack of fusion.

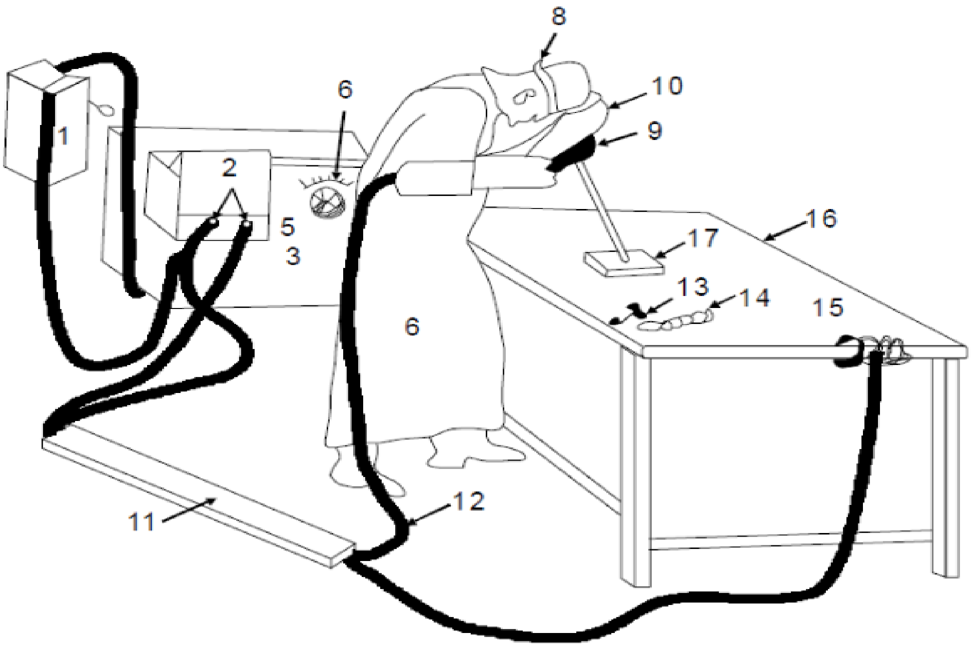
Self-Check -1	Written Test

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

PART I: choose the brief answer for the following equation's

1. In --------- work piece is the hottest, hence base metal penetration is narrow and deep.
   A. DCRP C. AC
   B. DCSP D. DC
2. From the listed alternatives which of the following is the factors that influence the selection of a power source
   A. Available power source (AC or DC) C. Duty cycle
   B. Required output D. All

PART II: write the name that indicate Arc welding equipment, setup, related tools, and accessories are shown in Figure below.



***Note:* Satisfactory rating - 10 points** **Unsatisfactory - below 10 points**

Answer Sheet

Score = ___________
Rating: ____________

Name: _____________________________ Date: _________________

Information Sheet-2	Adjusting current and voltage consistent

2.2 Introduction

All arc welding processes have a few basic requirements for their operation. They must have a safe voltage available that is sufficient for the operator to get the arc started and be maintained. They also require sufficient amperage to provide the heat for melting of the parent metal and filler material.

1.2.1. Power supplies

To supply the electrical energy necessary for arc welding processes, a number of different power supplies can be used. The most common welding power supplies are constant current power supplies and constant voltage power supplies. In arc welding, the length of the arc is directly related to the voltage, and the amount of heat input is related to the current.

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.

The type of current used in also plays an important role in arc welding. Consumable electrode processes such as shielded metal arc welding and gas metal arc welding generally use direct current, but the electrode can be charged either positively or negatively.

In welding, the positively charged anode will have a greater heat concentration, and as a result, changing the polarity of the electrode has an impact on weld properties. If the electrode is positively charged, the base metal will be hotter, increasing weld penetration and welding speed. Alternatively, a negatively charged electrode results in more shallow welds.

Non-consumable electrode processes, such as gas tungsten arc welding, can use either type of direct current, as well as alternating current. However, with direct current, because the electrode only creates the arc and does not provide filler material, a positively charged electrode causes shallow welds, while a negatively charged electrode makes deeper welds. Alternating current rapidly moves between these two, resulting in medium-penetration welds.

One disadvantage of AC, the fact that the arc must be re-ignited after every zero crossing, has been addressed with the invention of special power units that produce a square wave pattern instead of the normal sine wave, making rapid zero crossings possible and minimizing the effects of the problem.

1.2.2. Selection of type of Welding Current

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

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

DC offers the advantage of polarity selection (DCEN&DCEP) which helps in controlling the melting rate, penetration and required welding deposition rate (Fig. 12.1). DCEN results in more heat at work piece producing high welding speed but with shallow penetration. DCEN polarity is generally used for welding of all types of steel. DCEP is commonly used for welding of non-ferrous metal besides other metal systems. AC gives the penetration and electrode melting rate somewhat in between of that is offered by DCEN&DCEP.

1.2.3. Welding Currents

Generally, the amperage at which the rod runs most readily is indicated by the manufacturer. Differences in rod diameter and in material used for the flux coating require differences in the current settings used. Figure 4-1 indicates current settings which generally give satisfactory results.

Diameter of Electrode	**Amperage Used**					
	E-6010	E-601 1	E-6012	E-6013	I E-6020	E-6030
1/8”	80-120	80-120	80-130	70-120	100-140	100-140
5/32”	120-160	120-160	120-180	120-170	120-180	120-180
3/16”	140-220	140-220	140-250	140-240	*175-250*	*175-250*

Self-Check -2	Written Test

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

PART I: Choose brief answer for the following question.

1. ------------- hold the voltage constant and vary the current, and as a result,
   A. Constant Current C. Power supply
   B. Constant voltage power supplies D. All
2. Which one is the points careful considering for selection of welding current.
   A. Thickness of plate/sheet
   B. Length of cable required
   C. Arc blow D. All
3. Select the amperage used for1/8" electrode diameter of E-601 3 type electrode.
   A. 120-170 B. 140-240 C. 70-120 d All

Note: **Satisfactory rating – 2 points** **Unsatisfactory - below 2 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: ______________________________ Date: __________________

Information Sheet-3	Providing braces, stiffeners, rails and other jigs.

2.3.Fixtures and Tooling Holes

Tooling holes or other self-locating features on parts being welded into an assembly are of utmost importance and should therefore be part of the original design whenever possible. The significance of these features is the economical and quality impact they have on the finished product. This is especially true for smaller, close tolerance assemblies.

2.3.1. Use Jigs and Fixtures

Since holding the metal in a fixed position prevents excessive movements, the use of jigs and fixtures can help prevent distortion. A jig or fixture is simply a device used to hold the metal rigidly in position during the welding operation.

The use of welding fixtures is sometimes unavoidable and even dictated by circumstances, but do add an initial tooling cost to the project. Fixture assemblies are also slower to work with than self-fixturing features because of added bulk weight, which adds to the per-part-cost. Since fixtures have tolerances of their own, and gauging contacts, clamping pressures and deflections can vary from part to part, the tolerances of the welded assembly will reflect these variables.

The great variety in size and accuracy requirements of welded assemblies dictate different methods of fitting and fixturing. Exacting electronic housings, for example, need a different approach than a heavy wall and angle iron structure. With this in mind, the design tolerances should be based on material thickness, structure size and welding process. For a guide on locating parts to each other during welding, also see the "Positive Location of Work pieces" with details and illustrations in the preceding chapter on spot welding.

2.3.2. 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.

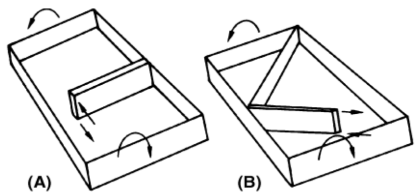
2.3.3. Stiffeners

The code permits (but does not require) the ends of transverse stiffeners (when used in pairs) to be welded to the compression flange. When stiffeners are used only on one side of the web, the code requires ends adjacent to the compression flange to be welded; without the weld or a second stiffener on the opposite side of the web, the compression flange will not have proper support against rotation.

2.3.4. Braces

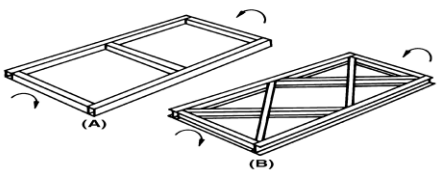
2.3.4.1. Diagonal Bracing. Diagonal bracing is very effectivein preventing the twisting of frames. A simple explanation of the effectiveness of diagonal bracing involves an understanding of the directions of the forces involved.

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 2.10(A), they contribute only relatively low torsional resistance. However, if the bars are oriented diagonally at 45° across the frame, as in Figure 2.10 (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 2.10—Frames Subjected to Torsionwith (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 2.11—Application of (A) Closed TubularSections or (B) Open Structures with Diagonal Bracing to Resist Torsion

A brace is a made-on-site anchor assembly consisting of one or more posts driven into the ground connected with one or more rails and tensioned together with wire. It forms the tie off point for the fence wire. It is named for the number of driven posts it requires, i.e. a two-post brace has two posts driven into the ground (and is completed with a rail and tensioned brace wire).

A brace can fail in one or more ways, by:

- structure failure (broken post or rail)
- soil failure (soil shear in front of the post allowing the post to move)
- end post pulls out (indicating poor brace design for the soil conditions

Some factors effecting the rigidity of a brace (in similar soil conditions):

- the deeper the post is set into the ground, the greater the load capacity
- the larger the diameter of the post the greater the load capacity
- a post driven into undisturbed soil has a greater load capacity than one placed in an over-sized hole and filled by ramming
- dry and clay type soils generally have more resistance than wet and sandy soils

Self-Check -3	Written Test

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

1. Write the purpose of the following.
   A. jig or fixture
   B. Braces

Note: **Satisfactory rating –1.5 points** **Unsatisfactory - below 1.5 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: ___________________________ Date: _______________

2.4. The Nature of welding distortion

The definition of *distortion* given in the *Oxford Dictionary* states that it is 'the action or an act of distortingor twisting out of shape (permanently or temporary)'.Also, the distorted condition is 'a condition of thebody ... 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 thatoccur during the welding process and in the ways in which distortion can appear (Figure 2.12) are principally:

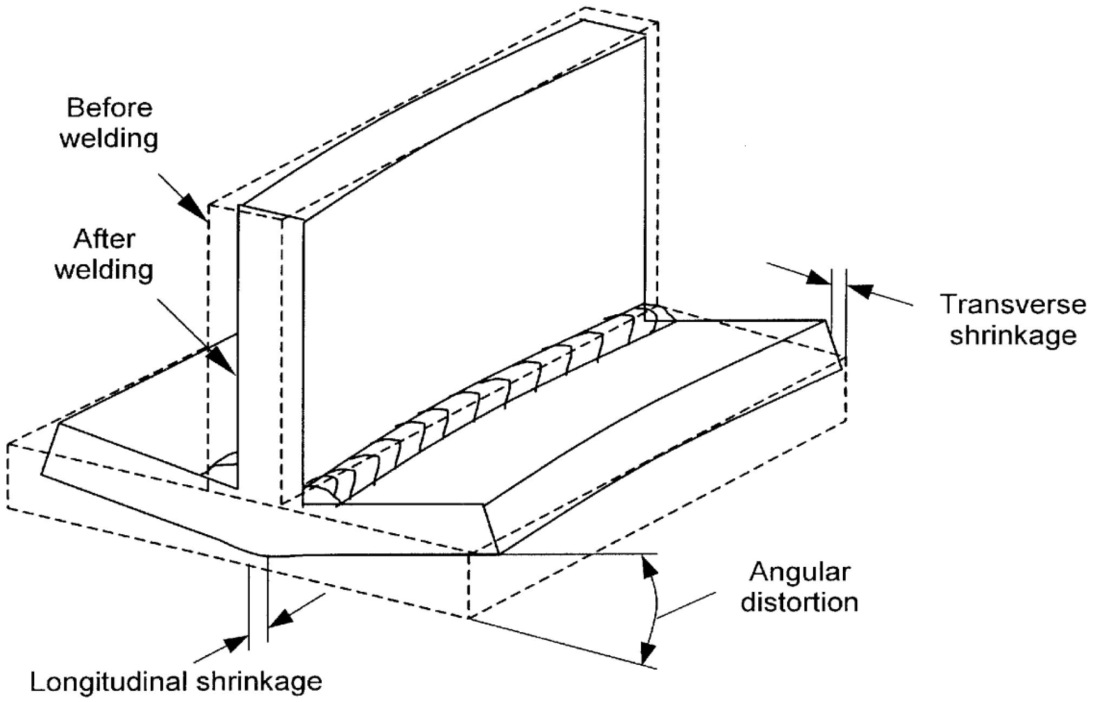
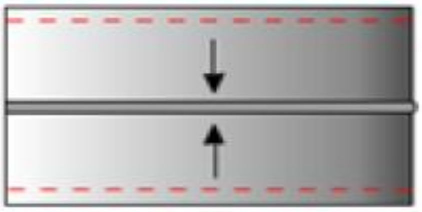


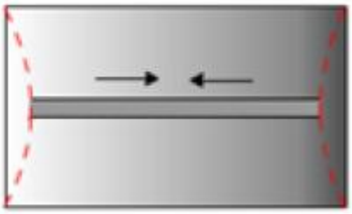
Figure 2. 12 Dimensional changes occurring in a fillet weld

2.4.1. The types of Distortion:

(a**) Transverse shrinkage perpendicular to the weld line,**

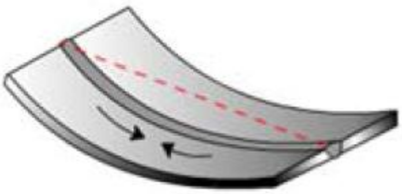


(b) **Longitudinal shrinkage parallel to the weld line and**



(c) **Angular distortion around the weld line.**

(d)**Bowing and dishing**



(e)**Buckling**

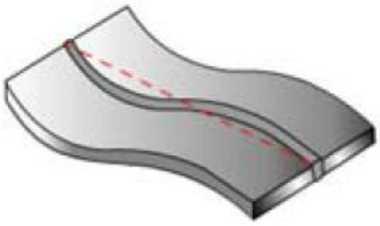


Figure 2.13 Types of Distortion

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.

2.4.2. Distortion Control

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 wire 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.).

2.4.3. 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.

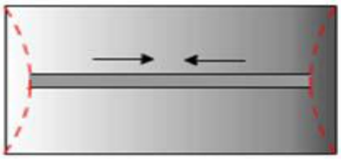
Self-Check -4	Written Test

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

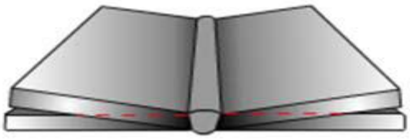
PART I: write short and brief answer

1. Definition of distortion. (1pts)
2. List three methods of distortion control in welding. (3pts)
3. List two methods for Correction of distortion(2pts)

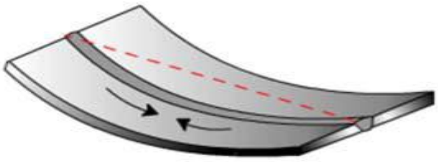
PART II: Match the following types of distortion by drawing a line from the image to the name of the distortion shown. (1pts each)



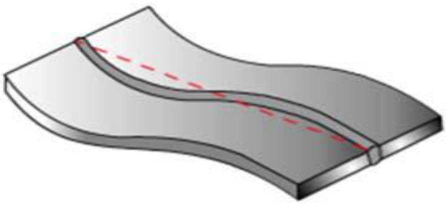
Bowing Distortion



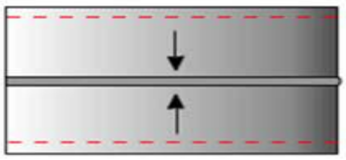
Buckling Distortion



Longitudinal Shrinkage



Transverse Shrinkage



|Angular Distortion

***Note:* Satisfactory rating - 6 points Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-5	Installing electrode and oven/heaters

2.5. Electrode Heating Oven

In order to keep pace with the never ending demands of customers, we are involved into offering wide range of Electrode Heating Oven. This product is well tested on various quality parameters. Our offered electrode heating oven is fabricated under the meticulous supervision of our dedicated team of professionals using the excellent quality components and ultra-modern technology.

Coatings on welding electrodes quickly absorb atmospheric moisture when taken out of the box/pack. This moisture contains hydrogen which will eventually enter the weld and cause cracking. Damaged electrodes need to be rebuked at high temperatures to restore them. Sensoheat Welding electrode drying / holding ovens are a perfect solution. Our Ovens ensure effective heating and restoration of your electrodes.

2.5.1. The Guide to Electrode & Flux Stabilization

- **PRIOR TO USE**

1. Check for correct power supply cord and plug.
2. Verify the oven is empty before heating.
3. Check nameplate for voltage ratings.
4. Check for desired thermometer (if equipped) display units (°F or °C). Unit is set to °F when shipped. To change to °C, see **Temperature Indication** section in this manual.

- **Power Supply**

Dry Rod II Ovens are designed to run on either AC or DC voltage and accept voltage between 100-240 volts. When power is supplied, the indicator light will illuminate

- **Guide to Storage**

Electrodes should be stored according to electrode supplier recommendations. In the absence of detailed storage information from your electrode manufacturer, the **Guide to Electrode and Flux Stabilization** section in this manual may be used as an indication of approximate temperatures.

- **Temperature Settings**

Dry Rod II Ovens utilize a variable thermostat, providing an operating range of 100°-300°F (38°-149°C) average stabilized load temperatures.

The oven operating temperature is set by rotating the thermostat knob clockwise to increase the temperature of the unit. To decrease the temperature, rotate the knob counter-clockwise. This setting is approximate and may need slight adjustment once the oven temperature stabilizes.

- **Temperature Indication**

Dry Rod II Ovens (Part #1205510) are supplied with a battery powered digital thermometer to indicate the actual temperature inside oven in either °F or °C.

The thermometers are supplied in °F mode. Conversion to °C mode is accomplished by pressing the button located in the battery holder. This will cycle between °F and °C. Thermometers are powered by one AA battery.

Replacement of the battery is also covered in the troubleshooting section of this manual.

Figure 2.14. Electrode Stabilization Ovens (Dry Rod II Ovens (Part #1205510))

Self-Check -5	Written Test

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

1. How to set temperature in Dry Rod II Ovens? (2pts)

Note: **Satisfactory rating – 1. points** **Unsatisfactory - below 1. points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

Mechanics Level-III

Learning Guide-20

Unit of Competence: Perform Plate and Tube Shielded Metal Arc Welding (SMAW)

Module Title: Performing Plate and Tube Shielded Metal Arc Welding (SMAW)

Module Code: XXX
LG Code: XXX
TTLM Code: XXX

LO3: Perform tack welding

Instruction Sheet	Learning Guide #20

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

- Making Joints free from foreign materials
- Performing root gap.
- Checking alignment within acceptable code and standard.
- Installing backing plate, stiffener and running plate.
- Performing tack welding.
- Making tack weld free from stress

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

- Make Joints free from foreign materials
- Perform root gap.
- Check alignment within acceptable code and standard.
- Install backing plate, stiffener and running plate.
- Perform tack welding.
- Make tack weld free from stress

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6
3. Read the information written in the information "Sheet 1, Sheet 2, Sheet 3 Sheet 4, Sheet 5, and Sheet 6".
4. Accomplish the "Self-check 1, Self-check 2, Self-check 3, Self-check 4, Self-check 5, and Self-check 6" **in page -61, 64, 67,71,75 and 78**respectively.
5. If you earned a satisfactory evaluation from the "Self-check" proceed to "Operation Sheet 1, Operation Sheet 2and Operation Sheet 3 and Operation Sheet 4"**in page -79,80,81 and 82.**
6. Do the "LAP test" in page – 83 (if you are ready).

Information Sheet-1	Making Joints free from foreign materials

3.1. 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.

Additional Precautions

When tack welding is used as fixturing for brazing, the area surrounding the tack must be thoroughly cleaned to remove oxides developed during welding.

In semiautomatic and automatic welding, the meeting points of the final weld electrode with tack welds can impair arc voltage control and filler wire feeding, making manual assistance especially important for maintaining quality.

Tack welding is an essential ingredient in a successful welding project, be it simple or complex. It is therefore very important to perform the process properly and minimize the risks associated with poor tack welding.

Final Cleaning Before setting up for welding, the pipe must be cleaned sufficiently to ensure fusion and to eliminate any form of contamination entering the weld zone. Mill scale, varnish, paint, rust, or other contaminants must be removed prior to joint fit-up to a distance of 1 inch (2.54 cm) from the bevel edge. These possible contaminants can be removed by mechanical means such as grinding. Further, any oils or fluids from cutting or storage must be removed with a cleaning solvent approved for welding operations to eliminate porosity or unwanted metallurgical effects. With aluminum base metals, oxide removal is necessary immediately prior to welding, for each weld pass, to ensure proper fusion.

Self-Check -1	Written Test

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

1. Discuss why Joints free from foreign materials(2pts)

Note: **Satisfactory rating – 3 and 4 points** **Unsatisfactory - below 3 and 4 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

3.2. Weld shapes, root openings (air gaps)

When preparing and assembling components, care shall be taken to ensure compliance with the weld shapes and root openings (air gaps) specified in the manufacturing documents. With single- and double bevel butt welds in particular, care shall be taken to make an adequate root opening to achieve sufficient root penetration.

