Ethiopian TVET-System

Electro Mechanical Equipment Operation and Maintenance
NTQF Level –II

Based on March, 2017G.C. Occupational Standard

Module Title: - Welding Using Shielded Metal Arc and Oxyacetylene Gas

TTLM Code: EIS EME2 TTLM 0920V1

This module includes the following Learning Guides

LG 26: Prepare welding equipment, materials and consumables

LG Code: EIS EME2 M06 L0 01-LG-26

LG 27: Set-up welding machine and oxyacetylene/ equipment, accessories and fixtures

LG Code: EIS EME2 M06 L0 02-LG-27

LG 28: Set-up pre heating tools/ equipment

LG Code: EIS EME2 M06 L0 03-LG-28

LG 29: Perform tack welding

LG Code: EIS EME2 M06 L0 04-LG-29

LG 30: Check gap and alignment

LG Code: EIS EME2 M06 L0 05-LG-30

LG 31: Weld to job specification

LG Code: EIS EME2 M06 L0 06-LG-31

LG 32: Ensure weld conformance

LG Code: EIS EME2 M06 L0 07-LG-32

Instruction Sheet 1	Learning Guide 26: **Prepare welding equipment, materials and consumables**

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

- Understanding job requirements, codes and standards, specification and/or drawings/work/order
- Assembling and adjusting Welding tools &equipment.
- Determining, obtaining and inspecting correct size, type and quantity of materials/components
- Preparing Materials
- Assembling /aligning materials

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 –

- Understand job requirements, codes and standards, specification and/or drawings/work/order
- Assemble and adjust Welding tools &equipment.
- Determine, obtain and inspect correct size, type and quantity of materials/components
- Prepare Materials
- Assemble /align materials

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 14.
3. Read the information written in the "Information Sheets 1". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the "Self-check 1" .
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to "Information Sheet 2". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1
7. Submit your accomplished Self-check. This will form part of your training portfolio.

8. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
9. Accomplish the “Self-check 2” in page __.
10. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).
11. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
12. Accomplish the “Self-check 3” in page __.
13. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).
14. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to for each Learning Activities.

Information Sheet-1	Understanding job requirements, specification and/or drawings/work/order

1.1Introduction

Arc Welder welds together metal components of products, for example pipelines, automobiles, boilers, ships, aircraft, and mobile homes, as specified by layout, blueprints, diagram, work order, welding procedures, or oral instructions, using electric arc-welding equipment

1.2Welding job requirements

You will operate appropriate equipment to put together mechanical structures or parts with a great deal of precision. Your job is important as it provides the foundation for strong infrastructure.

A welder must be competent in using potentially dangerous equipment following all safety precautions. The ideal candidate will also have a steady hand and great attention to detail. Knowledge of different kinds of metal and their properties is essential.

Responsibilities

- Read blueprints and drawings and take or read measurements to plan layout and procedures
- Determine the appropriate welding equipment or method based on requirements
- Set up components for welding according to specifications (e.g. cut material with powered saws to match measurements)
- Operate angle grinders to prepare the parts that must be welded
- Align components using calipers, rulers etc. and clamp pieces
- Weld components using manual or semi-automatic welding equipment in various positions (vertical, horizontal or overhead)
- Repair machinery and other components by welding pieces and filling gaps
- Test and inspect welded surfaces and structure to discover flaws
- Maintain equipment in a condition that does not compromise safety

1.3Safety requirements

2.1 Personal protective equipment (PPE)

If personal protective equipment is to be used at the workplace, the person conducting the business or undertakin must ensure the equipment is selected to minimize risk to health and safety including by ensuring that the equipn is:

- suitable for the nature of the work and any hazard associated with the work
- a suitable size and fit and reasonably comfortable for the person wearing it
- maintained, repaired or replaced so it continues to minimize the risk, and
- Used or worn by the worker, so far as is reasonably practicable.

A person conducting a business or undertaking who directs the carrying out of work must provide the worker wit

information, training and

instruction in the proper use and wearing of personal protective equipment; and the storage and maintenance of personal protective equipment.

A worker must, so far as reasonably able, wear the PPE in accordance with any information, training or reasonable instruction and must not intentionally misuse or damage the equipment.

In most cases PPE must be worn by workers when welding to supplement higher levels of controls such as ventilation systems or administrative controls (see Figure).

Fig.1.1 personal protective cloth

When workers wear PPE, it should not introduce other hazards to the worker, such as musculoskeletal injuries, thermal discomfort, or reduced visual and hearing capacity.

Table 1.1 The types of PPE recommended for use in welding

PPE type	Hazards	Recommendation
Eyes, face and head protection (e.g. goggles, helmets, hand shields and protective filters)	Light, radiation, burns from hot debris and sparks	Workers should always have their eyes, face and/or head protected whenever they are welding.
Hearing protection (e.g. ear muffs and ear plugs)	Hearing loss	Earplugs or earmuffs may be required to minimize the risks of noise.
Gloves/ gauntlets	Heat, ultraviolet light and burns from hot debris and sparks	Gloves should be fire resistant and protect exposed skin on the hands and wrists.
Clothing (e.g. flame resistant long sleeved shirts, long trousers, aprons and leather spats)	Heat, ultraviolet light and burns from hot debris and sparks	Avoid clothing that has the potential to capture hot sparks and metals, for example in pockets or other folds. Clothing should be made of natural fibres.

Foot protection (e.g. boots and shoes)	Hot metal debris, other metal debris and electric shock	Foot protection should be non-slip and be heat and fire resistant. Avoid using foot protection that has the potential to capture hot sparks and metal debris, for example in laces or in open style shoes
Screens	Exposure to the rays of an arc during electric welding operations	Opaque or appropriate translucent screens can be used to protect the health and safety of people within the vicinity of welding.
Respiratory protective devices (face respirators and air supplied respirators)	Dusts, hazardous fumes, gases and chemicals and oxygen depleted atmospheres	Respirators should be fitted for each person individually and if one is to be used by another operator, it must be disinfected and refitted before use. The tightness of all connections and the condition of the face piece, headbands and valves should be checked before each use. Air supplied respirators may be required in some situations, e.g. confined spaces.

This article gives guidelines on health and safety considerations when arc welding to ensure safe practice and prevent accidents. The hazards associated with this process are highlighted.

The wrong and right ways to carry out arc welding processes are shown schematically in the figure. Regarding safe welding practices, the principal hazards are associated with electric shock and arc radiation.

2.2 Electric shock

As the principal danger is an electric shock from the live parts of the welding circuit (the electrode and the work piece), the following practices are recommended..

2.3 Checking the equipment

Installation of welding equipment should be carried out by suitably qualified staff who must check that the equipment is suitable for the operation and connected in accordance with the manufacturer's recommendations. The welder is responsible for checking the equipment (cable, electrode holder and coupling devices) daily for damage and reporting defects. All external connections should be clean and tight and checked each time a reconnection is made. The welding return clamp should be connected directly to the work piece, as close as possible to the point of welding or to the work bench on which the work piece is placed.

2.4 Changing electrodes

In MMA welding, the electrode holder should be isolated when changing the electrode. Where a work piece is earthed, if the electrode is changed without isolating the electrode holder, the welder is relying on the insulation properties of the glove to avert shock from the OCV which can be 80V between the electrode and earth. If the glove is wet, the electrode a bad insulator or the welder in contact with a conductive surface, one or more of these layers of insulation may be ineffective.

2.5 Working in the open air

When welding outside, the equipment should have the appropriate level of waterproofing; see manufacturer's Rating Plate which should display one of the following ingress protection (IP) codes for enclosures:

- IP 23 protection against water spray <60 degrees from vertical
- IP 24 protection against water spray from any direction

If there is a risk of heavy rain, a cover for the welder, equipment and work piece should be in place.

2.6 Multiple welder operations

When two or more welders with separate power sources are working on the same work piece, or electrically-connected work pieces, it is essential that they are segregated. This will reduce the possibility of electric shock from simultaneous contact with any part of the two different systems.

Safe practice and accident avoidance

- Welders should not wear jewelry (especially rings) or metallic watch straps
- Appropriate clothing should be worn. Gloves, boots and overalls will provide some protection from electric shock
- The welder should check daily, and after each reconnection, that all external connections are clean and tight
- When changing the MMA electrode, the electrode holder should be isolated
- When welding stops for a short time, the MMA electrode holder should not be put on the face shield or flammable material as it may still be 'live' at 80V or hot enough to cause damage
- When two or more welders (with separate power sources) are operating on the same work piece, they should work out of reach of each other

Environments with increased hazard of electric shock

These are as follows:

- locations where the welder has restricted freedom of movement, working in a cramped position (kneeling or sitting) or in contact with conductive parts
- areas which are fully or partially restricted by conductive elements with which the welder is likely to make accidental contact
- welding in wet, damp or humid conditions which reduces the skin resistance of the body and insulating properties of accessories

Where electrically conductive parts have been insulated close to the welder, there is no increased shock hazard

The equipment should conform to BS EN 60974-1:1998. In MMA welding DC is safer than AC welding. However, if AC is used the OCV or no-load voltage should be limited, where possible, by a voltage reduction device. This limits the OCV to less than 48V until the electrode touches the work piece. Suitable power sources may be marked with S on the manufacturer's Rating Plate and it is also often displayed on the front of the power source.

Safe practice and accident avoidance

- Wear protective clothing including insulating safety boots
- Stand or kneel on a mat of insulating material which should be kept dry
- Only use an all-insulated electrode holder
- Place the welding power source outside the working environment
- Ensure qualified support staff are in close proximity outside the working space to give first aid and switch off the electrical supply
- When welding outside, check the power source protection rating is adequate for the environment and do not weld in the rain without a suitable cover

High frequency

In TIG welding, high frequency (HF) is used to start the arc and to stabilize the AC arc. HF consists of sparks of several thousand volts but because they last for only a few microseconds and are at a very low current, will not give an electric shock. However, HF can startle the welder who could injure himself. If HF is concentrated on the skin, for example through a hole in the glove, it can cause small, deep burns.