The root opening shall not exceed twice the specified gap. If the size of the gap permitted by this rule is exceeded locally over a limited area, the gap may be reduced by build-up welding of the side walls, subject to the consent of the Surveyor. With fillet welds, the "a" dimension shall be increased accordingly, or a single- or double-bevel weld shall be made if the air gap is large. Inserts and wires may not be used as fillers.

Joint Design Where fillet welds are common on plate welding design, groove welds are more common in pipe applications where complete joint penetration is needed. Open root groove designs have variations of those elements—groove or bevel angle, root face, and root opening—shown in Figure 3.1. A good practice for selecting a groove design is to follow recommendations from a welding code or standard directly related to the pipe welding being done.

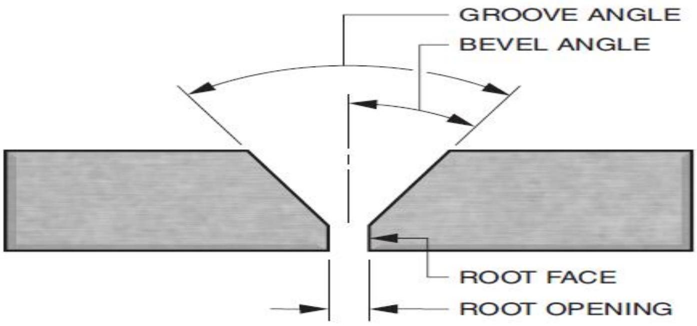
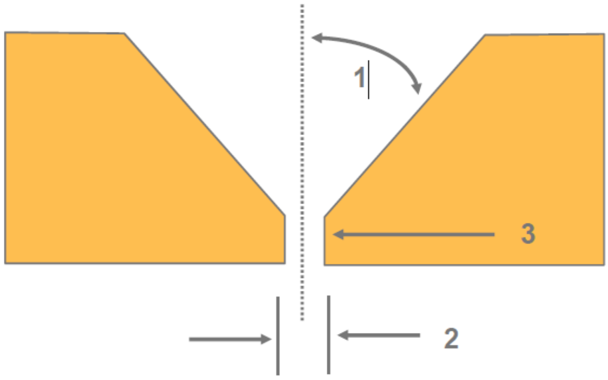


Figure 3.1 Groove joint design.

3.2.1. Joint Design Variables

1. Bevel angle
2. Root opening (root gap)
3. Root face (land)



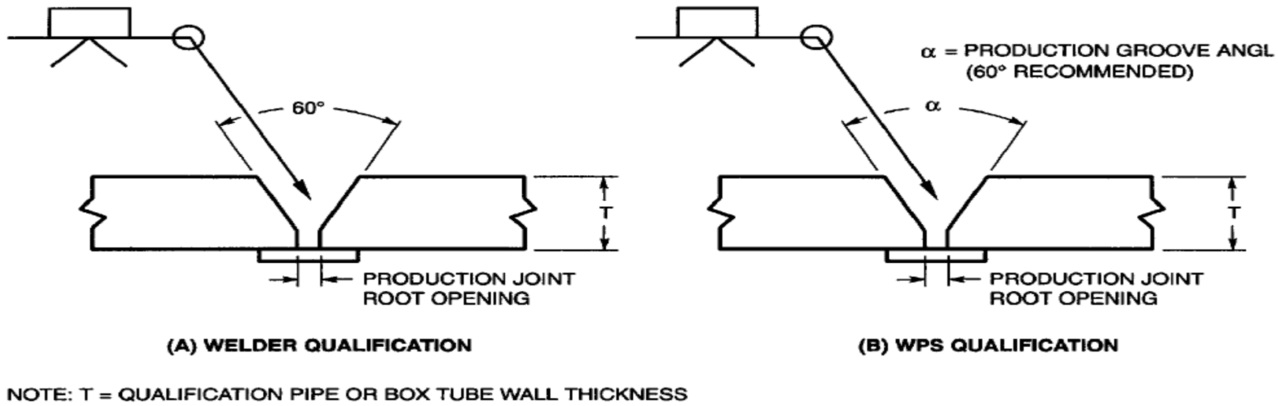


Figure 3.2. Joint Design Variables

Table.3.1 Tubular Root Opening Tolerances

	Root Face of Joint		Root Opening of Joints without Steel Backing		Groove Angle of Joint
	in.	mm	in.	mm	deg
SMAW	±1/16	±1.6	±1/16	±1.6	±5
GMAW	±1/32	±1	±1/16	±1.6	±5
FCAW	±1/16	±1.6	±1/16	±1.6	±5

Note: Root openings wider than permitted by the above tolerances, but not greater than the thickness of the thinner part, may be built up by welding to acceptable dimensions prior to the joining of the parts by welding.

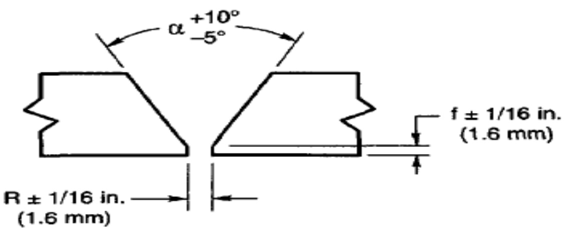
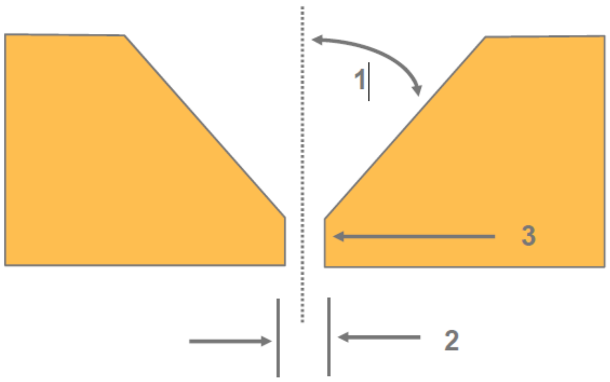


Figure 3.3. Root Gap Design

Self-Check -2	Written Test

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

1. List the three weld design variables



Note: **Satisfactory rating 1.5 points** **Unsatisfactory - below 1.5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

3.3. Mechanical Adjustments

The position of the welding wire must be maintained to control the shape of the weld and the depth of penetration. The wire may be guided mechanically or manually adjusted as the weld progresses. While the welding is going on, inspection will indicate whether the backing is tight against the underside of the joint. If it is not, too much metal may flow into the space, resulting in reduced weld reinforcement, undercutting, and a ruined weld.

ASME B31.8, Gas Transmission & Distribution Piping Alignment and Acceptance Criteria

3.3.1. JOINT FIT-UP AND ALIGNMENT

1. For piping systems that operate at hoop stress of less than 20% and the internal adjoining ends do not vary more than $^{1}/_{8}$ in. and adequate penetration and fusion can be obtained no special treatment is necessary. If the offset is greater than $^{1}/_{8}$ in. the following shall apply.
2. For piping systems that operate at hoop stress of 20% or more of the Specified Minimum Yield Strength the following shall apply.

    2.1 If the internal adjoining ends do not vary more than $^{3}/_{32}$ in. and adequate penetration and fusion can be obtained no special treatment is necessary. See Figure 14 of this Attachment.

    2.2 Where the nominal internal offset is greater than $^{3}/_{32}$ in. and no access to the inside for welding, a transition shall be made to the thicker section not to exceed 30º (3:1 taper) or less than 15º (1 ½:1 taper). See Figure 15 of this Attachment.

    2.3 Where the nominal internal offset is greater than $^{3}/_{32}$ in. but does not exceed ½ the thinner section and there is access to the inside for welding, the transition may be made with a tapered weld or transition as described in paragraph 9.2.2 shall be performed. See Figure 15 of this Attachment.

    2.4 Where the nominal internal offset is more than ½ the thinner section and there is access for welding, the transition may be made with taper cut or by a combination taper weld to ½ the thinner section see Figure 15 and taper cut from that point as shown in Figure 15 of Attachment.

3. Where the external offset does not exceed ½ t of the thinner section, the transition may be made by welding as shown by Figure 15 of this Attachment, provided the angle of the rise of the weld surface does not exceed 30º (3:1 taper) and both bevel edges are properly fused. Where the is an external offset exceeding ½ the thinner section, that portion of the offset over ½ t shall be tapered as shown in Figure 15 of this Attachment.
4. The root opening and fit-up tolerances shall be as specified in the weld joint design in this Attachment as applicable. If the tolerances cannot be achieved, the end preparations may be built up by welding (with an approved WPS or WTS) or re-prepped by machining or grinding.
5. Parts to be joined by a tee or fillet weld shall be brought into as close contact as is practicable. The maximum gap between these parts shall not exceed $^{1}/_{8}$ in. If the separation is greater than $^{1}/_{16}$ in., each leg of the fillet weld shall be increased by the amount of separation.
6. In assembly of socket weld joints, the pipe or tube shall be withdrawn a distance of approximately $^{1}/_{16}$ in. away from contact between the end of the pipe and the face of the shoulder of the socket. In sleeve-type joints without an internal shoulder, there shall be a distance of approximately $^{1}/_{16}$ in. between the butting ends of the pipe or tube and the butting ends shall be centered in the sleeve.

Note: Gap inserts (Gap lets or equivalent) and approved shims may be used with prior approval from the design engineer or LANL Welding Program Administrator.

Self-Check -3	Written Test

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

PART I: write the detail criteria of the following pipes

1. Write ASME B31.8, Gas Transmission & Distribution Piping Alignment and Acceptance Standard Criteria's (3pts)

Note: **Satisfactory rating – 1.5 points** **Unsatisfactory - below 1.5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

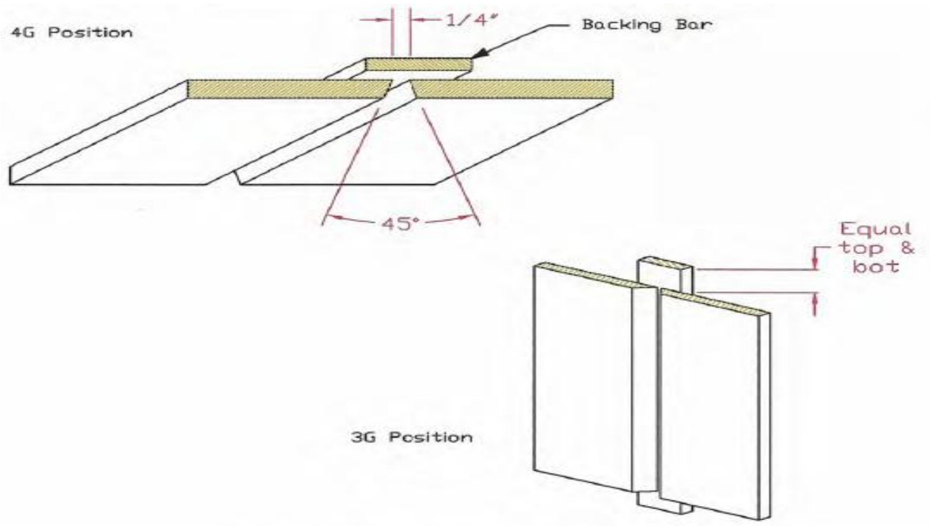
Name: ___________________________ Date: _________________

Information Sheet-4	Installing backing plate, stiffener and running plate.

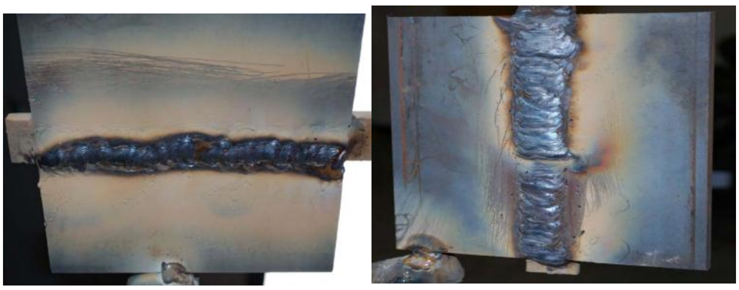
3.4. Backing plate(bar)

A material placed against the back side of the joint adjacent to the joint root to support and shield molten weld metal.

Steel backing shall be placed and held in intimate contact with the base metal. The maximum gap between steel backing and the base metal at the weld root shall be 2 mm (1/16 in). (AWS D-1.5 Section 3.13.5)



Coupon Fit-up.



Completed weld.

Figure 3.4 Backing plate

3.4.1. Running plate

Aligning the running surface/plate

Align the running surface (top) so that when the 1m straightedge is placed centrally over the gap, each end is 1.5mmabove the running surface (see Figure 3.5).

To peak the running surface, use the following steps:

For **double shouldered sleeper plates** (dog spikes):

1. Lift the 4 dogs on the sleeper each side of the gap using a pig's foot and hammer.
2. Place steel wedges between the rail and the sleeper plate through the lock spike holes and wedge the rail ends up to achieve correct peak without twisting the rail. (1.5mm on each end of a 1m straight edge).

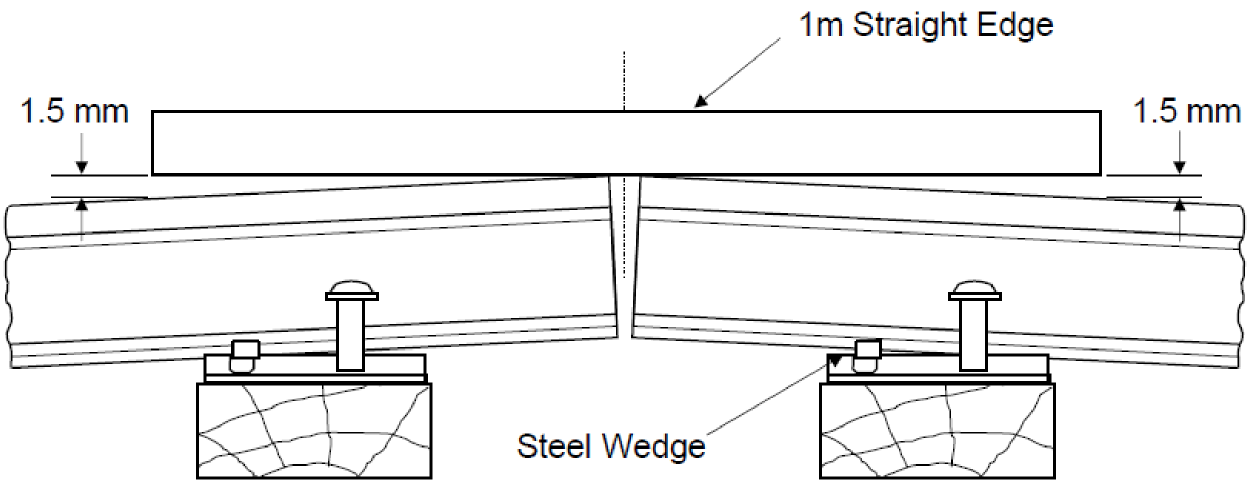


Figure 3.5 - Alignment of the Running Surface

3.4.2. Stiffeners

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

(1) Minimum length of each weld shall be 1-1/2 in. (38 mm).

(2) 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.

(3) 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).

(4) 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.

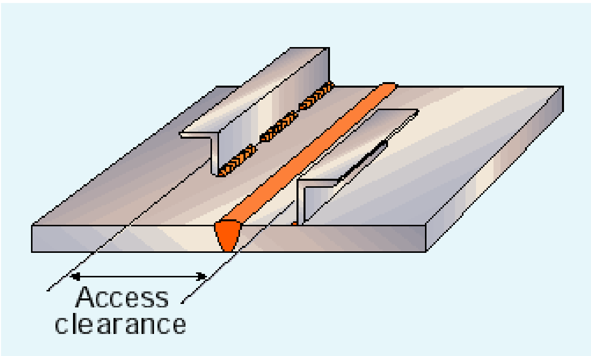


Figure 3.6. Longitudinal stiffeners prevent bowing in butt welded thin plate joints

Longitudinal shrinkage in butt welded seams often results in bowing, especially when fabricating thin plate structures. Longitudinal stiffeners in the form of flats or angles, welded along each side of the seam (Figure. 3.6) are effective in preventing longitudinal bowing. Stiffener location is important: they must be placed at a sufficient distance from the joint so they do not interfere with welding, unless located on the reverse side of a joint welded from one side.

Self-Check -4	Written Test

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

1. Write the purpose of backing plate, stiffener and running plate in welding? (3pts)
2. Discuss about the Arrangement Stiffeners in welding material? (1pts)

Note: **Satisfactory rating – 2 points** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-5	Performing tack welding.

3.5. 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

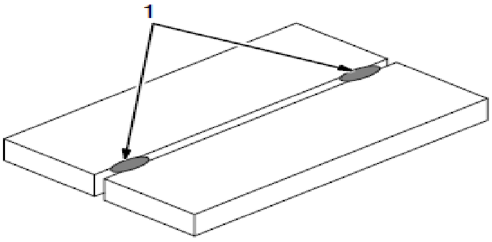


Figure3.7Tack Welding (1)

3.5.1. 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.

Important Note: Although the tacks seen in this photograph are messy and not quality work, the main point of failure is the arc strikes as these can affect the future structural integrity of the vessel.

Tack welds are commonly incorporated into the final weld therefore the tacker should always weld tacks with this in mind.

3.5.2. Pipe Tack Welding

Positioning of tack welds, both in number and location, is imperative to success in achieving complete joint penetration, meeting strength, and code requirements. Tack welds spaced equal distance and centered at the four quadrants of the pipe circumference as shown in Figure 3.8 are sufficient for smallest diameter pipe applications. For larger diameter pipe, more tack welds may be placed at intervals frequent enough to eliminate closing of the root opening. When welding pipe for procedure qualification or welder qualification, tack welds maybe placed at positions other than were test pieces are taken.

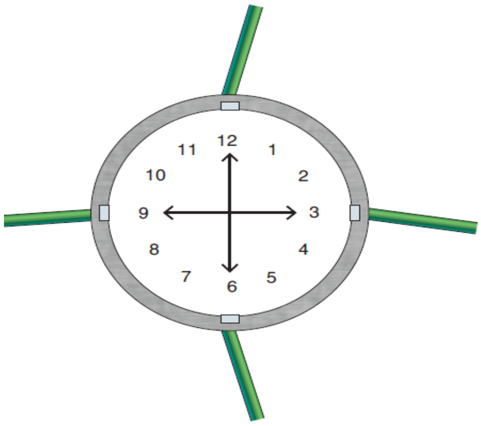


Figure 3.8 Placement of tack welds relative to clock positions.

Self-Check -5	Written Test

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

1.. Define tack welding? (1pts)

2. List four function of tack welding? (4pts).

3. State the difference between tack welding and temporary welding? (4pts)

4. Discuss how tack the pipe for SMAW welding? (1pts)

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: ___________________________ Date: ________________

Information Sheet-6	Making tack weld free from stress

3.6. 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.

Clamps, jigs, and fixtures that lock parts into a desired position and hold them until welding is finished are probably the most widely used means for controlling distortion in small assemblies or components. It was mentioned earlier in this section that the restraining force provided by clamps increases internal stresses in the weldment until the yield point of the weld metal is reached. For typical welds on low-carbon plate, this stress level would approximate 45,000 psi. One might expect this stress to cause considerable movement or distortion after the welded part is removed from the jig or clamps. This does not occur, however, since the strain (unit contraction) from this stress is very low compared to the amount of movement that would occur if no restraint were used during welding.

3.6.1. 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.

3.6.2. Base Metal Stresses. Limiting diameter/thickness and width/thickness ratios depend on the application.

The first three columns delimit stocky members for which simplified design rules apply; beyond these limits the more detailed calculations given in the Code must be performed.

The limits for designing members against local buckling at various degrees of plasticity are shown on the right-hand side. These are an amalgam of API, AISC and AISI requirements. Naturally, requirements of the governing design specification would take precedence here.

Self-Check -6	Written Test

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

1.. Write the negative or positive effect Welding residual stresses on the strength of the component. (2pts).
2. Write the purpose of Clamps, jigs, and fixtures in welding? (3pts)
3. Define Allowable Stresses (Tubular)? (1pts)

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Operation Sheet 1	Performing root gap

Work Preparation

1. Low carbon steel plates (S235) with the dimensions of 4x50x200 are prepared with the bevel heights of 0, 1, 2, 3 millimeters, bevel angle of 30°. Then, they were tack welded to get a gap distance of 0, 1 and 1.5 millimeters. The dimensions of the weld joint are also given in the table below. Figure below shows the single V-groove butt joint preparations.

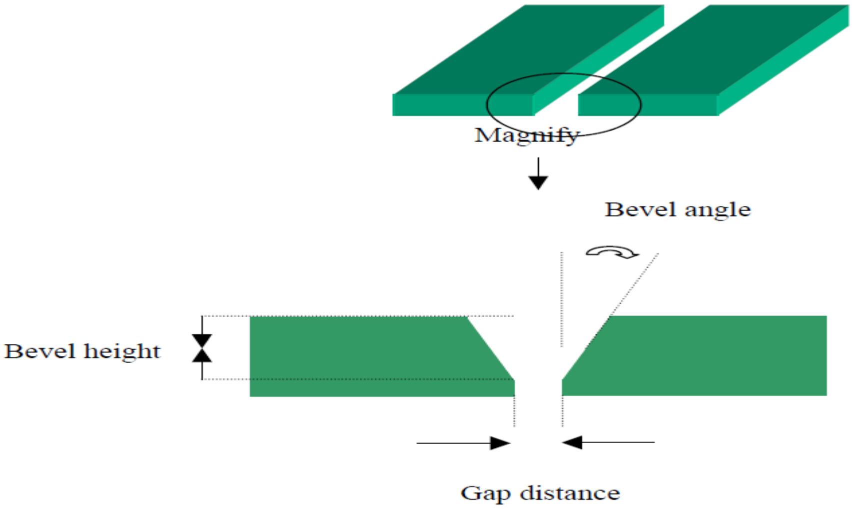
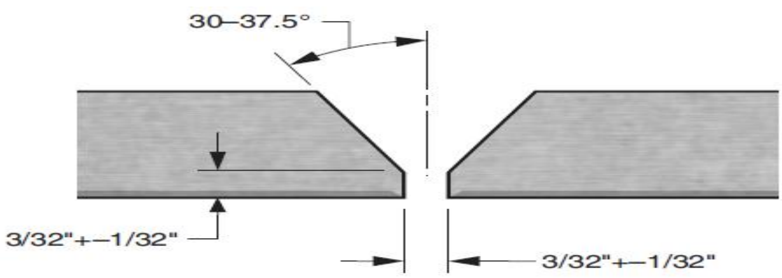


Figure. Single V-groove butt joint preparations

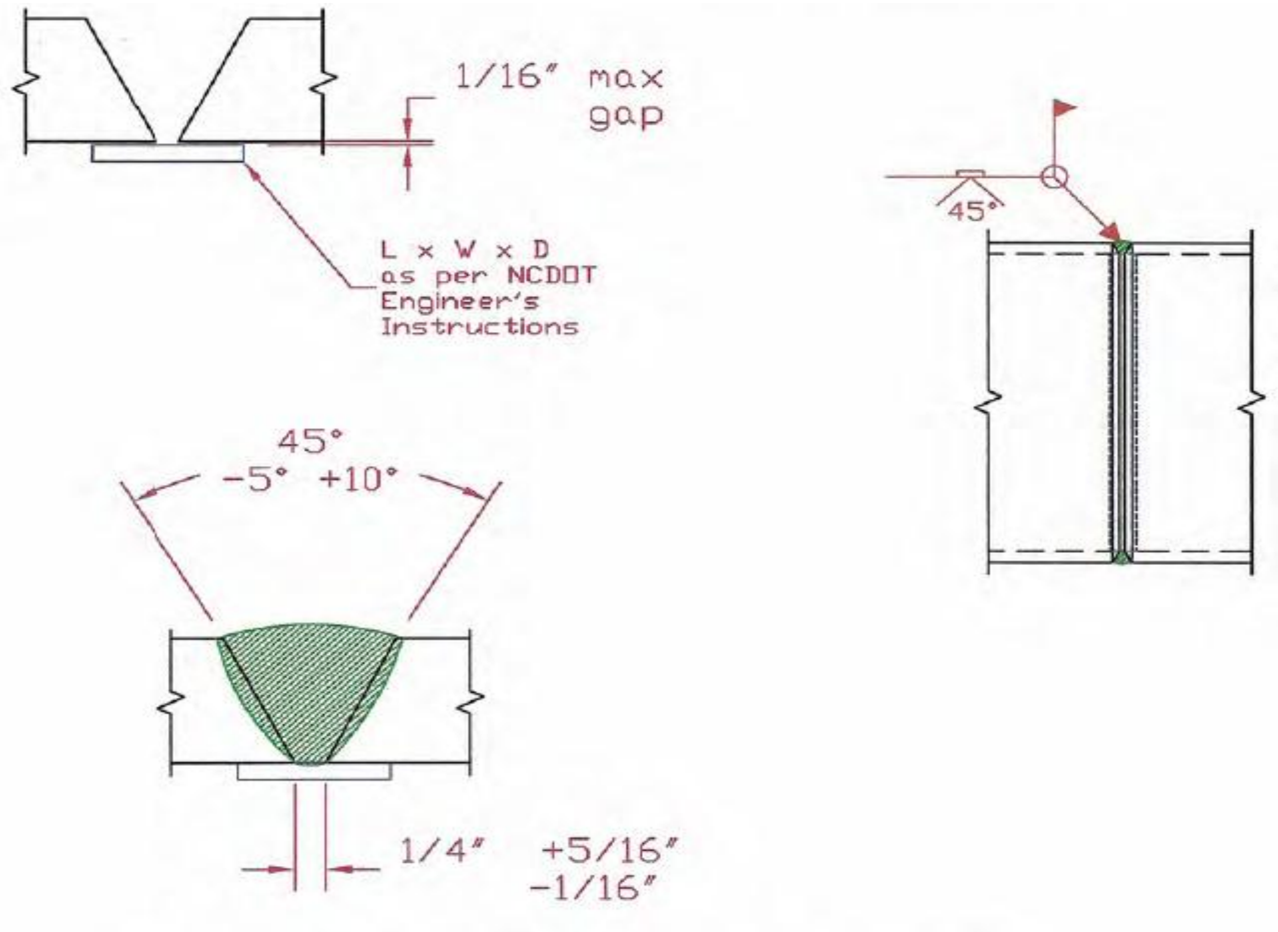
	S235	31CrV3
Gap distance	0 (zero) mm 1 mm 1.5 mm	0 (zero) mm 1 mm 1.5 mm
Bevel height	0 (zero) mm 1 mm 2 mm 3 mm	3 mm
Bevel angle	30°	

Figure below shows recommended bevel angle, root opening, and root face dimensions.



2. WPS Pipe-pile 082508003 R5 joint detail.

Figure below shows the single V-groove butt joint preparations.

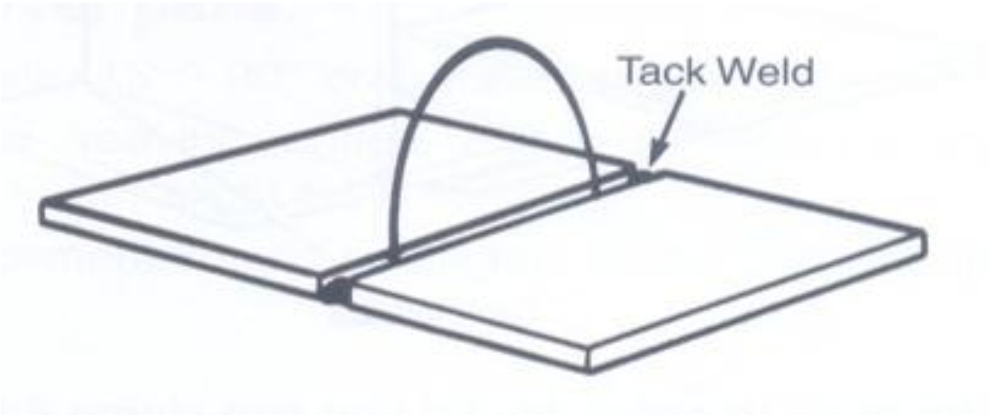


Operation Sheet 3	Performing tack welding

Do the following practical exercise

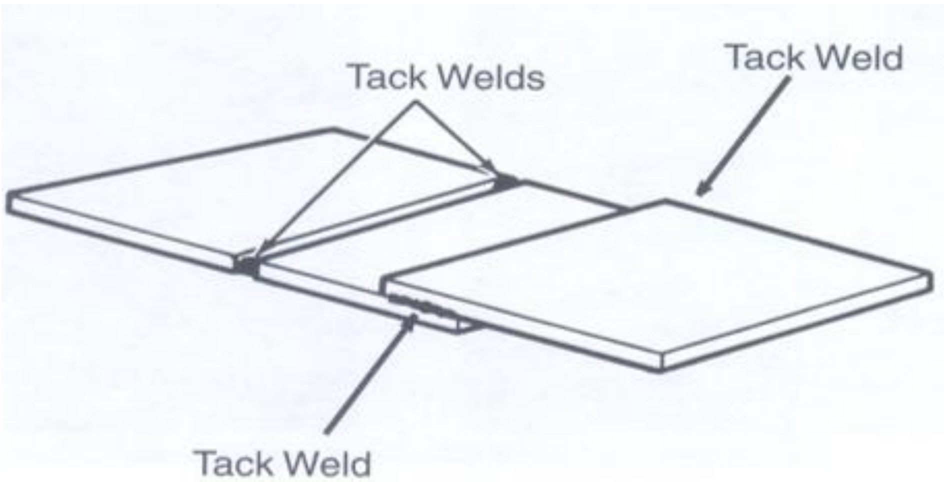
Position material and tack welding

- Position 2 plates to form an open butt joint.
- Use a 1/8” (3.2mm) spacer to make a 1/8” Root opening.
- Tack weld at both ends.



Place the third plate on the assembled butt joint to form a lap joint

- Tack weld at both ends



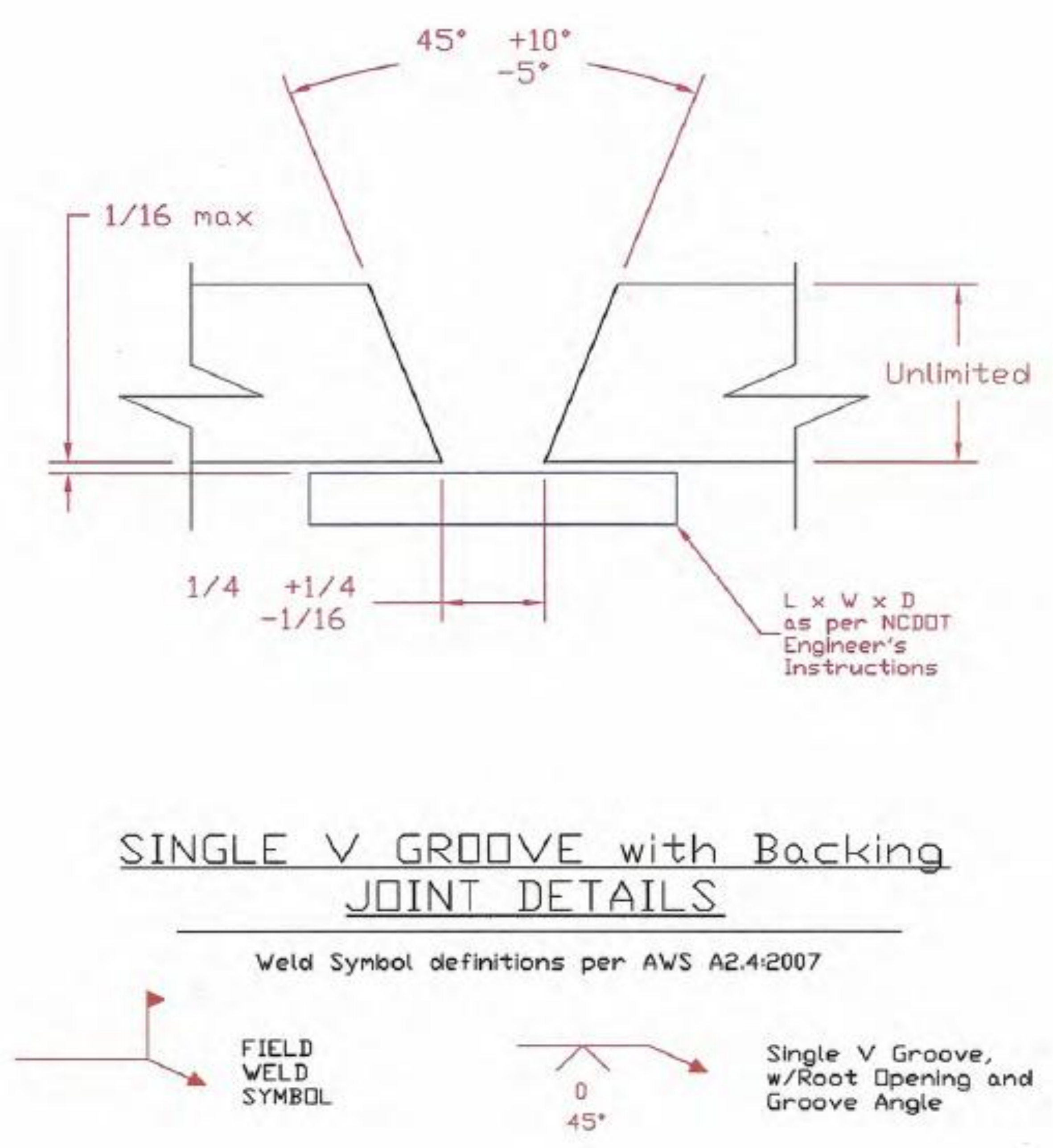
Operation Sheet 4	Performing tack welding

Work procedure and defect prevention

Thickness Min. Temp. Remove all coating, rust, dirt and mill scale within one inch of the area to be

welded. Remove all slag, spatter and weld discontinuities between passes. Clean the completed weld of all debris, slag and spatter.

The backing material needs to be in intimate contact with the base metal, but in all cases shall have no more than 1/16" gap (see attachment).



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 2 hours.

Task 1. Layout from the prepped metal.

Task 2. Cut to the required dimension.

Task 3. Complete the welding process.

Task4. Clean the joint correctly with the wrights cleaning equipments

Mechanics
Level –III

Learning Guide-21

Unit of Competence: Perform Plate and Tube Shielded Metal Arc Welding (SMAW)
Module Title: Performing Plate and Tube Shielded Metal Arc Welding (SMAW)

Module Code: XXX
LG Code: XXX
TTLM Code: XXX

LO4: Perform root pass

Instruction Sheet	Learning Guide #21

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

- Performing root pass.
- Performing task with company requirement.
- Making weld visually acceptable.
- Cleaning and making root pass free from defects.
- Performing task with the required standard.

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

- Perform root pass.
- Perform task with company requirement.
- Make weld visually acceptable.
- Clean and making root pass free from defects.
- Perform task with the required standard.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information "Sheet 1, Sheet 2, Sheet 3, Sheet 4, and Sheet 5".
4. Accomplish the "Self-check 1, Self-check 2, Self-check 3, Self-check 4, and Self-check 5" **in page -90, 93, 99, 102 and 106**respectively.
5. If you earned a satisfactory evaluation from the "Self-check" proceed to "Operation Sheet 1 and Operation Sheet 2" in page -107 and 108.
6. Do the "LAP test" in page – 109 (if you are ready).

4.1. 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 4.1) and the fusion face and toes of the weld (Figure 4.2).

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.

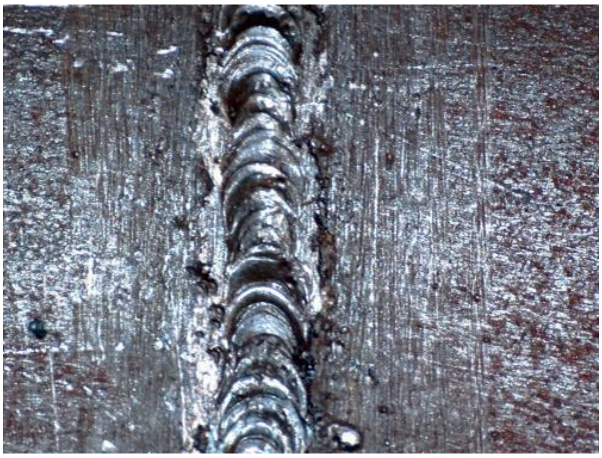


Figure 4.1 Fusion on the root side-both beveled pipe edges are melted.

Figure 4.2 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 4.3), 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.

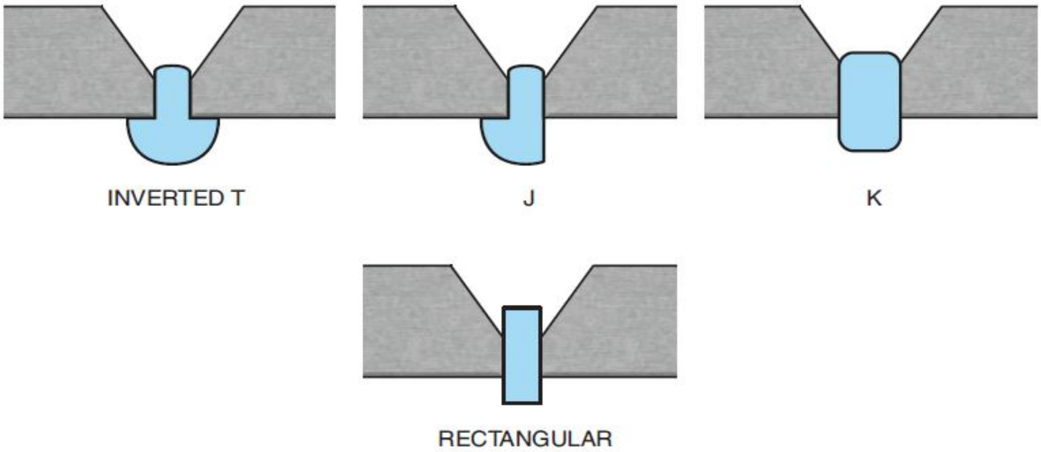


Figure 4.3 Consumable inserts for open root welding

When welding aluminum alloys, it is a common practice to use backing rings that fit inside the pipe and act as a backing bar. In addition, the extended-land bevel joint may be used (Figure 4.4). This design eliminates the need for a backing ring.

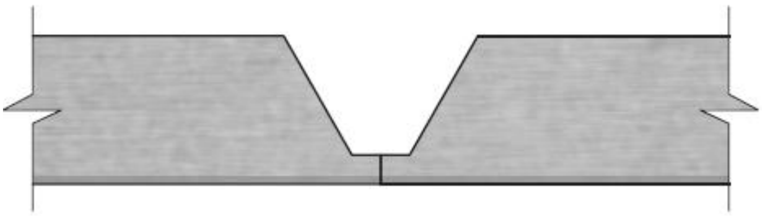


Figure 4.4 Extended land. *Source:* AWS D1.2/D1.2M:2003, Figure 3.31 reproduced with permission of the American Welding Society, Miami, Florida.

4.1.1. Open Root Pipe Welding Techniques

The 6G open root was done with a 1/8 E6010 electrode at 83 amps using a whipping technique. Most of the time I was dragging at about 5 degrees while pointing the rod to the center of the pipe. If you do not always point your rod to the center of the pipe and keep the keyhole centered, you will get a lack of fusion. In the event that the keyhole is closing up you need to lead the rod at about 5 to 10 degrees.

4.1.2. Common pipe welding positions.

Welding position is determined by the pipe position and if the pipe is in a fixed position or rotating. Pipe welding entails maintaining welding angles around the circumference of pipes. Rather than welding in one linear direction, the welder must constantly adjust the welding travel angle to account for the curvature of the pipe. Maintaining visibility of the weld pool is also complicated for welding fixed position pipe. Figure 4.5 shows common AWS pipe welding positions for groove joints.