HF generates electromagnetic (EM) emission, both airborne and transmitted along power cables. Care must be taken to avoid interference in equipment control systems and instruments in the vicinity of welding.

Guidance on installation and use of arc welding equipment to minimize the risk of EM interference is given in BS EN 60974-10:2003. In practice, the welder is advised to keep welding cables as short as possible, close together and near to the ground. Work piece earthling may be effective but should only be done if it does not increase the risk to users or damage other electrical equipment through stray currents

Arc radiation

The welder must be protected from light radiation emitted from the arc by a hand or head shield and protective clothing. The shield is fitted with filter glass, dark enough to absorb infrared and ultraviolet rays. Filter glasses conform to EN 169:2002 and are graded according to a shade number. This specifies the amount of light allowed to pass through - the lower the number, the lighter the filter. The shade number is selected according to welding process and current level.

For a given current level, the same shade number can be used for MMA and MIG welding on heavy metals such as steel. However, a higher shade number is needed for MIG welding light metals such as aluminum, and for MAG welding.

Screens must be used to protect other workers in the vicinity.

The contrast between good and bad practice in arc welding

Bad practice in arc welding

Good practice in arc welding

Bad practice	Hazards
1. No face protection	arc eye, burn
2. No arm protection	burn
3. Exposed cloth	fire
4. Exposed solvent	fire/explosion, toxic vapor
5. Bystander exposed to arc	arc eye
6. Fire exit obstructed	fire, burns
7. Fire bucket unsuitable for electrical fires - should contain sand	electric shock
8. Fume extraction not effective	inhalation of harmful fume
9. No work earth (if required)	shock
10. Cable damaged	stray arc, burns, electric shock

Self-Check -1	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. Explain the job requirement of a welder.
2. What are the responsibilities of a welder?
3. List protective equipment used for welding.

***Note:* Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

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2.1 Introduction

The process, in which an electric arc between an electrode and a work-piece or between two electrodes is utilized to weld base metals, is called an arc welding process. The basic principle of arc welding is shown in Figure1. However, the basic elements involved in arc welding process are shown in Figure2. Most of these processes use some shielding gas while others employ coatings or fluxes to prevent the weld pool from the surrounding atmosphere.

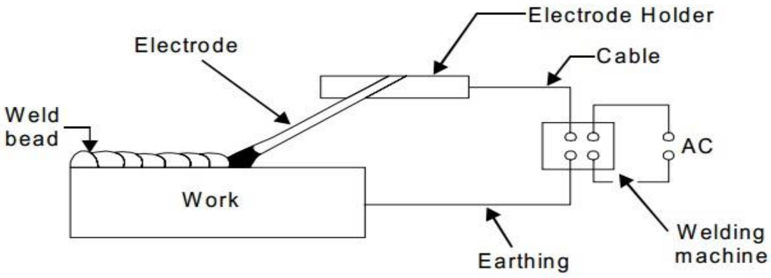


Fig 2.1 The basic principle of arc welding

Arc Welding Equipment and tools

1) Switch box.
2) Secondary terminals
3) Welding machine.
4) Current reading scale.
5) Current regulating hand wheel.
6) Leather apron. (Metallic).
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

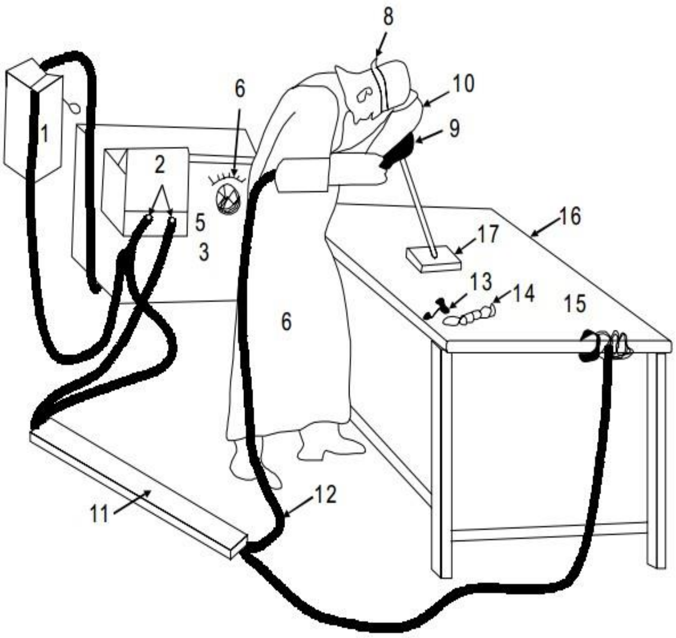


Fig2.2 the basic of arc welding

Arc welding equipment, setup and related tools and accessories are shown in Figure. However some common tools of arc welding are shown separately through Figure. Few of the important components of arc welding setup are described as under.

2.2 Arc welding power source

Both direct current (DC) and alternating current (AC) are used for electric arc welding, 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 normal open circuit welding voltage (50-90 volts). The following factors influence the selection of a power source:

a. Type of electrodes to be used and metals to be welded
b. Available power source (AC or DC)
c. Required output
d. Duty cycle
e. Efficiency
f. Initial costs and running costs
g. Available floor space
h. Versatility of equipment

1. 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.

2. 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.

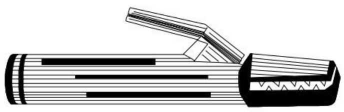


Fig2.3. Electrode Holder

3. Welding Electrodes

An electrode is a piece of wire or a rod of a metal or alloy, with or without coatings. An arc is set up between electrode and work piece. Welding electrodes are classified into following types-

I. Consumable Electrodes
   a. Bare Electrodes
   b. Coated Electrodes
II. Non-consumable Electrodes
   a. Carbon or Graphite Electrodes
   b. Tungsten Electrodes

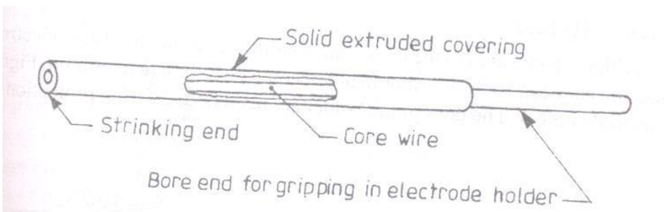


Fig. 2.4 Parts a electrode

Consumable electrode is made of different metals and their alloys. The end of this electrode starts melting when 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.

Non-consumable electrodes are made up of high melting point materials like carbon, pure tungsten or alloy tungsten etc. These electrodes do not melt away during welding. But practically, the electrode length goes on decreasing with the passage of time, because of oxidation and vaporization of the electrode material during welding. The materials of non-consumable electrodes are usually copper coated carbon or graphite, pure tungsten, throated or zirconated tungsten.

5. Hand Screen or Face Shield:

The function of screen and face shield is to protect the eyes and face of the welder from the harmful ultraviolet and infrared radiations produced during welding. The shielding may be achieved from head helmet or hand helmet. **Hand and head shield**

For most operations a hand-held or head shield constructed of lightweight insulating and non-reflecting material is used which conforms to EN175. The shield is fitted with a protective filter glass, sufficiently dark in color and capable of absorbing the harmful infrared and ultraviolet rays. The filter glasses conform to the strict requirements of EN 169 and are graded according to a shade number which specifies the amount of visible light allowed to pass through - the lower the number, the lighter the filter. The correct shade number for manual metal arc welding must be used according to the welding current level, for example:

- Shade 9 - up to 40A
- Shade 10 - 40 to 80A
- Shade 11 - 80 to 175A
- Shade 12 - 175 to 300A
- Shade 13 - 300 to 500A

6. Chipping hammer

The function of chipping hammer is to remove the slag after the weld metal has solidified. It has chisel shape and is pointed at one end.

7. Wire brush and Power Wire Wheel:

The function of wire brush is to remove the slag particles after chipping by chipping hammer. Sometimes, if available a power wire wheel is used in place manual wire brush.

Fig power wire wheel

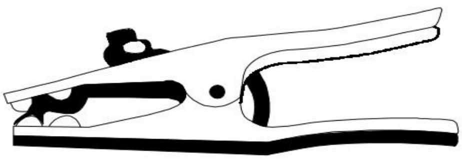


Fig. 17.11 Earth clamp

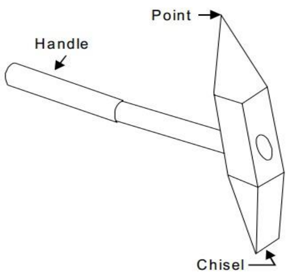


Fig. 17.13 Chipping and hammer

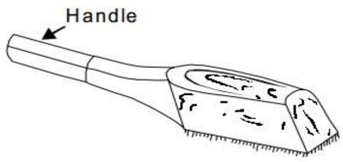
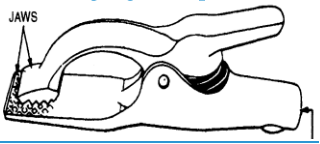


Fig. 17.14 Wire brush

Self-Check -2	Written Test

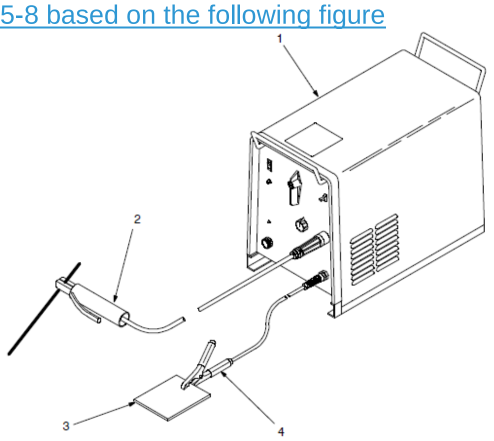
Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. The following figure represent



A. Electrode holder   C. Electrode
B. Ground clamp   D. Ground cable

Answer 5-8 based on the following figure



2. On the figure '1' represent
   A. Welding machine   C. Ground clamp
   B. Electrode holder   D. Work-pieces
3. On the figure '4' represent
   A. Welding machine   C. Ground clamp
   B. Electrode holder   D. Work-pieces
4. On the figure '3' represent
   A. Welding machine   C. Ground clamp
   B. Electrode holder   D. Work-pieces
5. On the figure '2' represent
   A. Welding machine   C. Ground clamp
   B. Electrode holder   D. Work-pieces

Note: **Satisfactory rating - 7.5 points and above   Unsatisfactory - below 7.5 points**
You can ask you teacher for the copy of the correct answers.