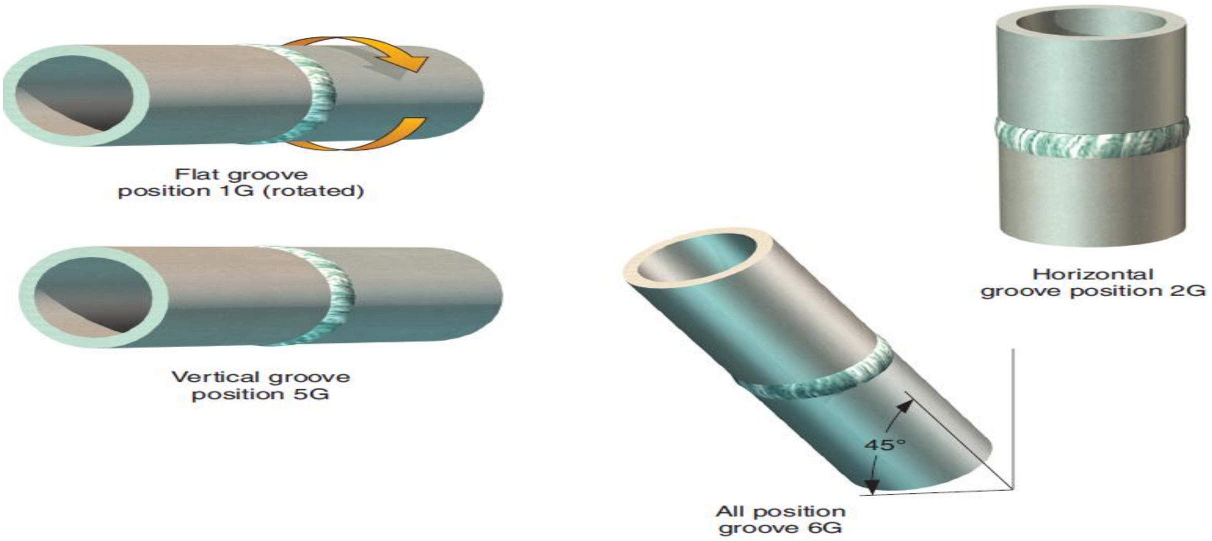


Figure 4.5 Pipe welding positions

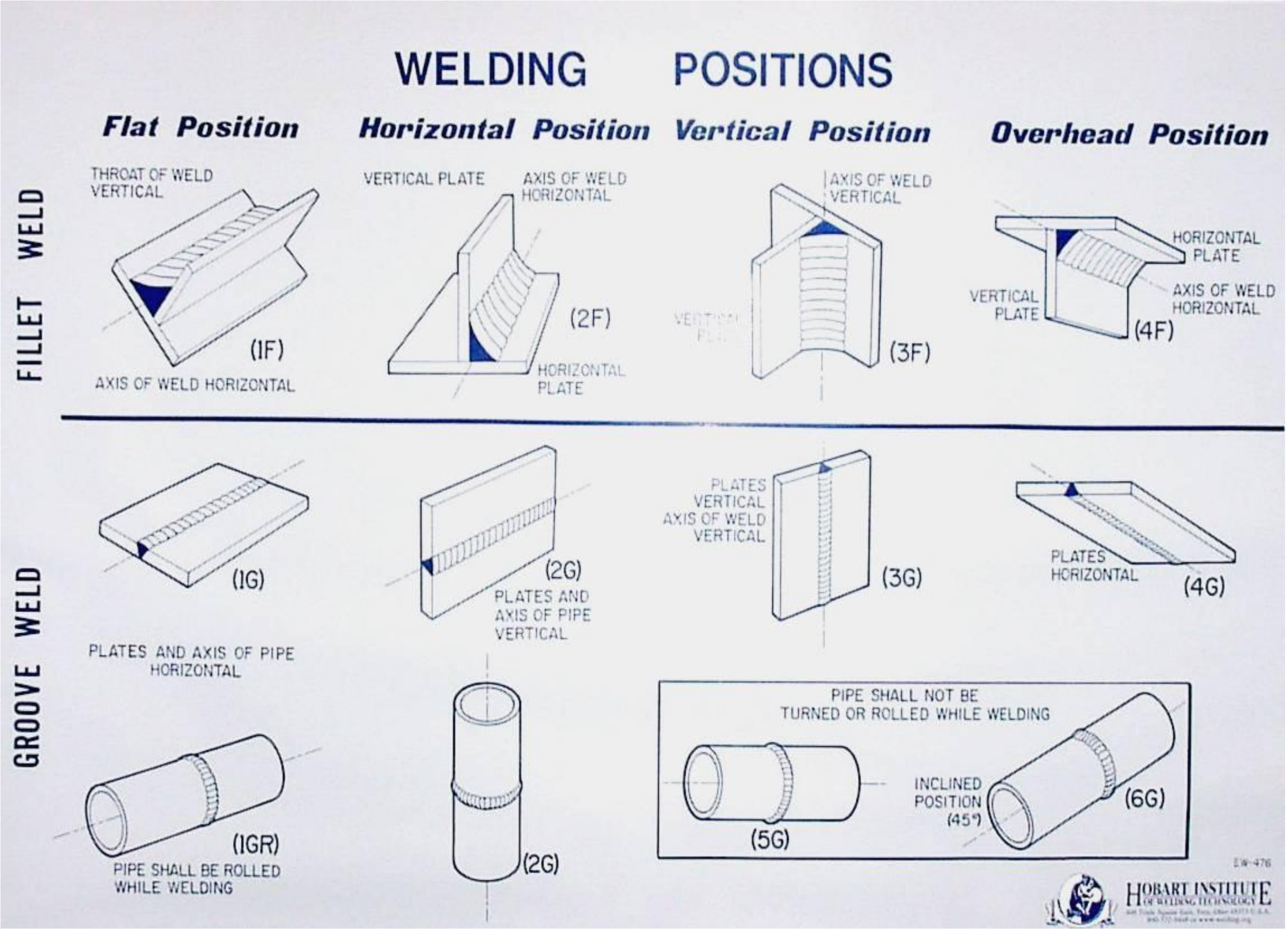


Figure 4.6 ASME and EN ISO positions

Definition of renewing and updating information regular way

During gathering information relating to the extent of local resource and their providers, renewing and updating information at the office level is important for making right decisions. Accordingly, right decisions are depending of quality of reviewing information.

I. Renewing: is making something valid for a further period of time, emphasizing something by saying or stating it again.
II. Updating: means add/give something recent information about to something.

In short, renewing and updating information is the process of reviewing or checking the collected information that is during the interpretation and analysis step. This indicates the value of support, supervision and monitoring to own work by any responsible body. This can be also done at individual level given there are guiding objectives in the initial phase.

Reference: - (https://youtu.be/LBp4miVvsxc)

Self-Check -1	Written Test

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

1. What is mean by root pass? (1pts)
2. What is the factor that the welder control that influenced the fusion? (2pts)
3. List the four type of pipe welding positions? (4pts)

Note: **Satisfactory rating – 4 points** **Unsatisfactory - below 4 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

4.2. Requirement

4.2.1. Specification of Standard on Contracts

When this Standard is specified on contract documents, a detailed weld process specification, as defined in NPR 7120.10, which meets the intent of this Standard shall be submitted. Industry, government, and company specifications can be used for welding flight hardware if they contain the information required by this Standard. The contractor has the responsibility to submit the detailed weld process specification.

4.2.2. Joint Classes

Welding performed using this Standard shall be classified in accordance with the service of the joints as follows in the next sections.

4.2.2.1 Class A

Critical applications. Welds where a single failure would cause loss of system, loss of major components, loss of control, and loss of crew.

4.2.2.2 Class A welds shall require visual, dimensional, surface, and volumetric inspections, and additional inspection when required by engineering drawing.

Note: Based on consequences of failure, all fracture-critical welds are, by definition, Class A joint. If the quality of the Class A joint cannot be verified as required by this Standard, e.g., inaccessible volume or root surfaces, then alternative rationale for acceptance is to be presented to the responsible NASA Fracture Control Board for approval as required by NASA-STD 5019, Fracture Control Requirements for Spaceflight Hardware.

4.2.3 Class B

Semi-critical applications. Welds where a failure would reduce overall efficiency of the system, preclude the intended function or use of the equipment, but loss of the system or endangering personnel would not be experienced.

4.2.3.1 Class B welds shall require visual, dimensional, and surface inspections, and additional inspection when required by engineering drawing.

4.2.3.2 Class B welds shall be subjected to volumetric inspection if required by engineering design and specified by drawing or special instruction.

4.2.3.3 Weld requiring fail-safe capability shall be classified as a Class B joint.

4.2.4 Class C

Non critical applications. Welds where a failure would not affect the efficiency of the system or endanger personnel.

4.2.4.1 Class C welds shall require visual and dimensional inspections, and, additional inspection when required by engineering drawing.

4.2.4.2 Class C joints shall require weld integrity verification based on function of the joint (e.g., seal welds require leak testing commensurate with the leak rate requirement).

Self-Check -2	Written Test

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

1. Explain the difference between**Critical applications,Semi-critical applications**and **Noncritical applications**(3pts)
2. Explain the difference between the Joint Classes? (3pts)

a)**Classes(A)**

b)**Classes(B)**

c)**Classes(C)**

Note: **Satisfactory rating –3 points** **Unsatisfactory - below 3 and 4 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

4.3. Unacceptable Weld Profiles

The profile of a completed weld may have a considerable effect on the performance of that weld in service. Welding inspectors must identify discontinuities through visual inspection and evaluate their acceptance or rejection according to the applicable welding code or standard acceptance criteria.

Unacceptable weld profiles can cause a reduction in base material thickness, reduction in weld size, or stress concentrations on the weld or plate surface. These types of weld discontinuities often seriously detract from the overall performance of a welded component in service.

Some weld profile discontinuities are undercut, overlap, insufficient throat, and excessive convexity. Undercut. Undercut is defined as a groove melted into the base metal adjacent the weld toe, or weld root, and left unfilled by weld metal.

The term **undercut** describes two specific conditions. The first is the melting away of the base material at the side wall of a groove weld at the edge of a bead, which produces a sharp recess in the side wall in the area where the next bead is to be deposited. This type of undercut can entrap inclusions within the recess, which then may be covered by a subsequent weld bead.

This condition usually can be corrected by grinding down the recess before depositing the next bead. If the undercut is slight, however, an experienced welder who knows how deep the arc will penetrate may not need to remove it. Undercut of the side wall of a groove weld won't affect the completed weld if the condition is corrected before the next bead is deposited.

The second condition is reduction of the base metal's thickness at the line where the weld bead on the final layer of weld metal ties into the surface of the base metal. This position is known as the toe of the weld. This condition can occur on a fillet weld or a butt joint.

The amount of undercut permitted at the surface of the completed weld usually is specified within the welding code or standard being used. The maximum permissible undercut requirements for completed welds should be followed stringently, because excessive undercut can seriously affect the performance of a weld, particularly if it's subjected to fatigue loading in service.

Both types of undercut usually are caused by an incorrect welding technique, incorrect electrode positioning, or incorrect travel speed. High currents and a long arc increase the probability of undercut.

4.3.1. Overlap. Overlap is defined as a protrusion of weld metal beyond the weld toe, or weld root. This condition occurs in fillet welds and butt joints and produces notches at the toe of the weld that are undesirable because of their resultant stress concentration under load. This discontinuity can be caused by incorrect welding techniques or insufficient current.

4.3.2. Insufficient Throat. Insufficient throat usually occurs in fillet weld and butt joint profiles that are concave. Excess concavity reduces throat thickness, which considerably reduces weld strength. This condition usually is caused by excessive welding current or arc lengths.

4.3.3. Excessive Convexity. Excessive convexity can produce a notch effect in the welded area and, consequently, concentration of stress under load. For this reason, some codes and standards specify the maximum permissible convexity of a weld profile. Insufficient current or incorrect welding techniques typically cause this condition.

4.3.4. Cracking

Cracks in a weldment are probably the most dreaded of all the weld discontinuities. Because so many materials and applications are used in welding, cracking is a complex subject.

The base material's crack sensitivity may be associated with its chemistry and its susceptibility to the formation of elements that reduce its ductility. Excessive stresses in the weld joint, particularly if the material is in a crack-sensitive condition, can cause cracking to occur.

The welding operation itself can produce stresses in and around the weld, introducing extreme localized heating, expansion, and contraction.

Cracking often is caused by stress concentration near discontinuities in welds and base metal and near mechanical notches in the weldment design. Hydrogen embrittlement, a condition that causes a loss of ductility and exists in weld metal because of hydrogen absorption, can contribute to crack formation in some materials.

Hot and Cold Cracks. Cracks are classified as one of two types: hot or cold.

Hot cracks develop at elevated temperatures, propagate between the grains of a material, and commonly form during solidification of weld metal.

Cold cracks develop after solidification of the weld, as a result of stresses, and propagate both between grains and through grains. Cold cracks in steel sometimes are called delayed cracks and often are associated with hydrogen embrittlement.

Hot cracks and cold cracks can be further categorized as base material cracks and weld metal cracks.

Base Material Cracks. Heat-affected zone (HAZ) cracking most often occurs with base material that can be hardened. High hardness and low ductility in a HAZ often are the result of a metallurgical response to welding thermal cycles. In ferrite steels, hardness increases and ductility decreases with an increase in carbon content and a faster cooling rate.

The HAZ hardness depends on the base material's ability to be hardened, which in turn depends on the base material's chemical composition. Carbon has a predominant effect on steel's hardenability. For instance, cast iron contains between 2 and 4.5 percent carbon, which gives the alloy high hardness and low ductility. Welding this material without seriously considering cooling rates and residual stress invariably will result in base material cracking.

Weld Metal Cracks. Weld metal cracks can be divided into three types:

1. Transverse, which are perpendicular to the direction of the weld.
2. Longitudinal, which travel in the same direction as the weld and often are confined to the center of the weld. This type of crack may be an extension of a crack that originally initiated at the end of a weld.
3. Crater, which can be formed by an abrupt weld termination if a crater is left unfilled with weld metal. These cracks usually are star-shaped and initially extend only to the edge of the crater. However, they can propagate into longitudinal weld cracks.

Dealing with Cracks. Cracks are unacceptable discontinuities and are detrimental to weld performance. A crack, by its nature, is sharp at its extremities, so it acts as a stress concentration. The stress concentration effect of a crack is greater than that of most other discontinuities.

Cracks have a tendency to propagate, contributing to weld failure under stress. Regardless of their size, cracks aren't permitted in weldments governed by most fabrication codes. They must be removed by grinding or gouging, and the excavation filled with sound weld metal.

Successful welding procedures incorporate the controls that are necessary to overcome the tendency for crack formation. Such controls are preheating temperature, inter pass temperature, consumable type and preparation, and post weld heat treatment.

Welding inspectors are responsible for evaluating these procedural controls during inspections to ensure welding is performed to minimize the possibility of weld cracking.

Unacceptable weld (overlap at the bottom of the weld, undercut/under fill at the top)

Unacceptable weld (overlap at the bottom of the weld, undercut/under fill at the top) Acceptable weld (arc strikes removed by grinding)

Figure 4.7. Illustrations for an acceptable Pipe Pile Welding

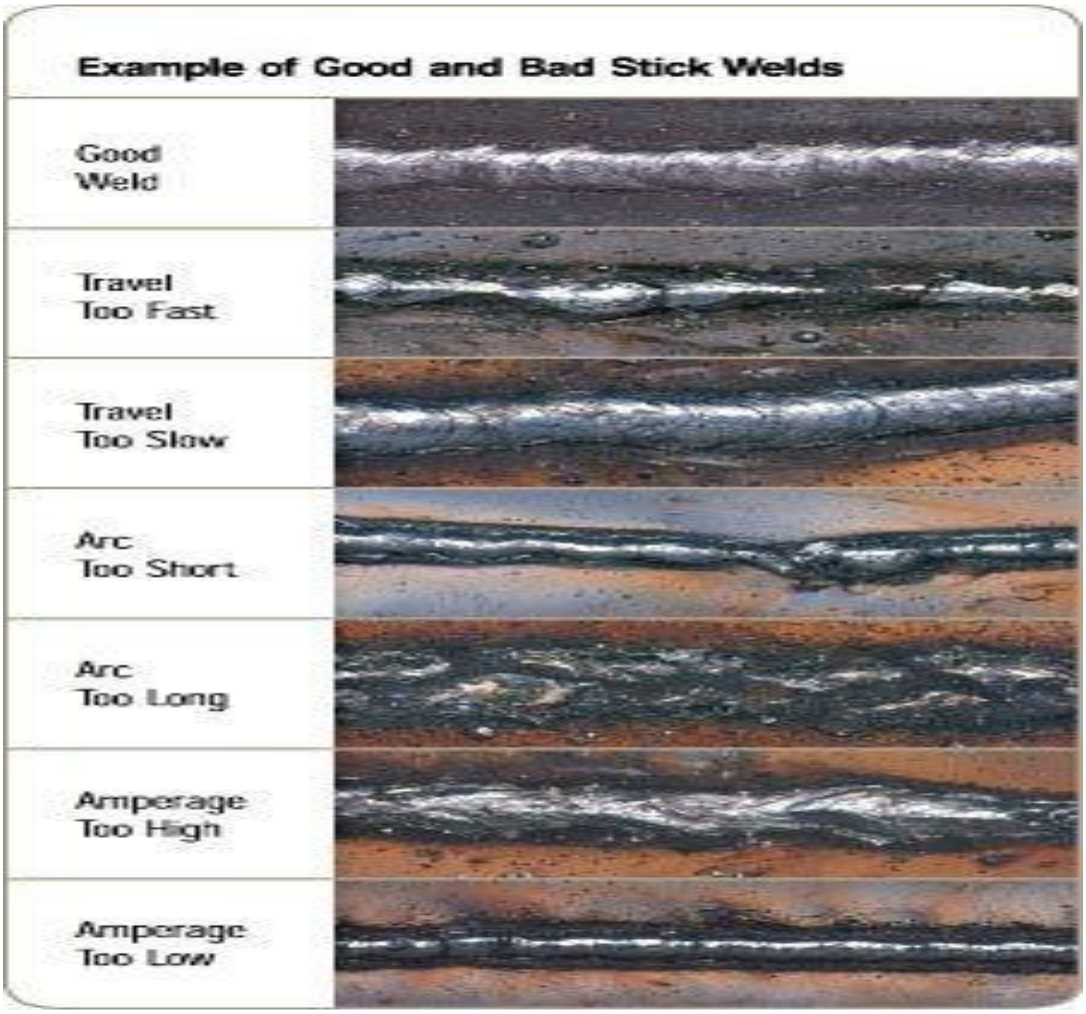


Figure 4.8. Good and Bad Stick Welding

Self-Check -3	Written Test

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

1. Describe the two specific conditions that describes the term **undercut**? (2pts)
2. List three types of Weld metal cracks? (3pts)

***Note:* Satisfactory rating –3 points** **Unsatisfactory - below 3 and 4 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

4.4. Weld Cleaning

Cleaning is necessary before welding, during welding (interpass) and is usually essential after welding in order to ensure maximum corrosion resistance. Each welding run must be thoroughly cleaned to remove **slag and spatter** before proceeding with the next run. The cleaning method used (chipping, brushing, grinding) will depend on the welding process, bead shape, etc. but care should be taken to see that the weld area is not contaminated in the process.

Any cleaning equipment should be suitable for stainless steel and kept for that purpose. During welding, a gas purge on the reverse side may be advantageous. After welding, weld spatter, flux, scale, arc strikes and the overall heat discoloration should be removed. This can involve grinding and polishing, blasting and brushing with a stainless steel wire brush, or use of a descaling solution or paste. The preferred procedure is usually dictated by end use. Grinding and dressing is to be carried out with iron-free brushes, abrasives, etc. and should not be so heavy as to discolor and overheat the metal. Rubber and resin bonded wheels are satisfactory. Wheels should be dressed regularly to prevent them becoming loaded thereby producing objectionable scratches. In any blasting process steel shot shall not be used

Slag or flux remaining after a pass, shall be removed before applying the next covering pass. After the final pass all slag and weld spatter shall be removed. Arc strikes shall be removed by grinding or other suitable means. Cracks or blemishes caused by arc strike shall be ground to a smooth contour and examined visually to assure complete removal.
Slag or flux remaining after a pass, shall be removed before applying the next covering pass. Prior to painting, etc., all slag shall be removed and the parts shall be free of loose scale, oil and dirt

4.4.1. Importance of cleaning

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

4.4.2. Methods of cleaning

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

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

4.4.3. In-Process Cleaning- Before welding over previously deposited metal, all slag shall be removed and the weld and adjacent base metal shall be brushed clean.

This requirement shall apply not only to successive layers but also to successive beads and to the crater area when welding is resumed after any interruption. It shall not, however, restrict the welding of plug and slot welds. (AWS D-1.5 Section 3.11.1)

4.4.4. Cleaning of Completed Welds.

Slag shall be removed from all completed welds, and the weld and adjacent base metal shall be cleaned by brushing or other suitable means. Tightly adherent spatter remaining after the cleaning operation is acceptable, unless its removal is required for the purpose of nondestructive testing. Welded joints shall not be painted until after welding has been completed and the weld accepted. (AWS D-1.5 Section 3.11.2).

Self-Check -4	Written Test

Directions: Answer all the questions listed below.
:

1. What is the use of cleaning the welding for quality? (1pts)
2. Explain what is to be removed from each welding root pass? (2pts)
3. List some cleaning equipments used after welding. (2pts)
4. What is the difference between in process cleaning and clean of complete weld? (2pts)

Note: **Satisfactory rating – 3.5 points** **Unsatisfactory - below 3.5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

5.5. Standards

The surfaces to be welded shall be free of slag, oil, grease, cement mortar, external coating, rust or mill scale, mud or sand, or any foreign substances which may affect the quality of the weld.

In multi-pass welding, each pass shall be thoroughly cleaned before the succeeding pass is applied.

Tack welds, which are to be incorporated in the final weld, shall be subjected to the same quality and workmanship requirements as the final weld. Any tack weld found to be cracked shall be completely removed and replaced by a tack weld of sound quality.

Welding and rendering debris inside of pipes shall be removed to avoid clogging and damage to other in-line components such as pumps, flow meters and valves.

5.5.1. Australian Standards

All metal fabrication and welding shall comply with the Standards and Codes of Practice specified for the project.

The applicable edition of standards and codes shall be those that are current two calendar weeks prior to the date of a work brief or, in the case of tendered work, the tender closing date. The specified standards and codes shall be the minimum applicable requirements

5.5.2. Water Corporation Standards

All metal fabrication and welding of pipe fittings and flanges shall comply with this Technical Specification and *Corporation* Design Standards including the Pipe Fittings Design Standard DS-65. The *Designer* will, by reference to Corporation Design Standards and by copying/adapting Corporation standard drawings, provide the *WSP* with project drawings, design details and workmanship specifications that enable the *WSP* to produce workshop drawings and fabrication details as necessary to construct welded assets of the specified quality.

5.5.3. Industry Standards

WTIA Technical Note 25 Quality Assurance templates and forms may be used by the WSP for documenting standards for welding and fabrication used in construction. Table in Figure 4.9 show format for welding procedure specification (WPS).

Weld Acceptance Criteria

AWS D-1.5 Section 6.26.1: All welds shall be visually inspected. A weld shall be acceptable by visual inspection if it conforms to the following requirements:

AWS D-1.5 Section 6.26.1.1: The weld shall have no cracks.

AWS D-1.5 Section 6.26.1.2: Thorough fusion shall exist between adjacent layers of weld metal and between weld metal and base metal.

AWS D-1.5 Section 6.26.1.3 : All craters are to be filled to the full cross section of the weld...

AWS D-1.5 Section 6.26.1.4 : Weld profiles shall be in conformance with 3.6.

AWS D-1.5 Section 6.26.1.5: In primary members, undercut shall be no more than 0.25mm [0.01 in] deep when the weld is transverse to tensile stress under any design loading condition. Undercut shall be no more than 1mm [1/32 in] deep for all other cases.

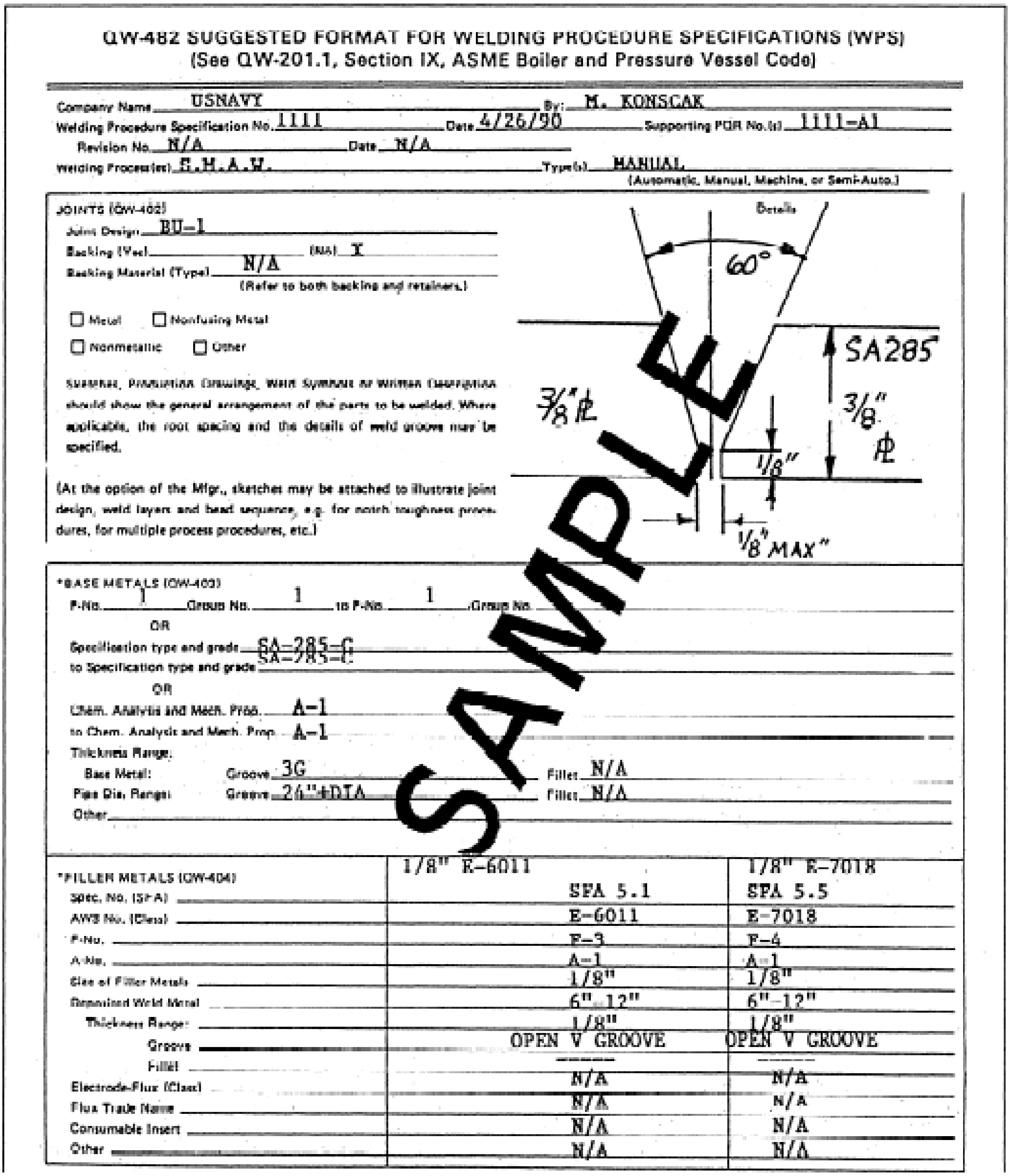
Porosity limitation guidelines (AWS D-1.5 Section 6.26.1.6) are too complex to be presented in this manual. Contact the M&T Unit (Steel Section) for technical assistance regarding discontinuities of this type.

AWS D-1.5 Section 6.26.1.7 A fillet weld in any single continuous weld may under run the nominal fillet weld size specified by 2mm [1/16 in] without correction, provided that the undersize portion of the weld does not exceed 10% of the length of the weld.

AWS D-1.5 C-6.26.1 Visual Inspection. All welds are required to be visually inspected. Visual inspection is performed before welding, during welding, and after welding, as necessary to ensure that the requirements of the Contract Documents are met and that all welds conform to the visual requirements of this sub-clause.

The Inspector is not required to inspect each weld pass, but periodically observe welding with sufficient frequency to verify the skills of the welder, proper joint preparation, WPS variables, and the visual quality of typical root, intermediate, and final weld passes. In addition to inspection before and during welding, the Inspector is expected to visually inspect every completed weld to verify conformance to these requirements.

AWS D-1.5 C-6.5 Each welder, welding operator and tack welder should be a visual inspector of his or her own work. Welding personnel should know when welds display visual discontinuities not acceptable under the Code. Because each weld pass of every weld is to be inspected by the welder, and the inspector monitors welding in progress and makes a detailed inspection of completed welds, major weld defects or gross nonconformance to the Code should be detected.



QW-482 SUGGESTED FORMAT FOR WELDING PROCEDURE SPECIFICATIONS (WPS)
(See QW-201.1, Section IX, ASME Boiler and Pressure Vessel Code)

Company Name USNAVY By: M. KONSCAK
Welding Procedure Specification No. 1111 Date 4/26/90 Supporting PQR No.(s) 1111-A1
Revision No. N/A Date N/A
Welding Process(es) S.M.A.W. Type(s) MANUAL
(Automatic, Manual, Machine, or Semi-Auto.)

JOINTS (QW-402) Details
Joint Design BU-1
Backing (Yes) (No) X
Backing Material (Type) N/A
(Refer to both backing and retainers.)

☐ Metal ☐ Nonfusing Metal
☐ Nonmetallic ☐ Other

Sketches, Production Drawings, Weld Symbols or Written Description should show the general arrangement of the parts to be welded. Where applicable, the root spacing and the details of weld groove may be specified.

(At the option of the Mfgr., sketches may be attached to illustrate joint design, weld layers and bead sequence, e.g. for notch toughness procedures, for multiple process procedures, etc.)

*BASE METALS (QW-403)
P-No. 1 Group No. 1 to P-No. 1 Group No.
OR
Specification type and grade SA-285-C
to Specification type and grade SA-285-C
OR
Chem. Analysis and Mech. Prop. A-1
to Chem. Analysis and Mech. Prop. A-1
Thickness Range:
Base Metal: Groove 3G Fillet N/A
Pipe Dia. Range: Groove 24"+DIA Fillet N/A
Other

*FILLER METALS (QW-404)	1/8" E-6011	1/8" E-7018
Spec. No. (SFA)	SFA 5.1	SFA 5.5
AWS No. (Class)	E-6011	E-7018
F-No.	F-3	F-4
A-No.	A-1	A-1
Size of Filler Metals	1/8"	1/8"
Deposited Weld Metal	6"-12"	6"-12"
Thickness Range:	1/8"	1/8"
Groove	OPEN V GROOVE	OPEN V GROOVE
Fillet	------	------
Electrode-Flux (Class)	N/A	N/A
Flux Trade Name	N/A	N/A
Consumable Insert	N/A	N/A
Other	N/A	N/A

Figure 4.9 Format for welding procedure specification (WPS)

Self-Check -5	Written Test

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

1. Write the standard codes for:

a. visual inspections.

b. The weld shall have no Cracks

c. In primary members undercut shall be no more than 0.25mm deep

Note: **Satisfactory rating –1.5 points** **Unsatisfactory - below 1.5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Operation Sheet 1	Performing root pass

1. Low carbon steel plates (S235) with the dimensions of 4x50x200 are prepared with the bevel heights of 0, 1, 2, 3 millimeters, bevel angle of 30°. Then, they were tack welded to get a gap distance of 0, 1 and 1.5 millimeters. Finally perform the root pass on the prepared material in figure below.

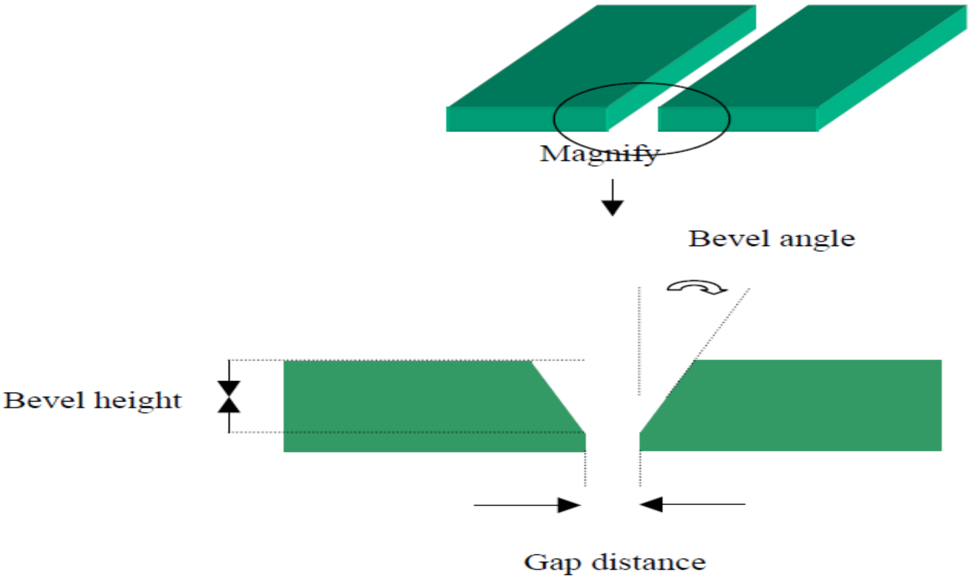
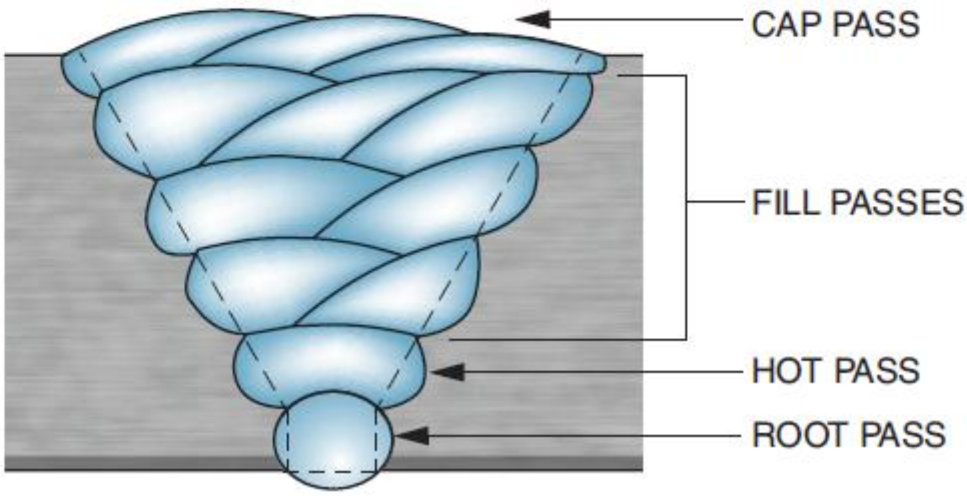


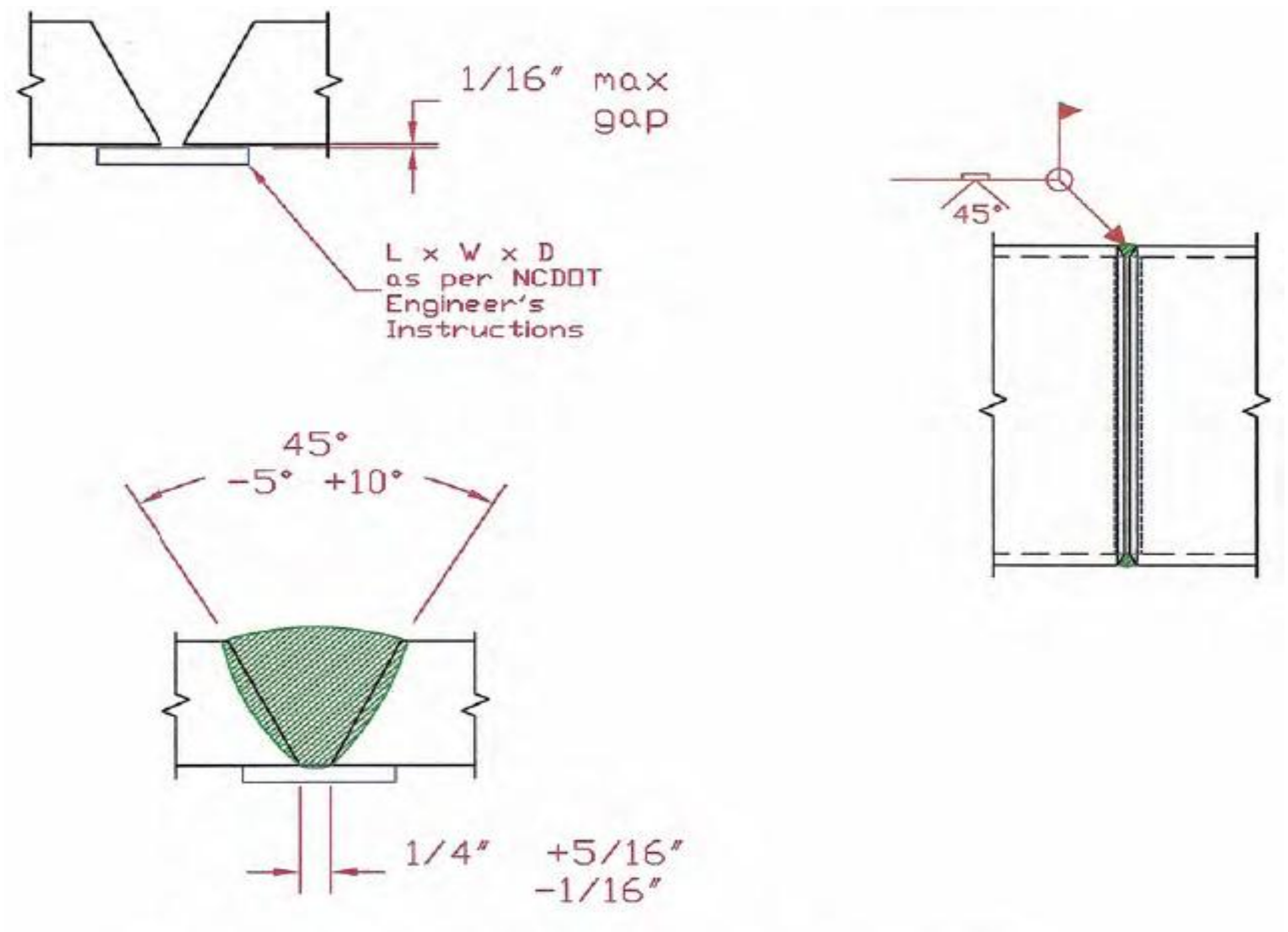
Figure. Single V-groove butt joint preparations

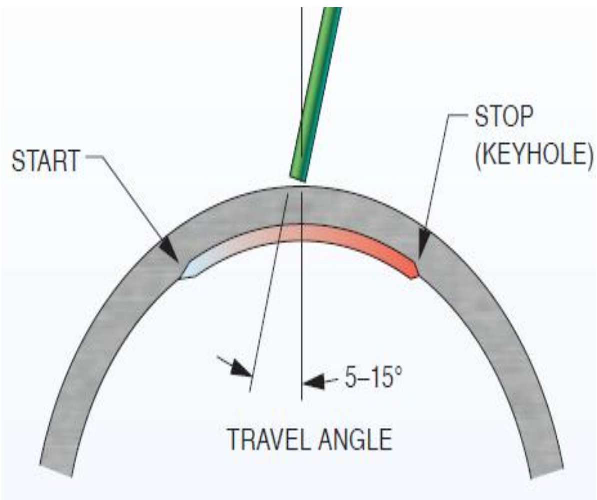


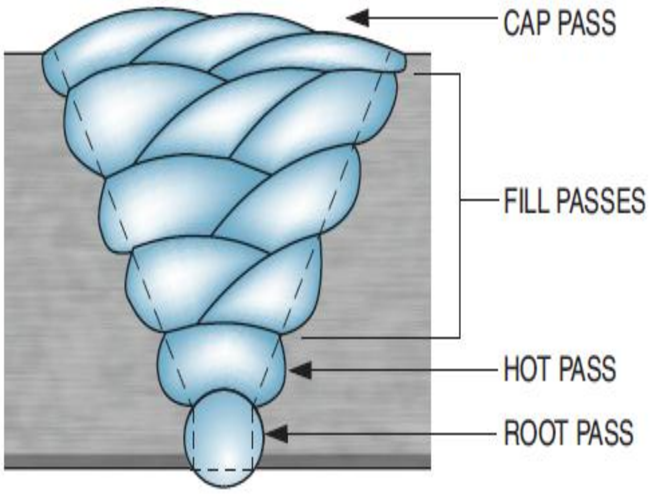
Operation Sheet 2	Performing root pass

1. WPS Pipe-pile 082508003 R5 joint detail.

Figure below shows the single V-groove butt joint root pass.







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 2 hours.

Task 1. Layout from the prepped metal.

Task 2. Cut to the required dimension.

Task 3. Complete the welding process.

Task4. Clean the joint correctly with the wrights cleaning equipments.

Mechanics Level-III

Learning Guide-22

Unit of Competence: Perform Plate and Tube Shielded Metal Arc Welding (SMAW)

Module Title: Performing Plate and Tube Shielded Metal Arc Welding (SMAW)

Module Code: XXX
LG Code: XXX
TTLM Code: XXX

LO5: Weld subsequent/ filling pass

Instruction Sheet	**Learning Guide #22**

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

- Performing subsequent/filling passes.
- Making weld visually acceptable with applicable codes and standards.
- Cleaning and making fill pass free from defects and discontinuities.

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

- Perform subsequent/filling passes.
- Make weld visually acceptable with applicable codes and standards.
- Clean and make fill pass free from defects and discontinuities.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information "Sheet 1, Sheet 2 and Sheet 3".
4. Accomplish the "Self-check 1, Self-check 2 and Self-check 3" **in page -115, 117 and 120 respectively**.
5. If you earned a satisfactory evaluation from the "Self-check" proceed to "Operation Sheet 1" **in page -121.**
6. Do the "LAP test" **in page – 122**(if you are ready).

Information Sheet-1	Performing subsequent/filling passes

5.1. Filling passes

The weld passes that follow the hot pass and fill the weld groove flush or almost flush with the surface of the work pieces.

Whether using stringer or weave beads, code requirements must be met. Some codes set limits on bead width and layer thickness (Figure 5.1) for qualified procedures. *AWS D1.1 Structural Welding Code-Steell-2010*, e.g., limits a fill pass layer thickness for SMAW.