3.1 Assembling and adjusting Oxyacetylene welding

Oxyacetylene welding, commonly referred to as gas welding, is a process which relies on combustion of oxygen and acetylene. When mixed together in correct proportions within a hand-held torch or blowpipe, a relatively hot flame is produced with a temperature of about 3,200 ^{o}C. The chemical action of the oxyacetylene flame can be adjusted by changing the ratio of the volume of oxygen to acetylene.

Three distinct flame settings are used, neutral, oxidizing and carburizing.

Fig 3.1Neutral flame

Fig 3.2 Oxidising flame

Fig 3.3 Carburizing flame

Welding is generally carried out using the neutral flame setting which has equal quantities of oxygen and acetylene. The oxidizing flame is obtained by increasing just the oxygen flow rate while the carburizing flame is achieved by increasing acetylene flow in relation to oxygen flow. Because steel melts at a temperature above 1,500 ^{o}C, the mixture of oxygen and acetylene is used as it is the only gas combination with enough heat to weld steel. However, other gases such as propane, hydrogen and coal gas can be used for joining lower melting point non-ferrous metals, and for brazing and silver soldering.

3.2 Essential equipment components of oxyacetylene welding

Torch

The basic oxyacetylene torch comprises:

- torch body (or handle)
- two separate gas tubes (through the handle connected to the hoses)
- separate control valves
- mixer chamber
- flame tube
- welding tip

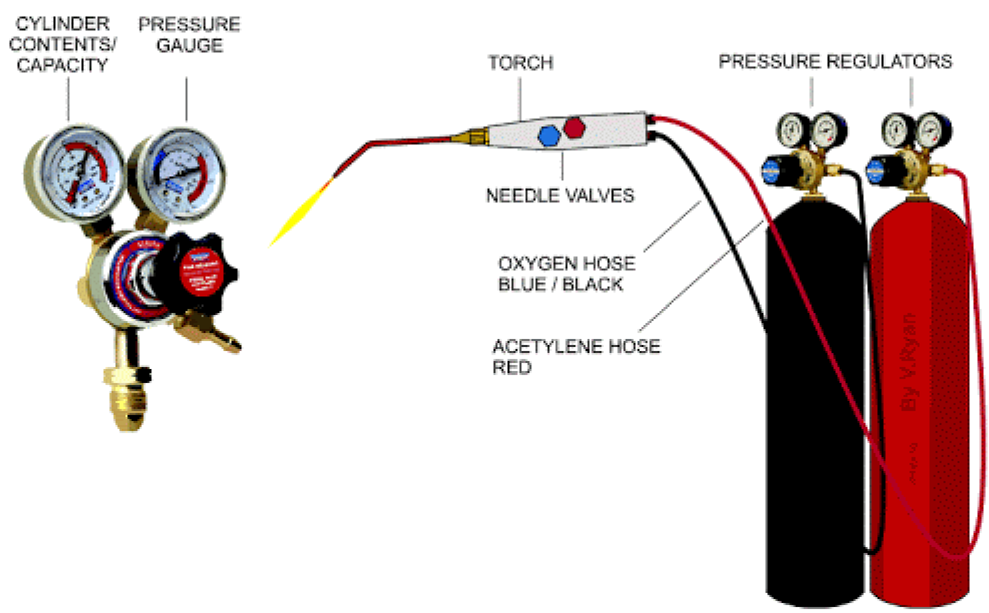


Fig 3.4 components of oxy acetylene welding

NB The cutting torch requires two oxygen supplies to the nozzle, one mixed with fuel gas for preheating and a separate oxygen flow for cutting.

Hoses

Hoses between the torch and the gas regulators should be colour-coded; in the UK: red for acetylene, and blue for oxygen. Fittings on the oxygen hose have right-hand threads; while those on the acetylene hose have left-hand threads.

Gas regulators

The primary function of a gas regulator is to control gas pressure. It reduces the high pressure of the bottle-stored gas to the working pressure of the torch, and this will be maintained during welding.

The regulator has two separate gauges: a high pressure gauge for gas in the cylinder and a low pressure gauge for pressure of gas fed to the torch. The amount of gas remaining in the cylinder can be judged from the high pressure gauge. The regulator, which has a pressure adjusting screw, is used to control gas flow rate to the torch by setting the outlet gas pressure. *Note* Acetylene is supplied in cylinders under a pressure of about 15 bar but welding is carried out with torch gas pressures typically up to 2 bar.

Flame traps

Flame traps (also called flashback arresters) must be fitted into both oxygen and acetylene gas lines to prevent a flashback flame from reaching the regulators. Non-return spring-loaded valves can be fitted in the hoses to detect/stop reverse gas flow. Thus, the valves can be used to prevent conditions leading to flashback, but should always be used in conjunction with flashback arresters.

A flashback is where the flame burns in the torch body, accompanied by a whistling sound. It will occur when flame speed exceeds gas flow rate and the flame can pass back through the mixing chamber into the hoses. Most likely causes are: incorrect gas pressures giving too low a gas velocity, hose leaks, loose connections, or welder techniques which disturb gas flow.

3.3 Identification of gas cylinders

Gas cylinders are color-coded. In Ethiopia, an oxygen cylinder is blue; and an acetylene cylinder is yellow. Cylinders should also carry a label that gives details of the type of gas.

Oxygen and acetylene are stored in cylinders at high pressure. Oxygen pressure can be as high as 300 bar. Acetylene, which is dissolved in acetone contained in a porous material, is stored at a much lower pressure, approximately 15bar.

It is vitally important to ensure that the regulator fitted to the oxygen cylinder is rated to at least the same pressure as the cylinder. Some oxygen regulators are only rated at 215 bar and should not be used on a 300 bar cylinder. Flammable gases such as acetylene (and propane) have left hand threads on the cylinder and regulator; the oxygen regulator and cylinder have a conventional right hand thread. On no account should oil or grease be allowed to come into contact with oxygen equipment.

Table 3.1 Typical gas pressures and flow rates for C-Mn steel:

Steel thickness (mm)	Nozzle size	Acetylene		Oxygen	
		Pressure (bar)	Consumption (l/min)	Pressure (bar)	Consumption (l/min)
0.90	1	0.14	0.50	0.14	0.50
1.20	2	0.14	0.90	0.14	0.90
2.00	3	0.14	1.40	0.14	1.40
2.60	5	0.14	2.40	0.14	2.40
3.20	7	0.14	3.30	0.14	3.30
4.00	10	0.21	4.70	0.21	4.70
5.00	13	0.28	6.00	0.28	6.00
6.50	18	0.28	8.50	0.28	8.50
8.20	25	0.42	12.00	0.42	12.00
10.00	35	0.63	17.00	0.63	17.00
13.00	45	0.63	22.00	0.63	22.00
25.00	90	0.63	42.00	0.63	42.00

3.4 Selection of correct nozzles

Welding torches are generally rated according to thickness of material to be welded. They range from light duty (for sheet steel up to 2mm in thickness) to heavy duty (for steel plate greater than 25mm in thickness). Each torch can be fitted with a range of nozzles with a bore diameter selected according to material thickness. Gas pressures are set to give correct flow rate for nozzle bore diameter. Proportions of oxygen and acetylene in the mixture can be adjusted to give a neutral, oxidizing or carburizing flame. (See the description of oxyacetylene processes) Welding is normally carried out using a neutral flame with equal quantities of oxygen and acetylene.

3.5 Equipment safety checks

Before commencing welding it is wise to inspect the condition and operation of all equipment. As well as normal equipment and workplace safety checks, there are specific procedures for oxyacetylene. Operators should verify that:

- flashback arresters are present in each gas line
- hoses are the correct color, with no sign of wear, as short as possible and not taped together
- regulators are the correct type for the gas
- a bottle key is in each bottle (unless the bottle has an adjusting screw)

It is recommended that oxyacetylene equipment is checked at least annually - regulators should be taken out of service after five years. Flashback arresters should be checked regularly according to manufacturer's instructions and, with specific designs, it may be necessary to replace if flashback has occurred.

Self-Check -3	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. What is oxyacetylene process?
2. List out oxyacetylene equipment and tools.
3. Explain the color code of hoses.
4. What are the three distinct flames of oxyacetylene welding?
5. What is the purpose of a gas regulator?

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = ___________

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Short Answer Questions

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Answer Sheet-1

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Short Answer Questions

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4.1 Introduction

Techniques to avoid imperfections such as lack of fusion and slag inclusions, which result from poor welder techniques, are relatively well known. However, the welder should be aware that the material itself may be susceptible to formation of imperfections caused by the welding process. In the materials section of the Job Knowledge for Welders, guidelines are given on material weld ability and precautions to be taken to avoid defects.