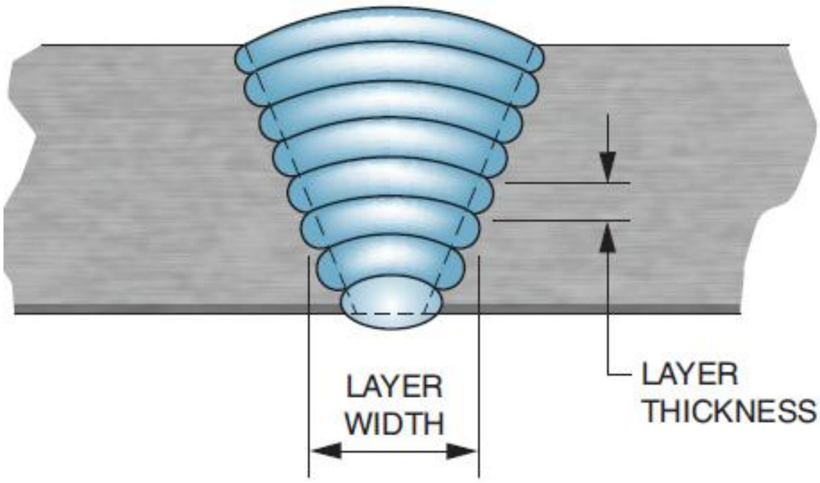
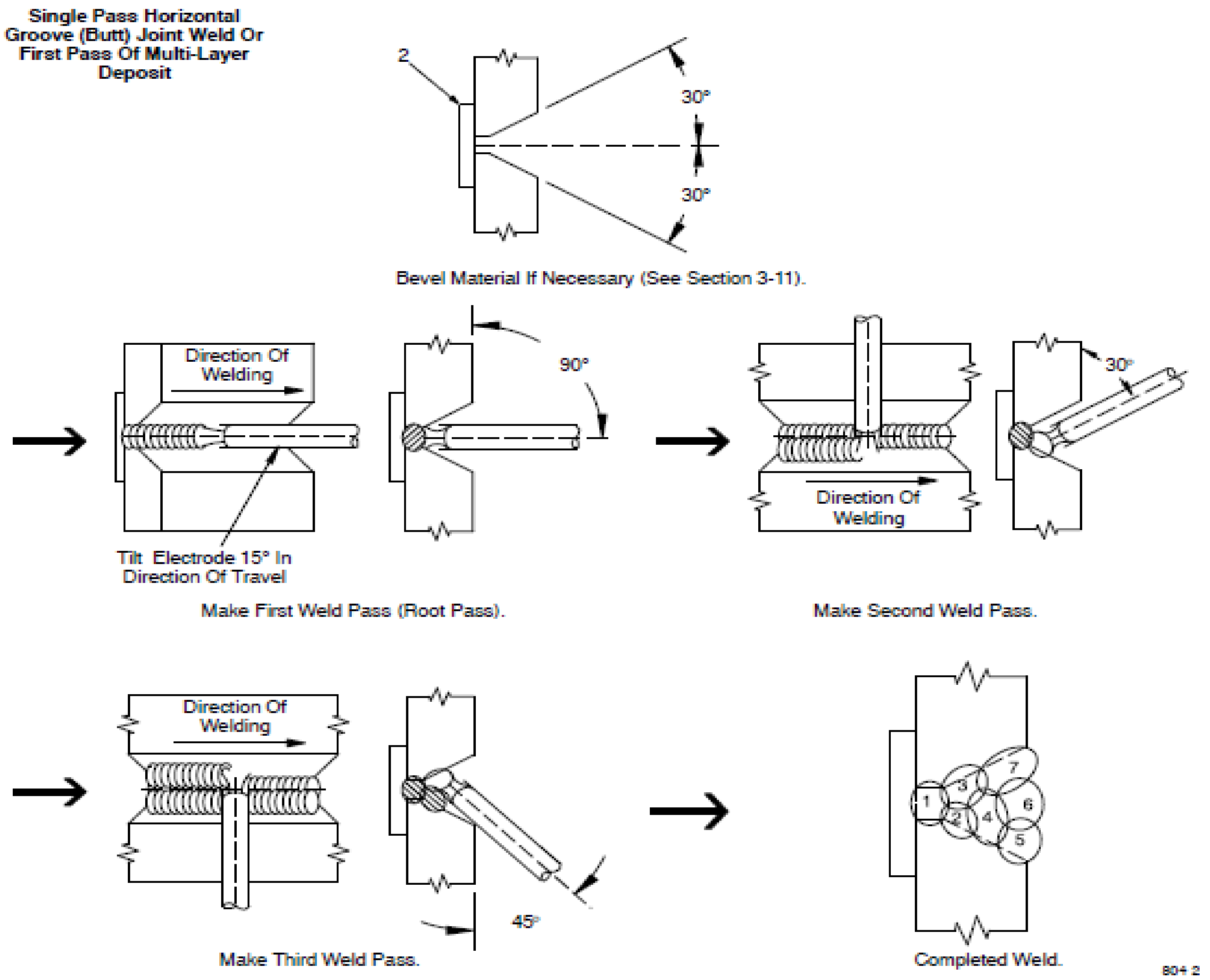


Figure 5.1 Example of layer thickness and width.

5.1.1. Multiple Pass Welding

Grove and fillet welds in heavy metals often require the deposit of a number of beads to complete a weld. It is important that the beads be deposited in a predetermined sequence to produce the soundest welds with the best proportions. The number of beads is determined by the thickness of the metal being welded.

Plates from 1⁄8-inch to ¼-inch can be welded in one pass, but they should be tacked at intervals to keep them aligned. Any weld on a plate thicker than ¼-inch should have the edges beveled and multiple passes.



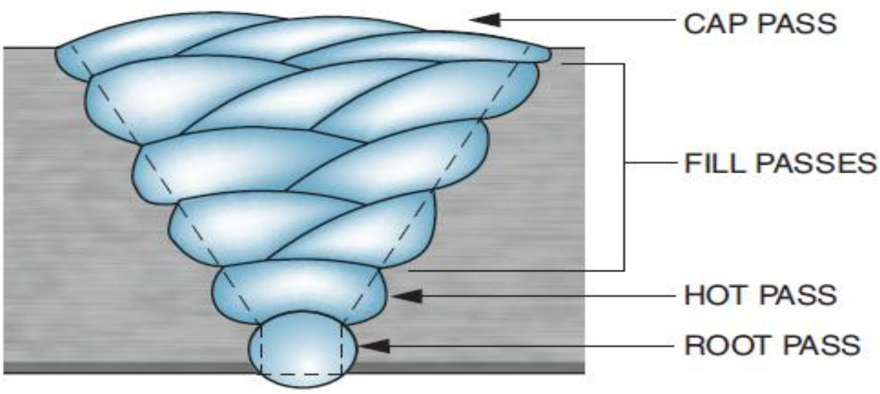


Figure 5.2 Fill pass

The sequence of the bead deposits is determined by the kind of joint and the position of the metal. All slag must be removed from each bead before another bead is deposited.

Typical multiple-pass grove welding of butt joints is shown in Figure 5.3.

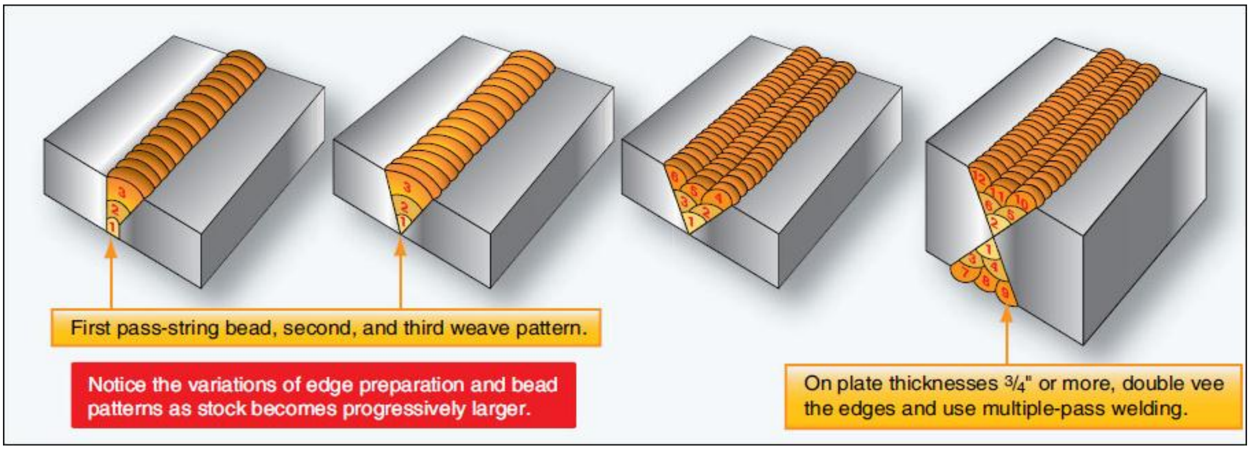


Figure5.3 Techniques of Position Welding

Self-Check -1	Written Test

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

1. List the two stage that pass before welding fill pass stage? (2pts)
2. How sequence of bead deposition is determined? (2pts)

Note: **Satisfactory rating – 2 points** **Unsatisfactory - below 2 and 4 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

5.2. Plug and Slot Weld Requirements

The details of plug and slot welds made by the SMAW, GMAW (except short circuiting transfer), orFCAW processes are listed in section below.

5.2.1. Diameter Limitations. The minimum diameter of the hole for a plug weld shall be no less than the thickness of the part containing it plus 5/16 in. (8 mm), preferably rounded to the next greater odd 1/16 in. (1.6 mm).

The maximum diameter shall equal the minimum diameter plus 1/8 in. (3 mm) or 2-1/4 times the thickness of the member, whichever is greater.

5.2.2. Slot Length. The length of the slot for a slot weld shall not exceed ten times the thickness of the part containing it. The width of the slot shall be no less than the thickness of the part containing it plus 5/16 in. (8 mm), preferably rounded to the next greater odd 1/16 in. (1.6 mm). The maximum width shall equal the minimum width plus 1/8 in. (3 mm) or 2-1/4 times the thickness of the member, whichever is greater.

5.2.3. Depth of Filling. The depth of filling of plug or slot welds in metal 5/8 in. (15.9 mm) thick or less shall be equal to the thickness of the material. In metal over 5/8 in. thick, it shall be at least one-half the thickness of the material. but no less than 5/8 in.

Figure 5.4 Welding standards

Self-Check -2	Written Test

Directions: Answer all the questions listed below.

1. Describe the plug and slot requirement in SMAW that listed below. (3 points)

   a. Diameter limitation

   b. Slot length

   c. Depth of filling

2. The length of the slot for a slot weld shall not exceed _________ times the thickness of the part containing it. (1 points)

***Note:* Satisfactory rating – 2 points** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: ___________________________ Date: ________________

Short Answer Questions

5.3. Fill pass welding

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 removed. Inter pass cleaning–chipping, wire brushing, and grinding are necessary steps in producing sound welds. 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 currents, 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.

For weld Bead width or thickness? Whether using stringer or weave beads, code requirements must be met. Some codes set limits on bead width and layer thickness for qualified procedures.

5.3.1. AWS D-1.5 Section 3.11.1 **In-Process Cleaning**. Before welding over previously deposited metal, all slag shall be removed and the weld and adjacent base metal shall be brushed clean. This requirement shall apply not only to successive layers but also to successive beads and to the crater area when welding is resumed after an interruption.

5.3.2. AWS D-1.5 Section 3.11.2 **Cleaning of Completed Welds**. Slag shall be removed from all completed welds, and the weld and adjacent base metal shall be cleaned by brushing or other suitable means. Tightly adherent spatter remaining after the cleaning operation shall be acceptable unless its removal shall be required for the purpose of NDT or painting. Welded joints shall not be painted until after welding has been completed and the weld has been accepted.

Discontinuity. An interruption of the typical structure of a material, such as a lack of homogeneity in its mechanical or metallurgical, or physical characteristics. A discontinuity is not necessarily a defect.

A Welding Discontinuity

Technically, a welding discontinuity is the lack of a mechanical, physical or metallurgical harmony in the weld. This could be manifested in terms of

- Varied porosity
- Incomplete fusion or joint penetration
- Unacceptable profiles
- Subtle tears and cracks

Welding Defects

All welding defects are developed discontinuities. If a discontinuity renders a weld incompetent or lowers its quality, it would be classified as a defect. Defects make the product risky to use or substandard. It is up to the quality control to decide whether the discontinuity qualifies as a defect or not.

The Differences between Discontinuities and Defects

Since the line between discontinuities and defects varies from one industry to another, only a generalized explanation can give a good guide to isolating defects from discontinuities.

- Any weld would be a defect if the welder or the quality control department rejects it and blacklists the product.
- A defined list of acceptable discontinuities will list the number or type of discontinuities allowed on a product before labelling it a defect.
- A discontinuity will survive a field test while a defect won't. A crack on a water pipe would be a defect since the water will leak while an unacceptable profile could pass as a discontinuity as long as the pipe doesn't leak.

Discontinuities can be ignored since they are always well within the acceptable production error margins. Defects, on the other hand, must be repaired. If the defect is irreparable, the product should get a red reject tag and head to the junk bin. It's important to understand the distinction between a weld defect and discontinuity to understand the quality of a weld, and if an imperfection is a safety concern or merely cosmetic. A perfect weld is a precarious achievement that requires meticulous care in the preparation of materials, a work area and careful adherence to welding techniques.

Self-Check -3	Written Test

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

1. Define Discontinuity. (1 points)
2. Discontinuity is a defect or not, if not why? (2pts)
3. Discus about In-Process Cleaning and Cleaning of Completed Welds? (2pts)

Start arc on sidewall or in center of tack weld, not in the gap.

***Note:* Satisfactory rating –2.5 points** **Unsatisfactory - below 2.5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

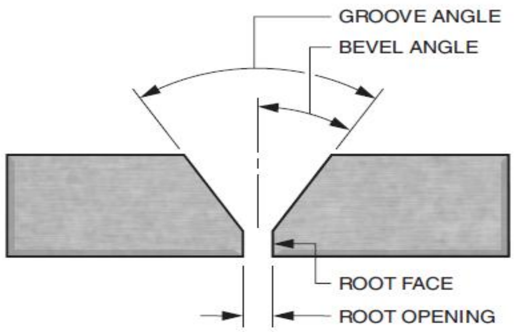
Rating: ____________

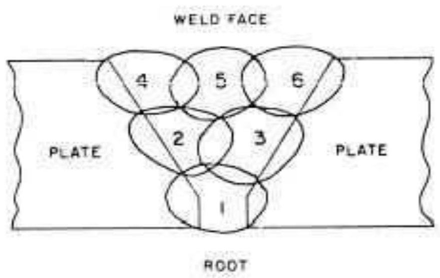
Name: _________________________ Date: _______________

Operation Sheet 1	Performing subsequent/filling passes

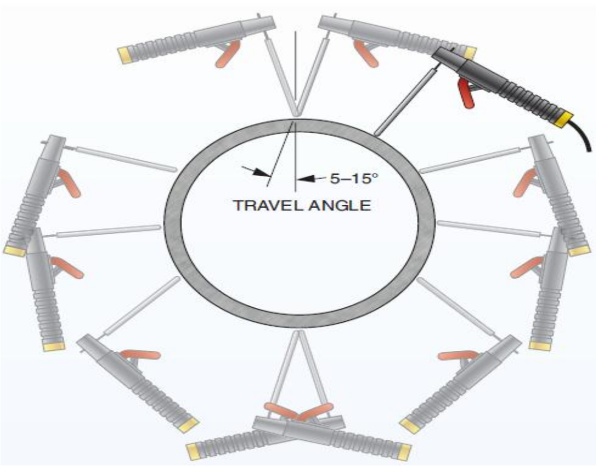
SMAW pipe 5G Vertical groove position

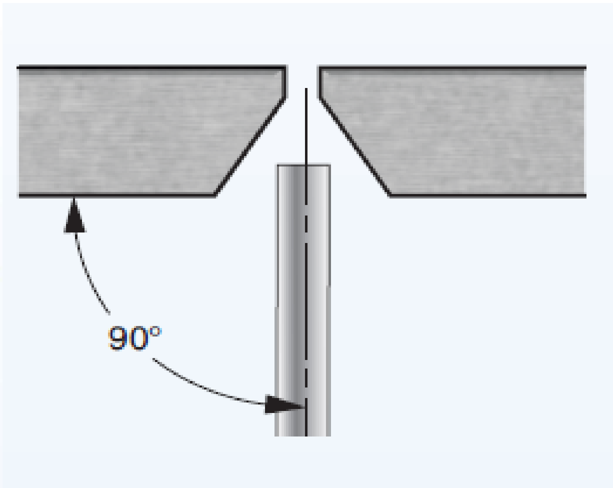
Instructions	
Base Metal Carbon Steel	Carbon Steel
Current DCEP	DCEP
Progression Vertical down	Vertical down
Root pass	EXX10 or EXX11 classification electrodes Backhand stringer, straight step whipping
Hot pass	As needed
Fill passes	EXX10 or EXX11 classification electrodes Backhand stringer, straight step whipping
Cover pass	EXX10 or EXX11 classification electrodes Backhand stringer, straight step whipping
Progression	Vertical up
Root pass	EXX10 or EXX11 classification electrodes Backhand stringer, straight step whipping, or circular weave





Weld layer sequence.





Travel angle. Work angle.

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 hours.

Task 1. Layout from the prepped metal.

Task 2. Cut to the required dimension.

Task 3. Complete the welding process.

Task4. Clean the joint correctly with the wrights cleaning equipments

Mechanics
Level-III

Learning Guide-23

Unit of Competence: Perform Plate and Tube Shielded Metal Arc Welding (SMAW)

Module Title: Performing Plate and Tube Shielded Metal Arc Welding (SMAW)

Module Code: XXX
LG Code: XXX
TTLM Code: XXX

LO6: Perform capping

Instruction Sheet	Learning Guide #23

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

- Performing Capping with WPS.
- Weld is visually acceptable with applicable codes and standards.

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

- Perform Capping with WPS.
- Weld is visually acceptable with applicable codes and standards.

Learning Instructions:

1.. Read the specific objectives of this Learning Guide.

2. Follow the instructions described below 3 to 6.
3. Read the information written in the information “Sheet 1 and Sheet2”.
4. Accomplish the “Self-check 1and Self-check 2” **in page -130, and 133**respectively.
5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1” **in page -134.**
6. Do the “LAP test” **in page – 135**(if you are ready).

6.1. Capping welding is the common term used for the projection spot welding of the caps (or lids) on electronic packages. The process seems to be fairly straightforward: place components in a metal package and seal. It is very important, however, to prevent moisture and oxygen ingress to the package during sealing, which, over time, will damage the sensitive electronic components housed within.

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. Figure 6.1 shows a

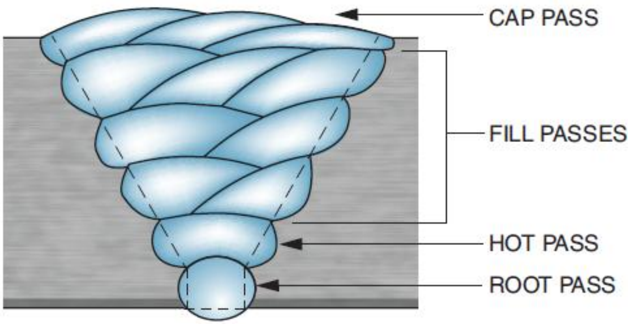


Figure 6.1 completed groove weld and layers (stringer bead technique).

6.1.1 Some basic guidelines for welding the cap are as follows:

- Keep your electrode angle pointed to the center of the pipe at all times with very few exceptions.
- Keep your arc length as short as possible.
- If possible, drag your electrode slightly no matter what the position is. Most people will disagree with this but it works for me because it keeps the slag behind the puddle. Once you build a shelf of weld then you can drag.
- Only move forward and side to side with the electrode otherwise the weld will become rough.

- When the pipe gets to hot let it cool down or put on a vice grip to lean on.
- Make sure you fuse the bevels edge by pushing the toe of the weld into it.
- Overlap stringer beads from at least 25% to a maximum of 50%. The goal is for the weld to have a single flat profile when finished.

6.1.2. Welding Cap Sizes

Use a flexible tape to measure around the part of the head that you'd like the band of the hat to rest. Make sure the tape is flat and that it is a comfortable fit. Don't pull too tight.

If you don't have a measuring tape, use a piece of string then lay the string on a ruler to get the measurement in inches.

Match your measurement to the chart below:

Cap Size	Head Circumference (in inches)
7	22
7 1/8	22 1/2"
7 1/4	23"
7 3/8	23 1/4"
7 1/2	23 3/4"
7 3/4	24 1/2"

The Cap Weld in The 6G Position

Before putting in the cap I cleaned the hot pass with a wire wheel and hit it with a grinder. I did not have to use a grinder, but if I can, I will. It's just safer if you are allowed. A light grinding of the surface will expose any trapped slag or porosity.

The hot pass ground down to make sure there were no slag inclusions.

View of the ground surface from the bottom of the pipe. This is where the cap weld will be started.

The cap was done from the bottom to top. There is not much to the cap except make sure you fuse the edges of the bevel and keep spreading out the weld. The pictures below are of the first stringer bead I put in. The weld is a little rough because I would sometimes pause or move the electrode slightly back into the weld crater. This is solved by only moving forward and side to side.

Starting the first stringer of the cap weld running from the 6 o'clock to 12 o'clock position.

Second stringer bead running from the 3 to 6 o'clock position with the slag covering.

Bottom half of the pipe with 2 rows of cleaned stringer beads.

Running my weld on top of the pipe and you could say I got stuck!

6 to 12 o'clock stringer cap weld cleaned.

Last stringer filler bead before the completion of the weld.

The last stringer bead was done once the pipe cooled down enough for me to lean on it. On the last stringer bead I made sure I spread the toe of the weld over the edge of the bevel and into the second stringer.

The complicated bottom half of the cap weld looking at the 3 to 6 o’clock position.

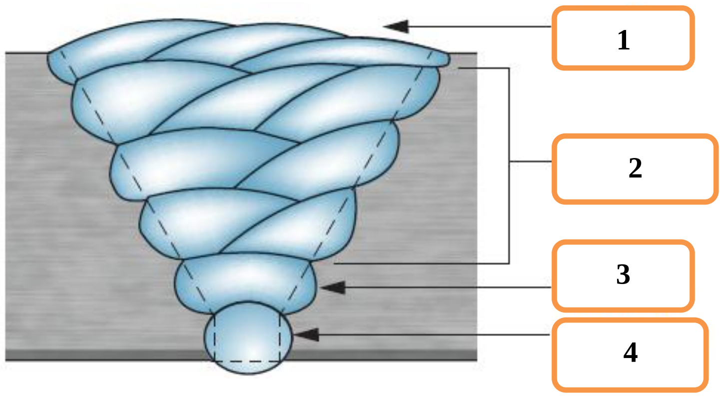
Finished top half of the cap weld cleaned.

Figure 6.2 The Cap Weld in The 6G Position

Self-Check -1	Written Test

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

1. ____________ is the common term used for the projection spot welding of the caps (or lids) on electronic packages.(1 pts)
2. Write the name of the following welding pass that indicate by number in the figure below. (4 pts)



Note: **Satisfactory rating –2.5 points** **Unsatisfactory - below 2.5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _____________________________ Date: _________________

6.2. Acceptance criteria for completed welds

6.2.1. <u>Butt Welds</u>

- As-welded surfaces are permitted; however, the surface of welds shall be sufficiently free from coarse ripples, grooves, overlaps, abrupt ridges, undercut, and valleys.
- The surface condition of the finished welds shall be suitable for the proper interpretation of radiographic and other nondestructive examinations when nondestructive examinations are required. In those cases, where there is a question regarding the surface condition on the interpretation of a radiographic film, the film shall be compared to the actual weld surface for interpretation and determination of acceptability.
- Undercuts shall not exceed $^{1}/_{32}$ in. and shall not encroach on the minimum required section thickness.
- For single-welded joints (i.e., butt joints welded from one side), concavity of the root surface shall not reduce the total thickness of the joint, including reinforcement, to less than the nominal thickness of the thinner component being joined. (This applies only when inside surface of the weld is readily accessible or the weld has been radiographed.)
- For single welded joints, the excess root penetration shall be limited to the lesser of $^{1}/_{8}$ in. or 25 % of the nominal wall thickness of the thinner component being joined, down to ¼ in. wall thickness. For any nominal wall thickness less than ¼ in., the excess penetration shall be limited to $^{1}/_{16}$ in. (applies only when inside surface of the weld is readily accessible or the weld has been radiographed).
- Weld reinforcement greater than the amounts specified in the weld reinforcement table at the end of this attachment shall be considered unacceptable.

6.2.2. <u>Socket and Fillet Welds</u>

- As-welded surfaces are permitted; however, the surface of welds shall be sufficiently free from coarse ripples, grooves, overlaps, abrupt ridges, undercut, and valleys.
- The surface condition of the finished welds shall be suitable for the proper interpretation of nondestructive examinations.

- Socket and fillet welds may vary from convex to concave. The size of a fillet weld is determined as shown in fillet weld diagrams at the end of this attachment. Typical minimum fillet weld details for slip-on flanges and socket-welding components are also contained in fillet weld diagrams at the end of this attachment.

WELD REINFORCEMENT TABLE
ASME B31.3

Thickness of Base Material	Thickness of Reinforcement or Internal Weld Protrusion
¼ in. and under	$^{1}/_{16}$ in.
Over ¼ in. to ½ in.	$^{1}/_{8}$ in.
Over ½ in. to 1 in.	$^{5}/_{32}$ in.
Over 1 in.	$^{3}/_{16}$ in.

Note: External weld reinforcement and internal weld protrusion shall be fused with and shall merge smoothly into the component surface.

Self-Check -2	Written Test

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

1. List at least three Acceptance Criteria for butt welds (3 points)
2. List at least two Acceptance Criteria for Socket and Fillet Welds. (2 points)

Note: **Satisfactory rating –2.5 points** **Unsatisfactory - below 2.5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

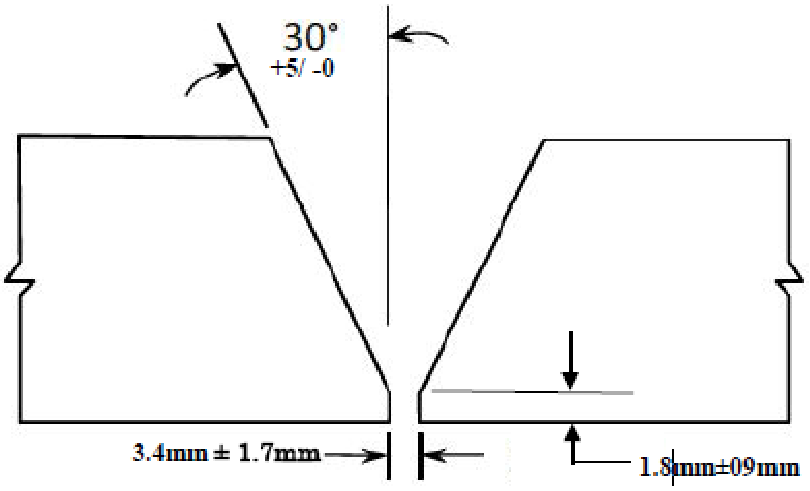
Operation Sheet 1	Performing Capping with WPS

JOINT GEOMETRY

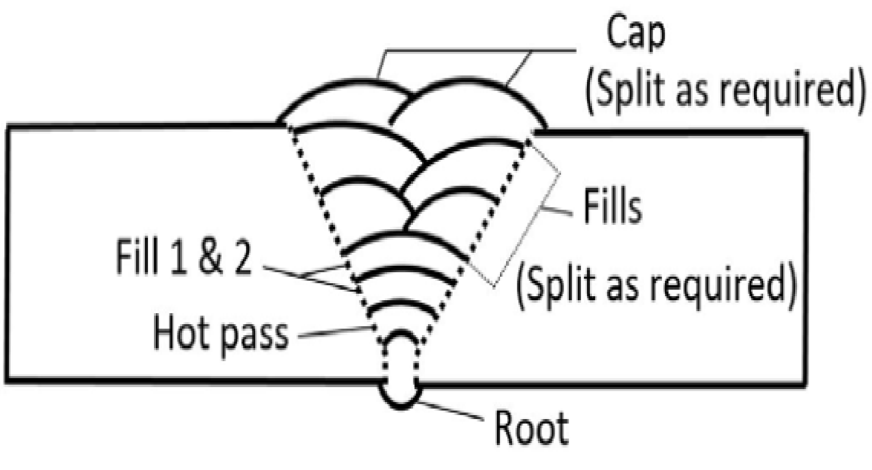
Note #1 - If cap pass is more than 2 beads wide the outer edges of the bevel shall be capped first and the final cap pass shall be in the center of the bevel.

Note # 2 - Maximum cap height above adjacent parent material: 2.5mm for W.T.≤ 10.0mm. 3.5mm for W.T. >10.0 mm. (+1mm permitted in localized areas).

Schematic of Joint Design



Pass Sequence



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 2 hours.

Task 1. Layout from the prepped metal.

Task 2. Cut to the required dimension.

Task 3. Complete the welding process.

Task4. Clean the joint correctly with the wrights cleaning equipments

Mechanics

Level-III

Learning Guide-24

Unit of Competence: Perform Plate and Tube Shielded Metal Arc Welding (SMAW)

Module Title: Performing Plate and Tube Shielded Metal Arc Welding (SMAW)

Module Code: XXX

LG Code: XXX

TTLM Code: XXX

LO7: Assure quality weld conformance

Instruction Sheet	**Learning Guide #24**

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

- Checking and Identifying defects/fault visually
- Rectifying welding defect
- Completing and maintaining weld records and completion.
- Performing OHS for SMAW process

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

- Check and Identify defects/fault visually
- Rectify welding defects
- Complete and maintain weld records and completion.
- Performing OHS for SMAW process

Learning Instructions:

1.. Read the specific objectives of this Learning Guide.

2. Follow the instructions described below 3 to 5.
3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3 and Sheet 4”.
4. Accomplish the “Self-check 1, Self-check t 2, Self-check 3and Self-check 4” **in page -145, 153, 156 and 160**respectively
5. If you earned a satisfactory evaluation from the “Self-check” proceed to the next **UC**.

7.1. Visual Inspection of the Specimens

Visual inspection is done not only to see the surface of the weld but also get any clues about what is underneath the surface of the weld. Typical weld defects such as spatter "metal particles left after welding, which do not form part of the weld" and undercut "an irregular groove at a toe of a run in the base metal"can be inspected by this technique.

7.1.1. Welding defect

Welding Defects can be defined as the irregularities formed in the given weld metal due to wrong welding process or incorrect welding patterns, etc. The defect may differ from the desired weld bead shape, size, and intended quality. Welding defects may occur either outside or inside the weld metal. Some of the defects may be allowed if the defects are under permissible limits but other defects such as cracks are never accepted.

Welding defects can be classified into two types as External and Internal defects:

External Welding Defects:

The various types of external defects are listed below

1. **Crack**

Weld Crack --This is the most unwanted defect of all the other welding defects. Welding cracks can be present at the surface, inside of the weld material or at the heat affected zones.

Hot Crack – It is more prominent during crystallization of weld joints where the temperature can rise more than 10,000-degree Celsius.

Cold Crack – This type of crack occurs at the end of the welding process where the temperature is quite low. Sometimes cold crack is visible several hours after welding or even after few days.

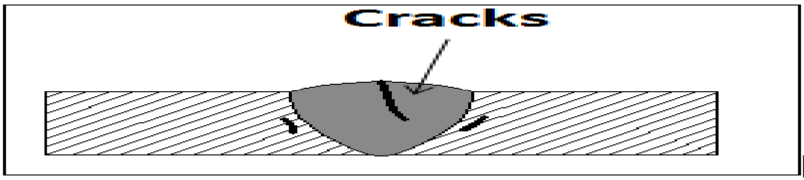


Figure 7.1 Crack

Causes of Weld Crack

1. Poor ductility of the given base metal.
2. The presence of residual stress can cause a crack on the weld metal.
3. The rigidity of the joint which makes it difficult to expand or contract the metals.
4. If there is high content on sulfur and carbon, then also the cracks may appear.
5. Using hydrogen as a shielding gas while welding ferrous materials.

2. Undercut

When the base of metal melts away from the weld zone, then a groove is formed in the shape of a notch, then this type of defect is known as Undercut. It reduces the fatigue strength of the joint**.**

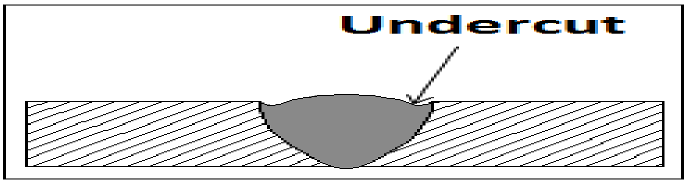


Figure 7.2 Undercut

Causes of Undercut:

1. If the arc voltage is very high, then this defect may occur.
2. If we use the wrong electrode or if the angle of the electrode is wrong, then also the defect may form.
3. Using a large electrode is also not advisable.
4. High electrode speed is also one of the reasons for this defect

6. Spatter

When some metal drops are expelled from the weld and remain stuck to the surface, then this defect is known as Spatter.

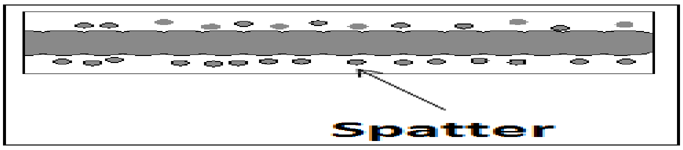


Figure 7.3 Spatter

Causes of Spatter:

1. High Welding current can cause this defect.
2. The longer the arc the more chances of getting this defect.
3. Incorrect polarity.
4. Improper gas shielded may also cause this defect.

7. Porosity

Porosity in the condition in which the gas or small bubbles gets trapped in the welded zone

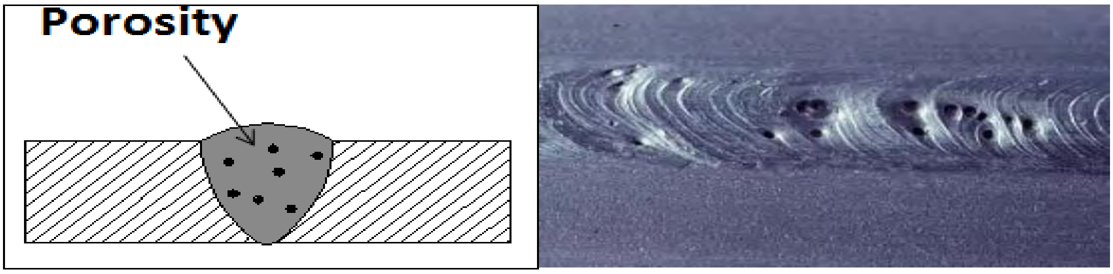


Figure 7.4 Porosity

Causes of Porosity:

1. It occurs when the electrode is not coated properly.
2. Using a longer arc may also increase its chances.
3. Increased welding currents.
4. Rust or oil on the welding surface.

5. Overlap

When the weld face extends beyond the weld toe, then this defect occurs. In this condition the weld metal rolls and forms an angle less than 90 degrees.

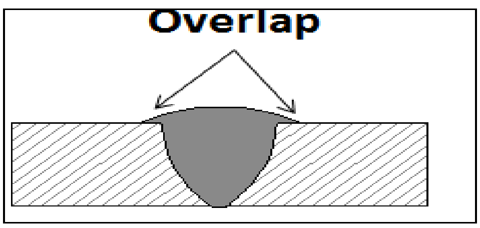


Figure 7.5 Overlap

Causes of Overlap:

1. Improper welding technique.
2. By using large electrodes this defect may occur.
3. High welding current

6. Crater

It occurs when the crater is not filled before the arc is broken, which causes the outer edges to cool faster than the crater. This causes a stress and then crack is formed.

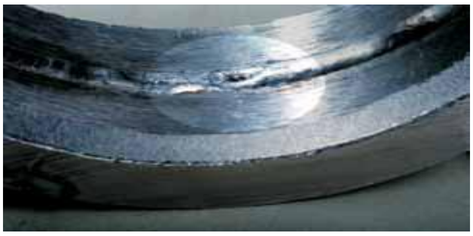


Figure 7.5 Crater

Causes of the crater:

1. Incorrect torch angle.
2. Use of large electrode:
3. Improper welding technique

Internal Welding Defects:

The various types of internal welding defects are listed below

1. Slag Inclusion

If there is any slag in the weld, then it affects the toughness and metal weldability of the given material. This decreases the structural performance of the weld material. Slag is formed on the surface of the weld or between the welding turns

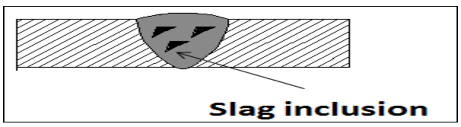


Figure 7.6 Slag Inclusion

Causes of Slag Inclusion:

1. Slag is formed if the welding current density is very small, as it does not provide the required amount of heat for melting the metal surface.
2. If the welding speed is too fast then also slag may occur.
3. If the edge of the weld surface is not cleaned properly then also slag may form.
4. Improper welding angle and travel rate of welding rod

2. Incomplete Fusion

Incomplete fusion occurs when the welder does not accurately weld the material and the metal pre solidifies which leads to a gap which is not filled with the molten metal.

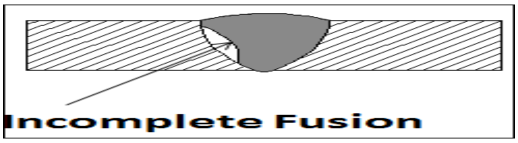


Figure 7.7 Incomplete fusion

Causes of Incomplete fusion:

1. It occurs because of the low heat input.
2. When the weld pool is very large and runs ahead of the arc.
3. When the angle of the joint is too low.
4. Incorrect electrode and torch angle may also lead to incomplete fusion.
5. Un proper bead position

3. Necklace cracking

It occurs in the use of electron beam welding where the weld does not penetrate properly. Therefore, the molten metal does not flow into the cavity and results in a cracking known as “Necklace Cracking”.

Causes of Necklace Cracking:

1. Improper welding technique.
2. It occurs in materials such as nickel base alloys, stainless steel, carbon steels and Tin alloys.
3. Using high speed of electron beam welding

4. **Incompletely filled groove or Incomplete penetration**

These defects occur only in the butt welds where the groove of the metal is not filled completely. It is also called as incomplete penetration defect.

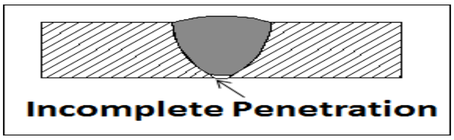


Figure 7.8 Incomplete Penetration

Causes of an Incomplete filled groove are:

1. Less deposition of the weld metal
2. Use of improper size of the electrode
3. Improper welding technique

Visual Inspection

- It is the most widely used nondestructive testing technique. It is extremely effective and is the least expensive inspection method.
- The welding inspector can utilize inspection visual inspection throughout the entire production cycle of a weldment.
- It is an effective quality control method that will ensure procedure conformity and will catch error at early stages.

1. The surfaces and back sides of the welds shall undergo a complete visual inspection, with the aid of optical (magnifying) appliances where necessary, to check their external characteristics. The following characteristics shall be checked:

– Completeness

– Dimensional accuracy

– Compliance with the specified weld shape

– Absence from inadmissible external defects.

2. The dimensional accuracy shall be checked with suitable measuring instruments on a random sampling basis. When measuring fillet weld throat thicknesses, measuring gauges which measure with sufficient accuracy in throats which are not an exact right angle shall be used where necessary.

3. When checking for the correct shape of weld and external defects, attention shall be paid to the following:

- Weld reinforcement or top bead depression

- Weld edge angles (transitions to surrounding material)
- Misalignment of edges
- Undercuts
- Visible pores and slag inclusions
- Fused weld spatter
- Arc strikes on the surface of the base material
- Concave root surface and incomplete root fusion
- Cracks
- Unequal side lengths (in the case of fillet welds).

Visual Inspection Technique

1. **What** – In order to perform final visual inspection, you need:

   a) Adequate lighting (use flashlight as needed)

   b) Weld gauges (bridge cam and finger gauges recommended)

   c) Prescription glasses (as required)

2. **How** – Distance and angle:

   a) The inspector's eyes should be within 24 inches of the surface to be inspected **and**

   b) At an angle of at least 30 degrees to the surface being inspected.

Visual inspection methods can be divided into three sub-groups:

- **Visual examinations prior to welding:** drawings, material specifications, edge preparation, dimensions, cleanliness of the welding joint etc.
- **Visual examination during welding:** welding process, electrode selection, operating conditions, preheat requirements, welder performance etc.
- **Visual examinations of the finished weldment:** weld size (using weld gauges), defects (surface cracks, creator cracks, surface porosity, and incomplete root penetration, undercut, under fill), warpage, base metal defects etc.

Self-Check -1	Written Test

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

Part I. Choose the best answer from the alternative

1. ________________ is done not only to see the surface of the weld but also get any clues about what is underneath the surface of the weld.(1 pts)
   - A. WeldingDefect C. Porosity
   - B. Visual inspection D. None

1. From the listed alternative which one is categorized under external defect? (1 pts)
   - A. Slag inclusion C. Porosity
   - B. Incomplete penetration D. None

2. _____________ can be defined as the irregularities formed in the given weld metal due to wrong <u>welding process</u> or incorrect welding patterns, etc. (1 pts)
   - C. Inspection C. Visual inspection
   - D. Welding Defects D. None

8. In visual inspection what is to be checked in their external characteristics of the weld. (1 pts)
   - A. Dimensional accuracy B. Completeness C. Compliance with the specified weld shape D. All

9. Which one is categorized under internal defects? (1 pts)
. A. Crack B. incomplete fusion C. Crater D. Overlap

6. which one is the cause for creating ***Crater Defect?*** (1 pts)
   - A. incorrect torch angle C. use of large electrode
   - B. improper welding technique D. All E. none

Part II. Choose the best answer from the alternative

7.List the three sub-groups of Visual inspection methods? (3 pts)

Note: **Satisfactory rating –5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _____________________________ Date: _________________

7.2. WELDING CRACKS

7.2.1. Crack

Definition

A tear, fracture or fissure in the weld or base metal appearing as a broken, jagged or straight line.

NOTE: Cracks are the most serious defect!

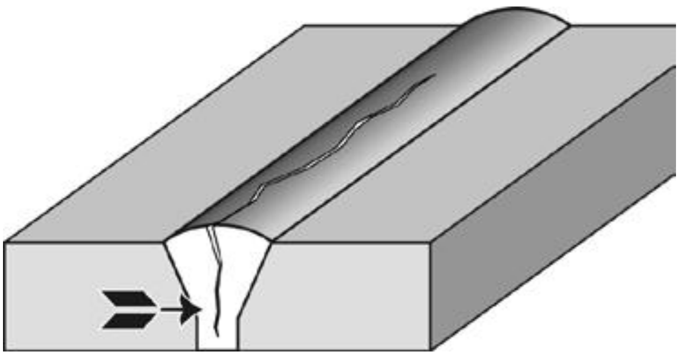


Figure 7.9 Crack Defect

Preventive Action

1. Remove contaminants from the joint (rust, grease, moisture, etc.) prior to welding.
2. Apply and maintain required preheat.
3. Do not allow the base material to cool too quickly.
4. Maintain filler metal control requirements.
5. Use correct filler metal type for the joint.
6. Apply proper bead size and sequencing to eliminate excessive distortion and/or stress in the base material.