4.2 Selecting and identifingy wieldable materials

- Wield ability – means a property of the metals to be welded.
- Metals can be classified as
  - Ferrous
  - Non ferrous
- Ferrous materials- contain iron based and have extensive use for industries
- Ferrous metals which can be used in welding application
  - Cast iron
  - Alloy steel
  - Stain bass steel
  - Carbon steel
- Non - ferrous metals- are those that are not iron based
- Non –ferrous materials which can be used in welding applications are:-
  - Copper & its alloy
  - Aluminum and its alloy
  - Magnesium & its alloy
  - Nickel & its alloy
  - Zinc & its alloy

But most common weld able metals to arc welding process are wrought iron, cast iron, carbon steel, alloy steel

5.1 Introduction

Material preparation is so critical that it is often documented to ensure consistency in the procedure, regardless of the material. Removing coatings such as paint, oils, greases, and rust (oxides) ensures that the area to be welded is in the best possible condition.

5.2 Material preparation prior to weld

When working with carbon steels, it is critical to remove any rust and other impurities such as mill scale. Oil-based coatings and acidic pickling chemicals also must be removed before welding takes place. Removing chromium oxide to produce a decorative finish on stainless steel alloys often is achieved in a direct process. However, the subsequent cleaning of the welded area to remove any surface oxide (often seen as the discoloration next to a weld) allows for the re-formation of a protective layer that is very important in the stabilization of stainless steel alloys. This stabilization is known as passivation.

Nonferrous materials present their own challenges in the weld preparation process. With metals such as aluminum and titanium, there is a shorter window of time between the surface cleaning and the welding, as oxidation can form very quickly. Cleaning large areas too early before welding often leads to the need for rework.

A **welding joint** is a point or edge where two or more pieces of metal or plastic are joined together. They are formed by welding two or more work pieces (metal or plastic) according to a particular geometry. There are five types of joints butt, corner, edge, lap, and tee. These configurations may have various configurations at the joint where actual welding can occur.

5.3 Butt welds

Butt welds are welds where two pieces of metal to be joined are in the same plane. These types of welds require only some kind of preparation and are used with thin sheet metals that can be welded with a single pass.[2] Common issues that can weaken a butt weld are the entrapment of slag, excessive porosity, or cracking. For strong welds, the goal is to use the least amount of welding material possible. Butt welds are prevalent in automated welding processes, such as submerged-arc welding, due to their relative ease of preparation.[3] When metals are welded without human guidance, there is no operator to make adjustments for non-ideal joint preparation. Because of this necessity, butt welds can be utilized for their simplistic design to be fed through automated welding machines efficiently.

Types of Butt welding

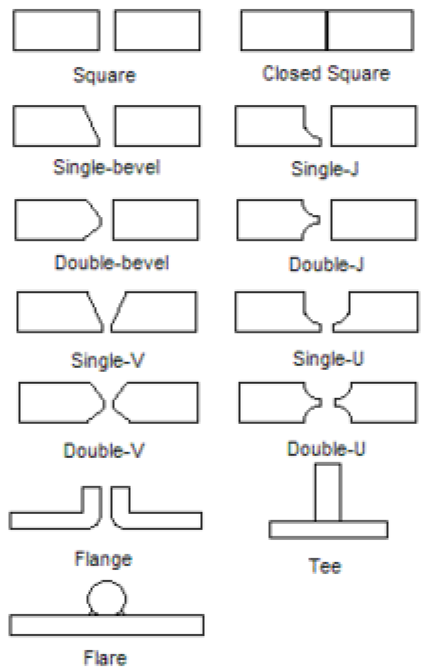

Fig.5.1Butt joint geometries

There are many types of butt welds, but all fall within one of these categories: single welded butt joints, double welded butt joint, and open or closed butt joints. A single welded butt joint is the name for a joint that has only been welded from one side. A double welded butt joint is created when the weld has been welded from both sides. With double welding, the depths of each weld can vary slightly. A closed weld is a type of joint in which the two pieces that will be joined are touching during the welding process. An open weld is the joint type where the two pieces have a small gap in between them during the welding process.

Square butt joints

The square-groove is a butt welding joint with the two pieces being flat and parallel to each other. This joint is simple to prepare, economical to use, and provides satisfactory strength, but is limited by joint thickness. The closed square butt weld is a type of square-groove joint with no spacing in between the pieces. This joint type is common with gas and arc welding.

For thicker joints, the edge of each member of the joint must be prepared to a particular geometry to provide accessibility for welding and to ensure the desired weld soundness and strength. The opening or gap at the root of the joint and the included angle of the groove should be selected to require the least weld metal necessary to give needed access and meet strength requirements. Only metal of up to 4.5mm thickness is usually used for square butt joints.

V-joints

Single butt welds are similar to a bevel joint, but instead of only one side having the bevelled edge, both sides of the weld joint are beveled. In thick metals, and when welding can be performed from both sides of the work piece, a double-V joint is used. When welding thicker metals, a double-V joint requires less filler material because there are two narrower V-joints compared to a wider single-V joint. Also the double-V joint helps compensate for warping forces. With a single-V joint, stress tends to warp the piece in one direction when the V-joint is filled, but with a double-V-joint, there are welds on both sides of the material, having opposing stresses, straightening the material.

J-joints

Single-J butt welds are when one piece of the weld is in the shape of a *J* that easily accepts filler material and the other piece is square. A J-groove is formed either with special cutting machinery or by grinding the joint edge into the form of a J. Although a J-groove is more difficult and costly to prepare than a V-groove, a single J-groove on metal between a half an inch and three quarters of an inch thick provides a stronger weld that requires less filler material. Double-J butt welds have one piece that has a *J* shape from both directions and the other piece is square.

U-joints

Single-U butt welds are welds that have both edges of the weld surface shaped like a J, but once they come together, they form a U. Double-U joints have a U formation on both the top and bottom of the prepared joint. U-joints are the most expensive edge to prepare and weld. They are usually used on thick base metals where a V-groove would be at such an extreme angle, that it would cost too much to fill.

Tee-Joints

The Tee Weld Joint is formed when two bars or sheets are joined perpendicular to each other in the form of a *T* shape. This weld is made from the resistance butt welding process. It can also be performed by Extrusion Welding. Usually two flat pieces of poly are welded at 90 degrees to each other, and extrusion welded on both sides.

Others

Thin sheet metals are often flanged to produce edge-flange or corner-flange welds. These welds are typically made without the addition of filler metal because the flange melts and provides all the filler needed. Pipes and tubing can be made from rolling and welding together strips, sheets, or plates of material.

Flare-groove joints are used for welding metals that, because of their shape, form a convenient groove for welding, such as a pipe against a flat surface.

Selection of the right weld joint depends on the thickness and process used. The square welds are the most economical for pieces thinner than 3/8”, because they don’t require the edge to be prepared. Double-groove welds are the most economical for thicker pieces because they require less weld material and time. The use of fusion welding is common for closed single-bevel, closed single J, open single J, and closed double J butt joints. The use of gas and arc welding is ideal for double-bevel, closed double-bevel, open double-bevel, single-bevel, and open single-bevel butt welds.

Below are listed ideal joint thicknesses for the various types of butt. When the thickness of a butt weld is defined it is measured at the thinner part and does not compensate for the weld reinforcement.

Work piece thickness limits per joint type

Joint type	Thickness
Square butt joint	Up to ¼ in (6.35 mm)
Single-bevel joint	3⁄16–⅜ in (4.76–9.53 mm)
Double-bevel joint	Over ⅜ in (9.53 mm)
Single-V butt joint	Up to ¾ in (19.05 mm)
Double-V butt joint	Over ¾ in (19.05 mm)
Single-J joint	½–¾ in (12.70–19.05 mm)
Double-J joint	Over ¾ in (19.05 mm)
Single-U joint	Up to ¾ in (19.05 mm)
Double-U joint	Over ¾ in (19.05 mm)
Flange (edge of corner)	Sheet metals less than 12 gauge (0.1046 in or 2.657 mm)
Flare groove	All thickness

Cruciform

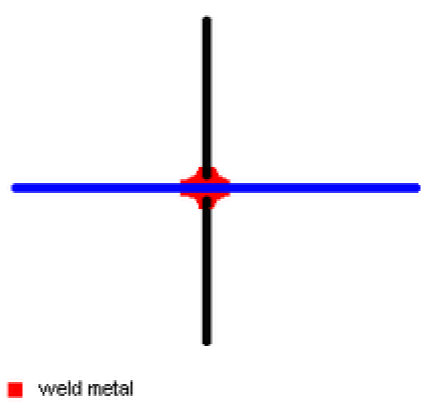

Diagram of a cruciform joint between 3 plates of metal

A *cruciform joint* is a specific joint in which four spaces are created by the welding of three plates of metal at right angles. Cruciform joints suffer fatigue when subjected to continuously varying loads.[6]

In the American Bureau of Shipping Rules for Steel Vessels, cruciform joints may be considered a double barrier if the two substances requiring a double barrier are in opposite corners diagonally. Double barriers are often required to separate oil and seawater, chemicals and potable water, etc.[7]

5.4 Plate edge preparation

In common welding practices, the welding surface needs to be prepared to ensure the strongest weld possible. Preparation is needed for all forms of welding and all types of joints. Generally, butt welds require very little preparation, but some is still needed for the best results. Plate edges can be prepared for butt joints in various ways, but the five most common techniques are oxyacetylene cutting (oxy-fuel welding and cutting), machining, chipping, grinding, and air carbon-arc cutting or gouging. Each technique has unique advantages to their use.

For steel materials, oxyacetylene cutting is the most common form of preparation. This technique is advantageous because of its speed, low cost, and adaptability. Machining is the most effective for reproducibility and mass production of parts. Preparation of J or U joints is commonly prepared by machining due to the need for high accuracy. The chipping method is used to prepare parts that were produced by casting. The use of grinding to prepare pieces is reserved for small sections that cannot be prepared by other methods. Air carbon arc cutting is common in industries that work with stainless steels, cast iron, or ordinary carbon steel.

Prior to welding dissimilar materials, one or both faces of the groove can be buttered. The buttered layer can be the same alloy as the filler metal or a different filler metal that will act as a buffer between the two metals to be joined.

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. What is the first procedure of material preparation
2. Define welding joint
3. Define weld ability
4. Discuss classification of materials
5. List types of weld joints and explain them

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

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Assemble and align *Materials*

Bearing Contact Area:
The overlapping area between two steel plates either in contact with one another or in contact with that have a separation not greater than 0.1 mm between them.

Erection Diagram:
Complete set of drawings prepared by the Fabricator showing the dimensioned layout of the steel structure from which Shop Drawings and details are made and that relate the structural steel fabricator's piece markings with the piece locations in the finished structure.

Material Preparation

1. **Straightening Material**
   - All steel shall be flat and straight according to the specified mill tolerances before commencement (beginning) of fabrication.
   - Material with sharp kinks or bends shall only be straightened with the approval of the Engineer.
   - When straightening is approved, material may be straightened using mechanical means or by the application of controlled heating according to CSA W59.
2. **Edge Preparation**
   - Sheared edges of plates with a 16 mm thickness or greater and that carry calculated tension shall have 3 mm of edge material removed by planning, milling or grinding.
   - Oxygen cutting of structural steel shall be done by machine except hand-guided cutting will be allowed for copes, blocks and similar cuts where machine cutting is impractical.
   - Re-entrant corners shall be ground smooth and shall have a fillet of the largest practical radius, but in no case shall the radius be less than 25 mm.
   - Plasma arc cutting shall only be done when approved in writing by the Engineer.
   - All nitrogen plasma arc cut edges shall be ground back by 0.5 mm when welding will be carried out on these edges.
   - In addition all edges of all members and plates exposed to view or weather in the finished assembly shall be rounded to a 1.5 mm radius by grinding.
   - All steel edges that will be painted whether resulting from rolling, cutting or, shearing operations shall be rounded to a 1.5 mm radius by grinding prior to blast cleaning.

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

- Identifying and selecting welding machine and oxyacetylene cylinder settings, accessories, filler materials and consumables
- Understanding polarity and Adjusting current and voltage
- Understanding welding electrodes
- Connecting/wiring or setting up welding machine
- Setting up oxyacetylene accessories and consumables and Adjusting oxyacetylene flame
- Providing braces, stiffeners, rails and other jigs
- Protecting work items/materials from strong winds, drafts and rainfall
- Selecting appropriate distortion prevention measures
- Completing task

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 and select welding machine and oxyacetylene cylinder settings, accessories, filler materials and consumables
- Understand polarity and Adjust current and voltage
- Understand welding electrodes and oxyacetylene
- Connect or setting up welding machine
- Set up oxyacetylene accessories and consumables and Adjust oxyacetylene flame
- Provide braces, stiffeners, rails and other jigs
- Protect work items/materials from strong winds, drafts and rainfall
- Select appropriate distortion prevention measures
- Complete task

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 14.

3. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the “Self-check 1” in page __.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1
7. Submit your accomplished Self-check. This will form part of your training portfolio.
8. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
9. Accomplish the “Self-check 2” in page __.
10. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).
11. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
12. Accomplish the “Self-check 3” in page __.
13. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).
14. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to for each Learning Act

1.1 Identifying and selecting welding machine

The number of different welding processes has grown in recent years. These processes differ greatly in the manner in which heat and pressure (when used) are applied, and in the type of equipment used. There are currently over 50 different types of welding processes; we will focus on three examples of ***electric arc welding***, which is the most common form of welding.

- The most popular processes are shielded metal arc welding **(SMAW)**, gas metal arc welding **(GMAW)** and gas tungsten arc welding **(GTAW)**.

- All of these methods employ an electric power supply to create an arc, which melts the base metal(s) to form a molten pool. The filler wire is then added automatically either (GMAW) or manually (SMAW & GTAW) and the molten pool is allowed to cool.

- Finally, all of these methods use some type of flux or gas to create an inert environment in which the molten pool can solidify without oxidizing.

1.2 Shielded Metal Arc Welding (SMAW)

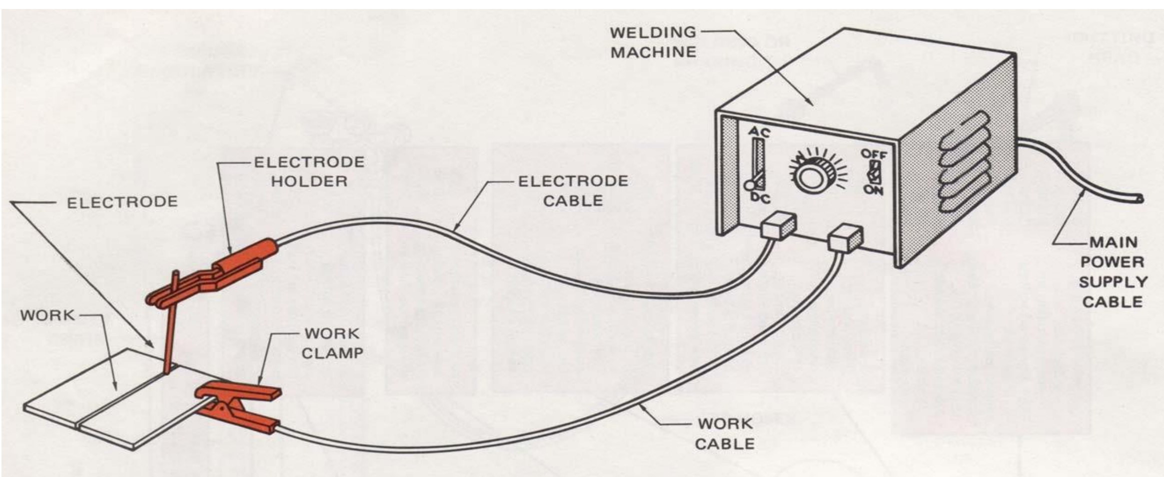


Figure 1-5 Shielded metal arc welding equipment

1.3 Shielded Metal Arc Welding (SMAW)

SMAW is a welding process that uses a flux covered metal electrode to carry an electrical current. The current forms an arc that jumps a gap from the end of the electrode to the work. The electric arc creates enough heat to melt both the electrode and the base material(s). Molten metal from the electrode travels across the arc to the molten pool of base metal where they mix together. As the arc moves away, the mixture of molten metals solidifies and becomes one piece. The molten pool of metal is surrounded and protected by a fume cloud and a covering of slag produced as the coating of the electrode burns or vaporizes. Due to the appearance of the electrodes, **SMAW is commonly known as 'stick' welding**.

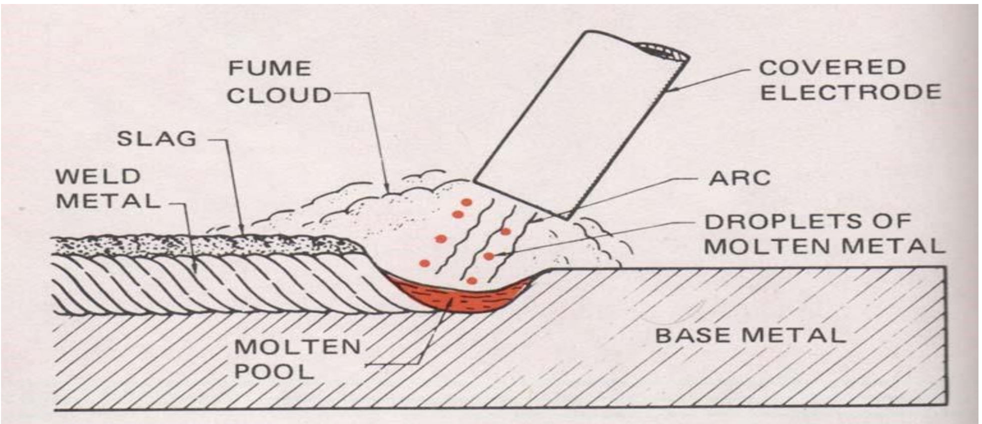


Figure 6-1 Shielded metal arc welding

SMAW is one of the oldest and most popular methods of joining metal. Moderate quality welds can be made at low speed with good uniformity. SMAW is used primarily because of its low cost, flexibility, portability and versatility. Both the equipment and electrodes are low in cost and very simple. SMAW is very flexible in terms of the material thicknesses that can be welded (materials from 1/16" thick to several inches thick can be welded with the same machine and different settings). It is a very portable process because all that is required is a portable power supply (i.e. generator). Finally, it is quite versatile because it can weld many different types of metals, including cast iron, steel, nickel & aluminum.

Some of the biggest drawbacks to SMAW are

1. That it produces a lot of smoke & sparks
2. There is a lot of post-weld cleanup needed if the welded areas are to look presentable,
3. It is a fairly slow welding process
4. It requires a lot of operator skill to produce consistent quality welds.