Corrective Action

Repair in accordance with local procedures.

7.2.2. UNDERCUT

Definition

A groove melted into the base metal and left unfilled by weld metal.

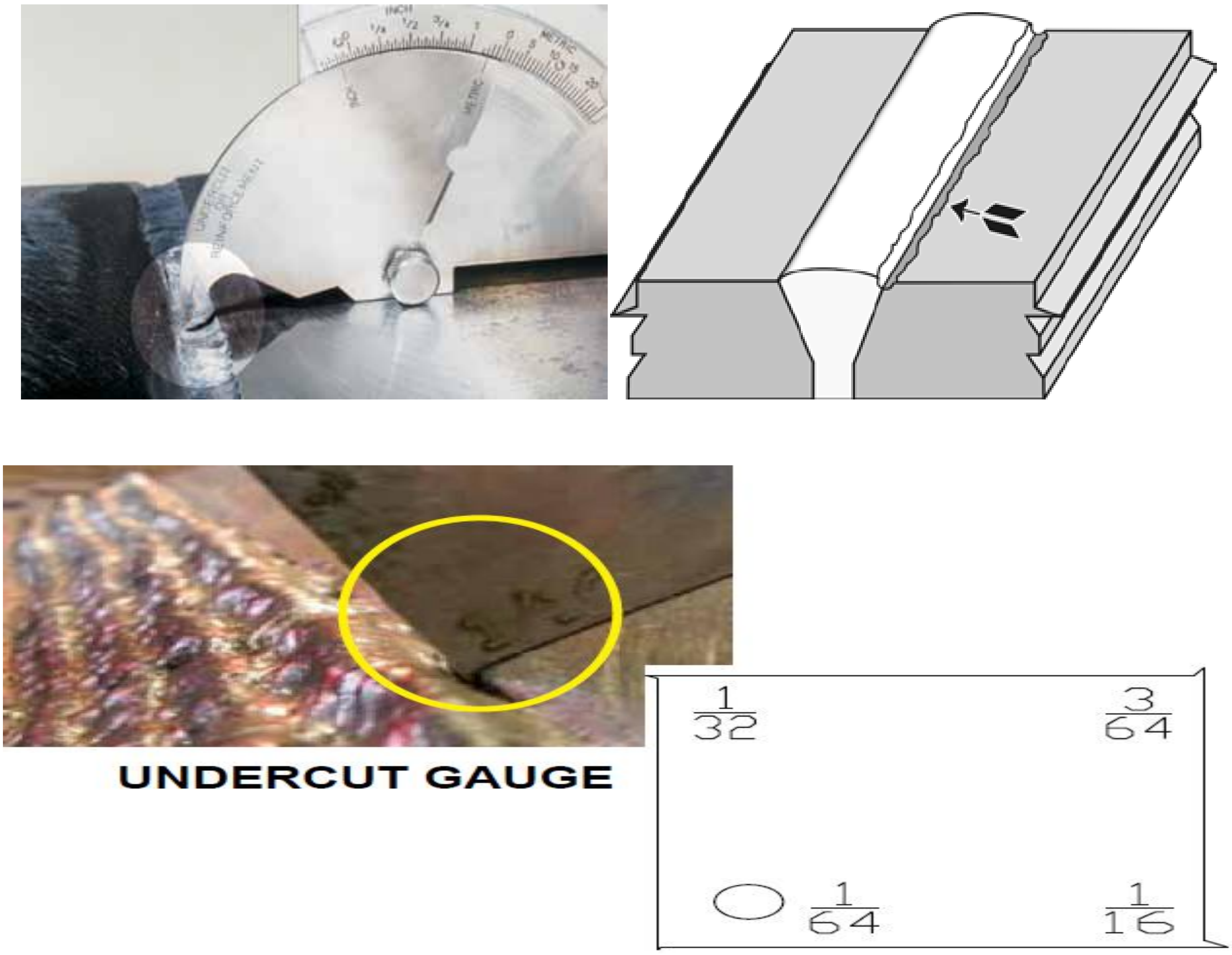


Figure 7.10 Undercut

Preventive Action

1. Decrease amps/volts.
2. Decrease travel speed.
3. Maintain appropriate arc length/wire stick out.
4. Adjust torch/rod angle.
5. Feed more wire into the puddle when manual TIG welding.
6. Increase stop time (dwell time) on weaved beads.
7. Use undercut gauge to verify acceptability.

Corrective Action

1. Grind the toe of the weld until the unacceptable undercut blends smoothly into the base material.
2. Weld repair the affected area, if needed.

7.2.3. SPATTER

Definition

The metal particles expelled during welding that do not form a part of the weld.

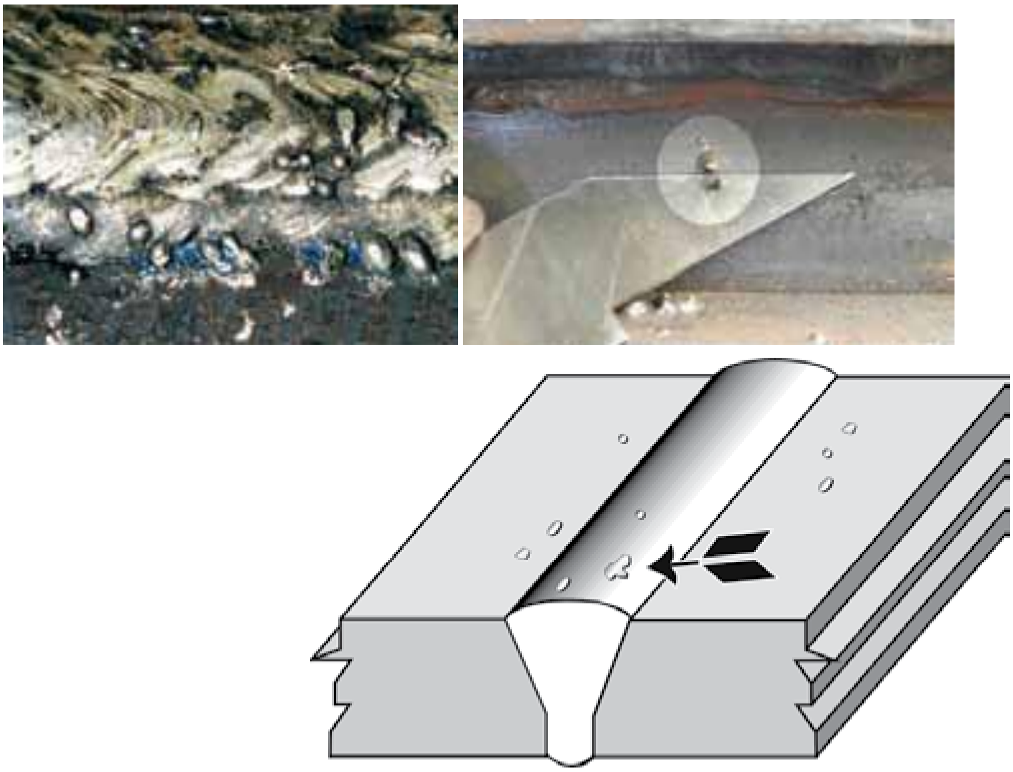


Figure 7.11. Spatter

Preventive Action

1. Remove contaminants from the joint (rust, grease, moisture, etc.) prior to welding.
2. Maintain filler metal control requirements.
3. Use Reversal to protect surrounding surfaces from secondary weld spatter.
4. Adjust amps/volts.
5. Adjust torch/rod angle.
6. Maintain appropriate arc length/wire stick out.
7. Use ceramic tape or approved metal backing strap on areas with root gap.
8. Consult local Welding Engineering in cases where the base material is magnetized.

Corrective Action

1. Completely remove spatter from all intermediate weld areas.
2. Remove all loose spatter with a needle gun.

3. Grind all **tightly adhering, unacceptable spatter** until it blends smoothly into the base material or weld.

7.2.4. POROSITY

Definition

Open holes formed by gas that was trapped when the weld cooled. Sometimes called “pinholes.”

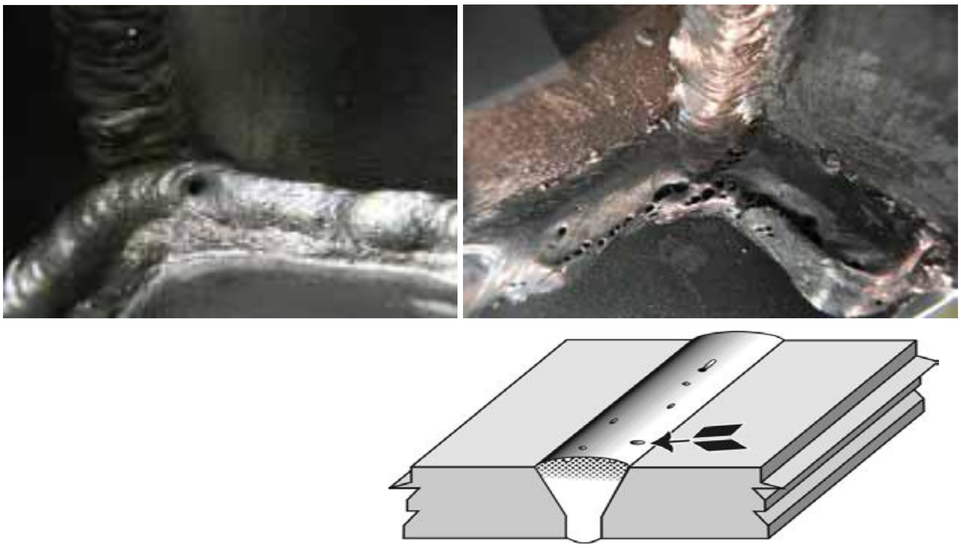


Figure 7.12. Porosity

Preventive Action

1. Remove contaminants from the joint (rust, grease, moisture, etc.) prior to welding.
2. Maintain filler metal control requirements.
3. Maintain appropriate arc length/wire stick out.
4. Adjust torch/rod angle.
5. Use the largest size gas cup possible and keep it free of spatter.
6. Position wind screens between the welding operation and any heavy flow of air.

Corrective Action

1. Completely remove porosity from all intermediate weld areas.
2. Grind or carbon arc the affected area until the unacceptable porosity is removed from the weld.
3. Weld repair the affected area, if needed.

7.2.5. OVERLAP

Definition: A condition where the weld metal rolls over forming an angle less than 90°. Sometimes referred to as "weld bead rollover."

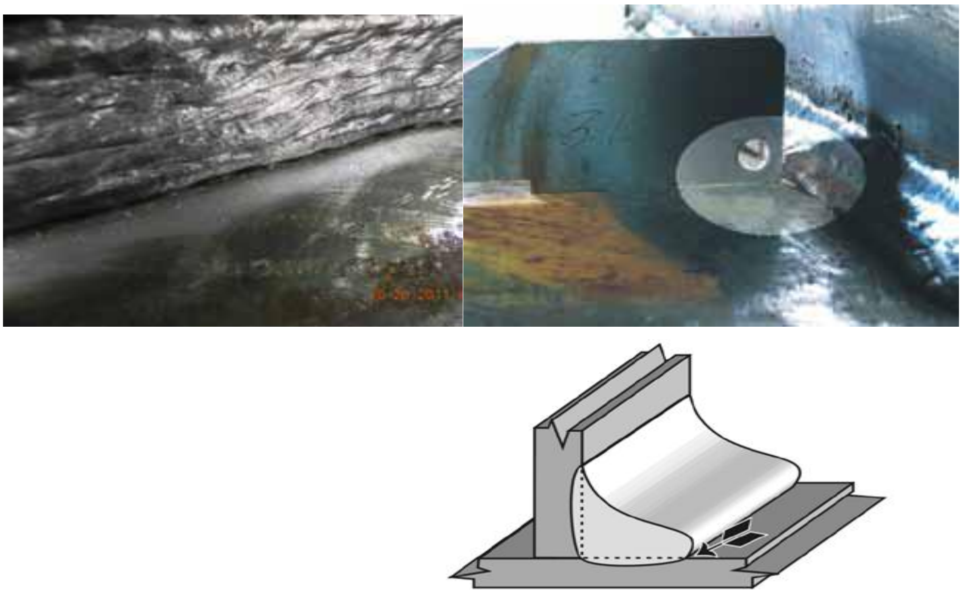


Figure 7.13. Overlap

Preventive Action

1. Adjust amps/volts.
2. Increase travel speed.
3. Maintain appropriate arc length/wire stick out.
4. Adjust torch/rod angle.

Corrective Action

1. Grind or carbon arc the weld to sound metal.
2. Weld repair the affected area, if needed.

7.2.6. CRATER

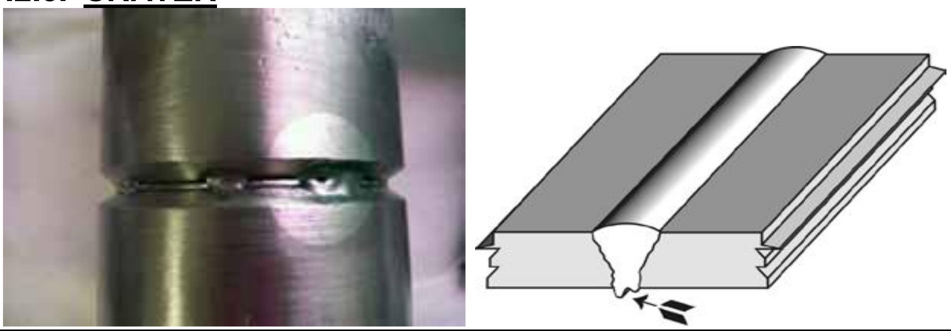


Fig7.14. Crater

Preventive Action

1. Remove contaminants from the joint (rust, grease, moisture, etc.) prior to welding.

2. When breaking the arc for TIG welding, rapidly pop the trigger several times to avoid sudden pull-offs. This will provide sufficient post purge of the weld puddle.

Corrective Action

1. Grind the weld to sound metal and (2) Weld repair the affected area, if needed.

7.2.7.SLAG INCLUSION

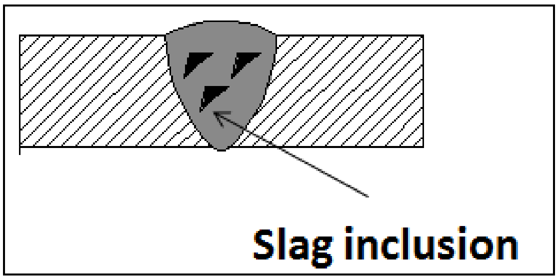


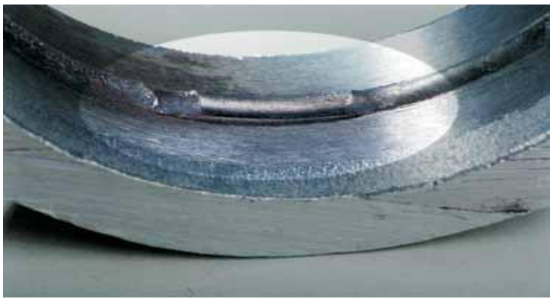
Figure 7.15. Slag Inclusion

Preventive Action

1. Increase the current density
2. Adjust the welding speed so that the slag and weld pool do not mix with each other.
3. Clean the weld edges and remove the slags of previous weld layers
4. Have a proper electrode angle and travel rate.

7.2.7. INCOMPLETE FUSION

Definition: A situation where the weld metal does not fuse or completely bond with the base metal or previously deposited weld metal.



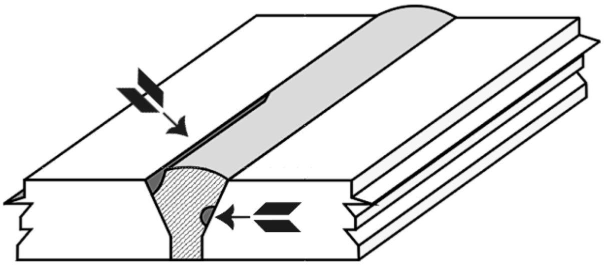


Figure 7.16. Incomplete Fusion

Preventive Action

1. Increase amps/volts.
2. Decrease travel speed.
3. Maintain appropriate arc length/wire stick out.
4. Adjust torch/rod angle.

5. Ensure previous beads are free of overlap (bead roll-over) and slag prior to welding additional passes.

Corrective Action

1. Grind or carbon arc the weld to sound metal.
2. Weld repair the affected area.

Self-Check -2	Written Test

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

1. ________________ is the process of reviewing or checking the collected information that is during the interpretation and analysis step. (3 points)
   A. Incomplete Fusion C. Undercut
   B. Slag Inclusion D. All
2. _________ is the metal particles expelled during welding that do not form a part of the weld.
   C. Porosity C. Spatter
   B. Overlap D. Crater
3. Which action to be applied to prevent cracks in welding.
   A. Decrease amps/volts C. adjust torch/ rod angle
   B. Do not allow the base material to cool quickly D. Decrees travel angle

***Note:* Satisfactory rating –2 points** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: ___________________________ Date: ________________

7.3. Maintenance is a set of organised activities that are carried out in order to keep an item in its best operational condition with minimum cost acquired (British Standard Glossary of terms 3811:1993).

All actions necessary for retaining an item, or restoring to it, a serviceable condition, include servicing, repair, modification, overhaul, inspection and condition verification

- Increase availability of a system
- Keep system's equipment in working order

7.3.1. Maintenance Activities

Activities of maintenance function could be either repair or replacement activities, which are necessary for an item to reach its acceptable productivity condition or these activities, should be carried out with a minimum possible cost.

7.3.2. Maintenance Objectives

Maintenance objectives should be consistent with and subordinate to production goals.

The relation between maintenance objectives and production goals is reflected in the action of keeping production machines and facilities in the best possible condition.

- Maximising production or increasing facilities availability at the lowest cost and at the highest quality and safety standards.
- Reducing breakdowns and emergency shutdowns.
- Optimising resources utilisation.
- Reducing downtime.
- Improving equipment efficiency and reducing scrap rate.
- Optimising the useful life of equipment.
-

Verification/proof of fault elimination.

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

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 -3	Written Test

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

1. _________________ is a set of organised activities that are carried out in order to keep an item in its best operational condition. (3 points)

   A. Inspection C. Maintenance

   B. Reducing downtime D. All

2. which one is not some Maintenance objectives.

   A. increase unproductivity C. Maximising production or increasing facilities

   B. Reducing downtime D. Optimising resources utilisation

3. As a minimum requirement the repair procedure should include -----------------.

   A. Method of defect removalC. Method of exploration of the defect

   B. Welding processes and other specification informationD. All

Note: **Satisfactory rating –2 points** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

7.4. 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)

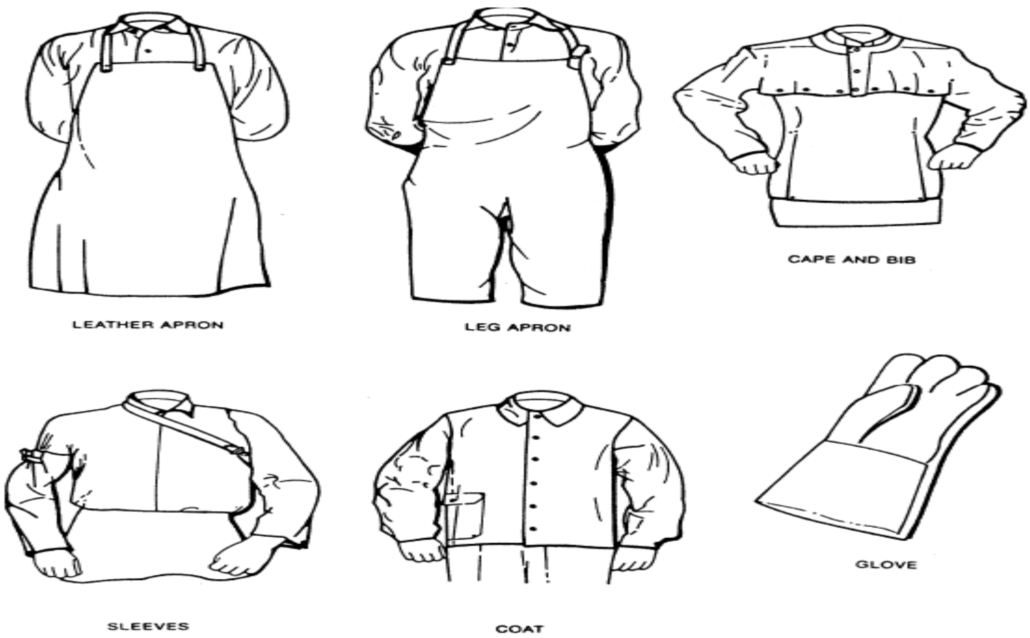


Figure 7.17 Welder's protective clothing.

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 .

Self-Check -4	Written Test

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

1. As discussed Welding safety starts with having the right protective gear, list what it includes.
2. List personal Protective Clothing required for welding.

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 3 and 4 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ____________

Rating: _____________

Name: ______________________________ Date: __________________

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