1.4Gas Metal Arc Welding (GMAW)

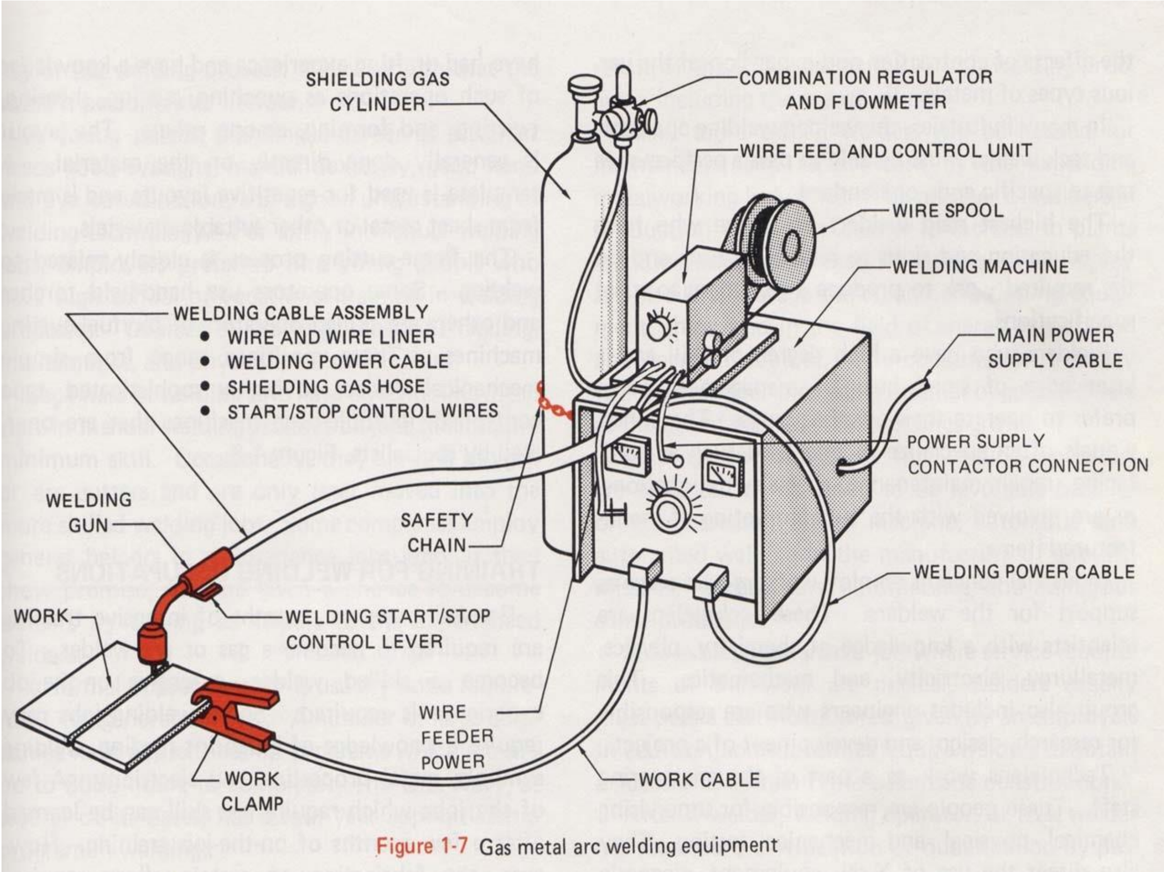


Figure 1-7 Gas metal arc welding equipment

1.5 Gas Metal Arc Welding (GMAW)

In the GMAW process, an arc is established between a continuous wire electrode (which is always being consumed) and the base metal. Under the correct conditions, the wire is fed at a constant rate to the arc, matching the rate at which the arc melts it. The filler metal is the thin wire that's fed automatically into the pool where it melts. Since molten metal is sensitive to oxygen in the air, good shielding with oxygen-free gases is required. This shielding gas provides a stable, inert environment to protect the weld pool as it solidifies. Consequently, **GMAW is commonly known as MIG (*metal inert gas*) welding**. Since fluxes are not used (like SMAW), the welds produced are sound, free of contaminants, and as corrosion-resistant as the parent metal. The filler material is usually the same composition (or alloy) as the base metal.

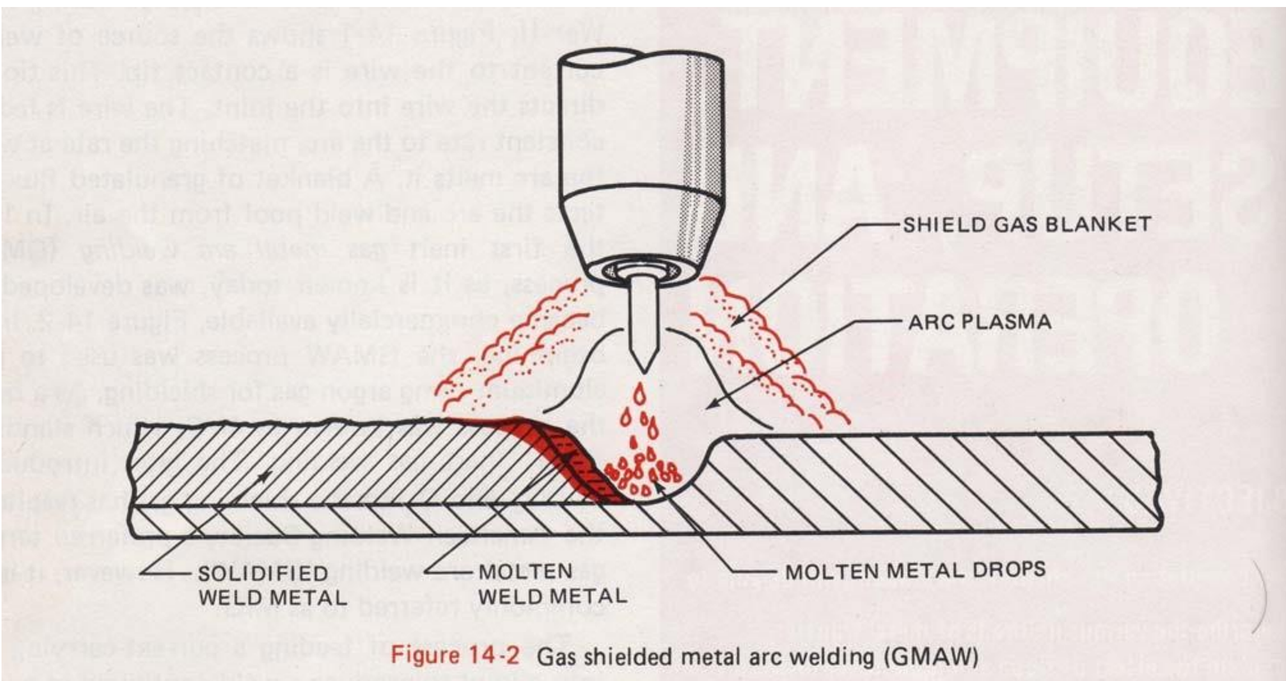


Figure 14-2 Gas shielded metal arc welding (GMAW)

GMAW is extremely fast and economical. This process is easily used for welding on thin-gauge metal as well as on heavy plate. It is most commonly performed on steel (and its alloys), aluminum and magnesium, but can be used with other metals as well. It also requires a lower level of operator skill than the other two methods of electric arc welding discussed in these notes. T**he high welding rate and reduced post-weld cleanup are making GMAW *the* fastest growing welding process.**

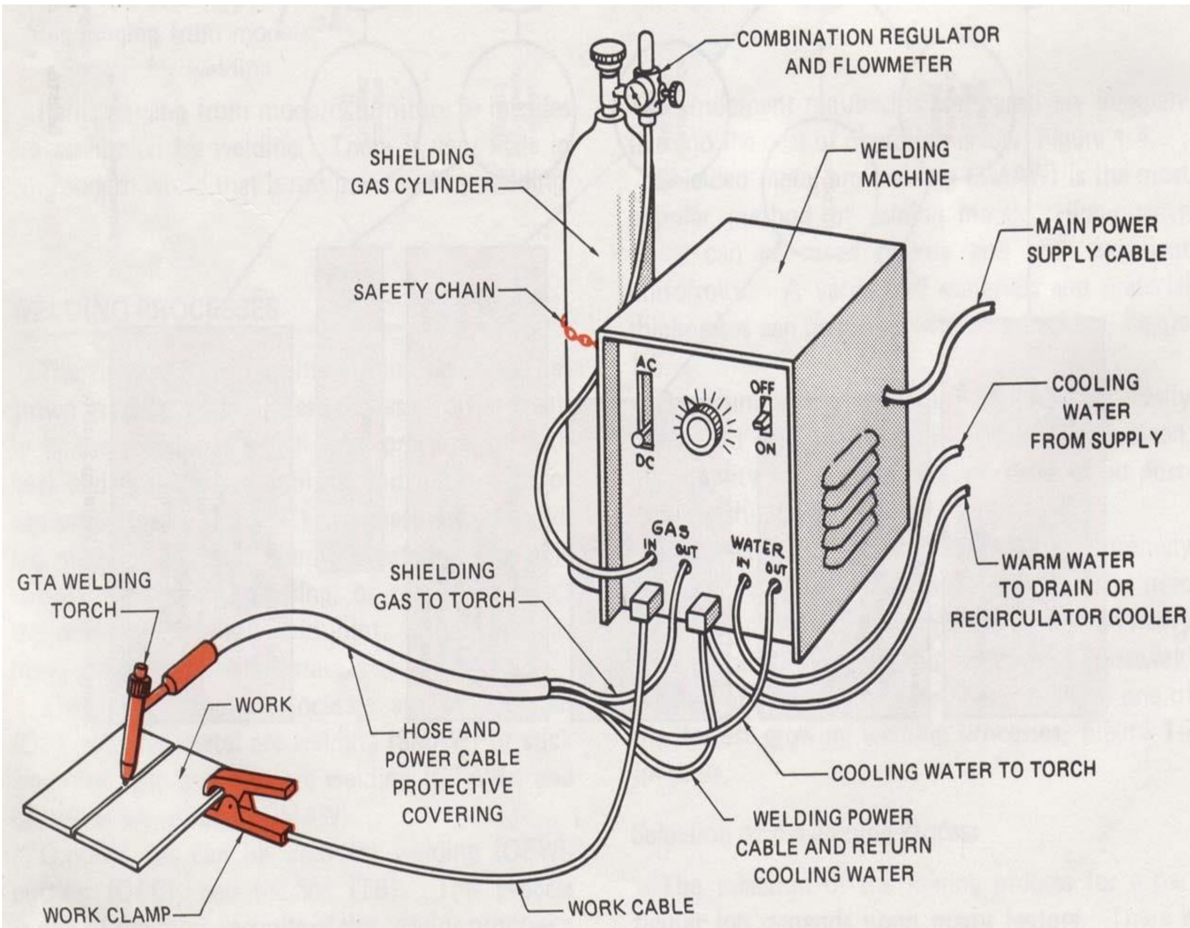


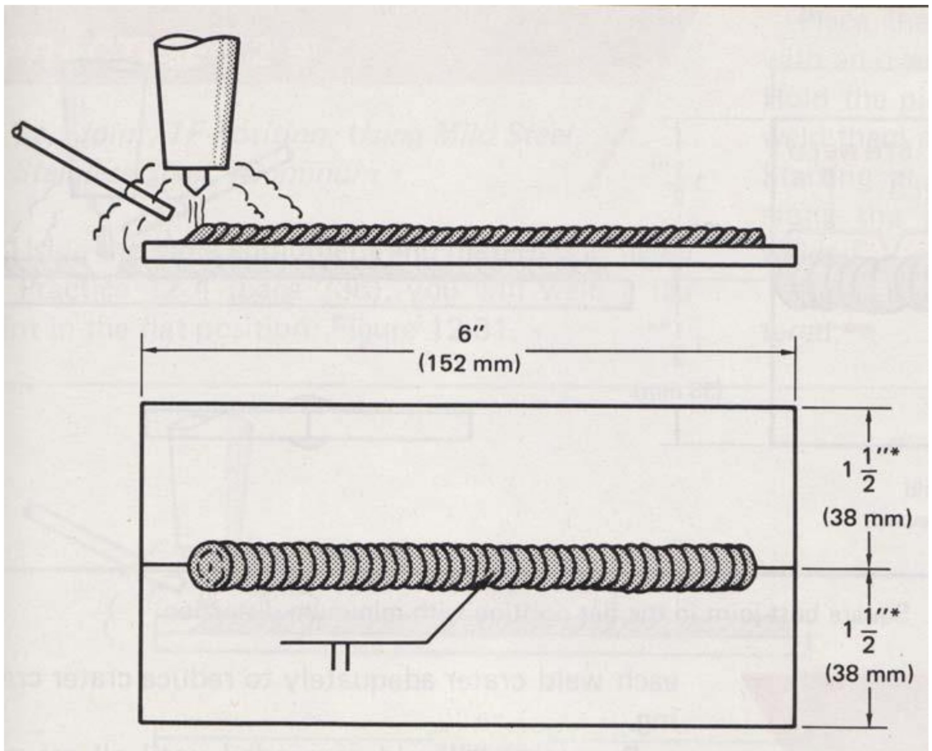
Figure 1-6 Gas tungsten arc welding equipment

1.6 Gas Tungsten Arc Welding (GTAW)

In the GTAW process, an arc is established between a tungsten electrode and the base metal(s). Under the correct conditions, the electrode does not melt, although the work does at the point where the arc contacts and produces a weld pool. The filler metal is thin wire that is fed manually into the pool where it melts. Since tungsten is sensitive to oxygen in the air, good shielding with oxygen-free gas is required. The same inert gas provides a stable, inert environment to protect the weld pool as it solidifies.

Consequently, **GTAW is commonly known as TIG (*tungsten inert gas*) welding**. Because fluxes are not used (like SMAW), the welds produced are sound, free of contaminants and slags, and as corrosion-resistant as the parent metal.

Tungsten's extremely high melting temperature and good electrical conductivity make it the best choice for a non-consumable electrode. The arc temperature is typically around 11,000° F. Typical shielding gasses are Ar, He, N, or a mixture of the two. As with GMAW, the filler material usually is the same composition as the base metal.



GTAW is easily performed on a variety of materials, from steel and its alloys to aluminum, magnesium, copper, brass, nickel, titanium, etc. Virtually any metal that is conductive lends itself to being welded using GTAW. Its clean, high-quality welds often require little or no post-weld finishing. **This method produces the finest, strongest welds out of all the welding processes.** However, it is also one of the slower methods of arc welding.

Self-Check -1	**Written Test**

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. What are the most popular welding processes?
2. Explain shield metal arc welding
3. Why SMAW commonly called stick welding?
4. What is the disadvantage of SMAW?
5. What is the advantage of MIG welding?

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

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Information Sheet-2	Identifying and selecting oxyacetylene cylinder settings, accessories, filler materials and consumable

2.1 Oxyacetylene Cylinders

Oxyacetylene equipment consists of a cylinder of acetylene, a cylinder of oxygen, two regulators, two lengths of hose with fittings, a welding torch with tips, and either a cutting attachment or a separate cutting torch.

Accessories include a friction igniter to light the torch, an apparatus wrench to fit the various connections on the regulators, the cylinders, and the torches; goggles with filter lenses for eye protection; and gloves for protection of the hands. Flame-resistant clothing is worn when necessary.

fig2.1 oxyacetylene Cylinders

2.2 Regulators

Reduce the gas pressure in a cylinder to a suitable working pressure before it can be used. This is done by a regulator or reducing valve. Regulators are either the single-stage or the double-stage type:

- Single-stage regulators reduce the pressure of the gas in one step;
- Two-stage regulators do the same job in two steps or stages. Less adjustment is generally necessary when two-stage regulators are used.

Acetylene regulators and oxygen regulators are of the same general type, although those designed for acetylene are not made to withstand such high pressures as are those designed for use with oxygen cylinders.

fig 2.2 Regulator

2.3 Welding Torches

The oxyacetylene welding torch is used to mix oxygen and acetylene gas in the proper proportions and to control the volume of these gases burned at the welding tip. Torches have two needle valves, one for adjusting the flow of oxygen and the other for adjusting the flow of acetylene. They have a handle (body), two tubes (one for oxygen and one for acetylene), a mixing head, and a tip. Welding tips are made from a special copper alloy, which dissipates heat (less than 60 percent copper), and are available in different size to handle a wide range of plate thicknesses

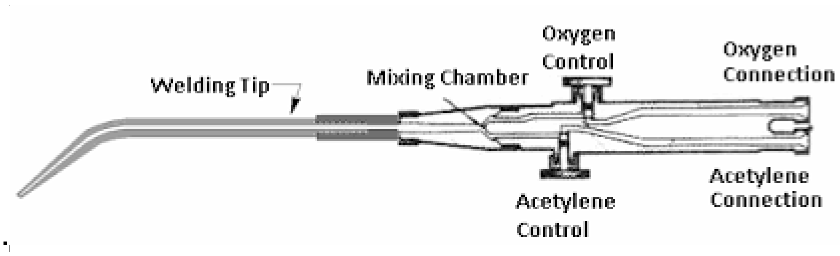

Fig.2.3 Welding Torches

Fig.2.4 Welding tips/nozzles

2.4 Hoses

Hoses used to make the connection between a torch and a regulator are strong, nonporous, and flexible and light enough to make torch movements easy. It is made to withstand high internal pressures, and the rubber used in its manufacture is specially treated to remove sulfur to avoid the danger of spontaneous combustion.

The hoses used for acetylene and oxygen are the same in grade, but they differ in color and have different types of threads on the hose fittings. The oxygen hose is GREEN, and the acetylene hose is RED. For added protection against mixing of the hoses during connection, the oxygen hose has right-hand threads and the acetylene hose has left-hand threads. The acetylene fittings also have a notch that goes around the circumference of the fittings for an additional identification factor

Fig 2.5 Hoses

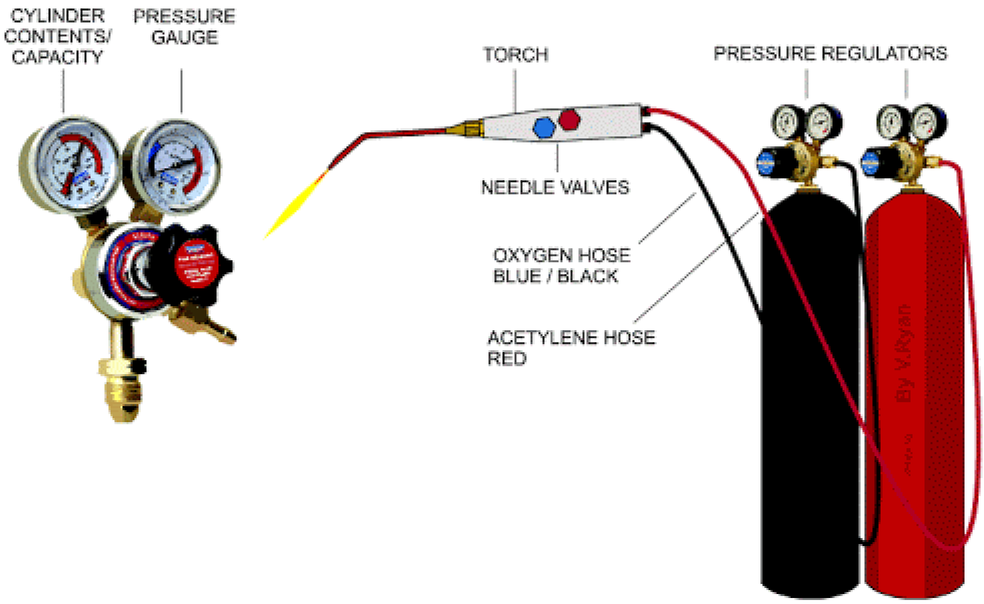

Fig 2.6 oxyacetylene accessories

2.5 Welding, Cutting, and Brazing

Welding is a process that joins materials together by melting a metalwork piece along with a filler metal to form a strong joint. Heat metal parts to a temperature that is high enough to join the metal parts by coalescence.

Coalescence

Coalescence occurs when two metals seem to pull together, or grow into one body, of the base metal parts when there is the slightest contact. There are two basic requirements for coalescence: heat and intimacy of contact.
Heat: Welding processes differ depending on the source of heat, the manner in which heat is applied or generated and the intensity of the heat. The fuel used as a heat force may be:

- acetylene or hydrogen in air or in oxygen;
- an electric arc;
- an electric, gas, or oil furnace;
- the resistance of metal to the flow of electric current; or
- a chemical reaction between a metal oxide and finely divided aluminum.

The intensity of heat applied or generated at the joint varies according to the metals being joined and to the welding process being used. All welding processes, except brazing, use temperatures high enough to melt the base metals.

Intimacy of contact

In the second basic requirement for coalescence, intimacy of contact, you can divide the welding processes into two groups: pressure processes and non-pressure processes.

- **Pressure Processes**: In pressure processes, there should not be any space between the surfaces being joined. Welders apply pressure while the contact surfaces are at a high enough temperature to allow plastic flow of the metal.
- **Non-pressure processes**: In non-pressure processes, leave space between the joined surfaces. Fill this space, either progressively or all at once, with molten metal. The molten metal may be produced by
  - a filler metal (welding rod or electrode),
  - melting the surfaces to be joined, or
  - Combining a filler metal and melted base metal.

2.6 Brazing

Brazing is a welding process using nonferrous filler alloys that do not contain iron or steel and have a melting point above 840°F but below that of the base metal. Brazing is also called 'hard soldering' or 'silver soldering. 'Brazing is the only welding process in which the melting of the base metal is not necessary for coalescence.

2.7 Soldering

Soldering is a joining process using non-ferrous filler alloys. Soft soldering uses alloys that melt between 190 to 840°F and is used in electronics, plumbing, and joining sheet metal parts. Soldering is not considered a welding process. Lead and tin are common alloys used in soldering, but there is also less common lead-free solder to decrease environmental impacts.

2.8 Weldability

The term WELDABILITY, or join ability, means

- the ability of metal to be welded into a structure that will perform its purpose satisfactorily, and
- the degree of simplicity of the procedures used to produce welds with properties that are equal to or better than the properties of the base material.

Many factors influence the weld ability of metal, including:

- the chemical composition of the metals involved;
- the effect of radical temperature changes on the various elements;
- the expansion and contraction characteristics of the base metals;
- the filler metal (welding rod or electrode);
- the joint design; and
- the welding procedure

2.9 Filler Materials and Flux

The metals added during the welding process are known as filler materials or filler metals. In welding processes in which space is lef between the parts to be joined, filler metals provide the intimacy of contact necessary for coalescence. Filler materials used in welding processes include welding rods and electrodes.

Welding Rods: The term welding rod refers to a filler metal, in wire or rod form, used in gas welding and brazing processes and in certain electric welding processes (tungsten inert gas) in which the filler metal is not a part of the electric circuit. A welding rod serves only one purpose—it supplies filler metal to the joint.

As a rule, rods are uncoated except for a thin film resulting from the manufacturing process. Welding rods for steel are often copper-coated to protect them from corrosion during storage. Most rods are furnished in 36-inch lengths and a wide variety of diameters, ranging from 1/32 to 3/8 inch. Rods for welding cast iron vary from 12 to 24 inches in length and are frequently square rather than round in cross section. The rod diameter selected for a given job is governed by the thickness of the metals being joined.

Self-Check -2	Written Test

Direction I: choose the correct answer to the following questions. Use the Answer sheet provided in the next page:

1. In gas welding, the hoses are mainly used for making the connection between gas torch and regulators.
   a) True
   b) False

2. A flashback is a condition in gas welding, when the pure methane gas is used as fuel gas instead of acetylene.
   a) True
   b) False

3. A welding torch is mainly used for mixing and burning the gases in the desired proportions.
   a) True
   b) False

4.

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = ___________

Rating: ____________

Name: ___________________________ Date: ________________

Answer Questions

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3.1 Factors to be considered for selecting a suitable type of welding current and polarity

Introduction

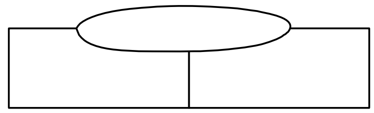
This information sheet describes the factors to be considered for selection of suitable type of welding current and polarity. Further, the coating factor and its influences of quality of weld metal have also been elaborated. Mode of metal transfer in shielded metal arc welding and factor affecting the same have been presented.

3.2 Selection of type of welding current

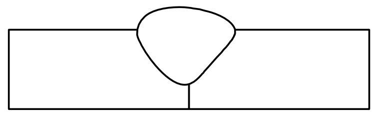
It is important to consider various aspects while selecting suitable type of welding current for developing weld joints in a given situation. Some of the points need careful considerations for selection of welding current are given below.

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.

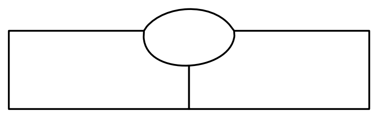
DC offers the advantage of polarity selection (DCEN&DCEP) which helps in controlling the melting rate, penetration and required welding deposition rate (Fig. 12.1). DCEN results in more heat at work piece producing high welding speed but with shallow penetration. DCEN polarity is generally used for welding 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.



a) DCEN



b) DCEP



c) AC

Fig.3.1 Schematic diagram showing effect of welding current and polarity

4.1 An electrode is a metal wire that is coated.

It is made out of materials with a similar composition to the metal being welded.

There are a variety of factors that go into choosing the right electrode for each project.

SMAW or stick electrodes are consumable, meaning they become part of the weld, while TIG electrodes are non-consumable as they do not melt and become part of the weld, requiring the use of a welding rod.

The MIG welding electrode is a continuously fed wire referred to as MIG wire.

Electrode selection is critical to ease of cleanup, weld strength, bead quality and for minimizing any spatter.

Electrodes need to be stored in a moisture-free environment and carefully removed from any package (follow the directions to avoid damage).

4.2 Covered Welding Electrodes

When molten metal is exposed to air, it absorbs oxygen and nitrogen, and becomes brittle or is otherwise adversely affected.

A slag cover is needed to protect molten or solidifying weld metal from the atmosphere. This cover can be obtained from the electrode coating.

The composition of the welding electrode coating determines its usability, as well as the composition of the deposited weld metal and the electrode specification.

The formulation of welding electrode coatings is based on well-established principles of metallurgy, chemistry, and physics

The coating protects the metal from damage, stabilizes the arc, and improves the weld in other ways, which include:

1. Smooth weld metal surface with even edges
2. Minimum spatter adjacent to the weld
3. A stable welding arc
4. Penetration control
5. A strong, tough coating
6. Easier slag removal
7. Improved deposition rate

The metal-arc electrodes may be grouped and classified as bare or thinly coated electrodes, and shielded arc or heavy coated electrodes

The covered electrode is the most popular type of filler metal used in arc welding.

The composition of the electrode covering determines the usability of the electrode, the composition of the deposited weld metal, and the specification of the electrode.

The type of electrode used depends on the specific properties required in the weld deposited.

These include corrosion resistance, ductility, high tensile strength, the type of base metal to be welded, the position of the weld (flat, horizontal, vertical, or overhead); and the type of current and polarity required.

Fig 4.1 electrode

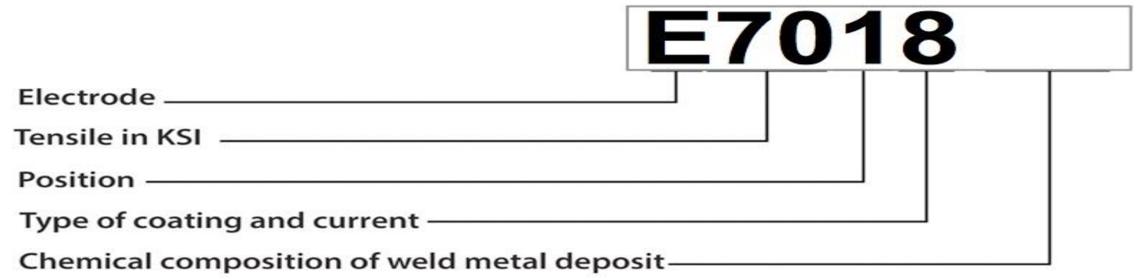
Popular Welding Electrode (E6010) used for general purpose fabrication, construction, pipe welding, and shipbuilding

Classification

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

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

1. **E** – indicates electrode for arc welding.
2. **The first two (or three) digits** – indicate tensile strength (the resistance of the material to forces trying to pull it apart) in thousands of pounds per square inch of the deposited metal.
3. **The third (or fourth) digit** – indicates the position of the weld. 0 indicates the classification is not used; 1 is for all positions; 2 is for flat and horizontal positions only; 3 is for flat position only.
4. **The fourth (or fifth) digit** – indicates the type of electrode coating and the type of power supply used; alternating or direct current, straight or reverse polarity.
5. The types of coating, welding current, and polarity position designated by the fourth (or fifth) identifying digit of the electrode classification are listed in the table 5-4 below.
6. **The number E6010** – indicates an arc welding electrode with minimum stress relieved tensile strength of 60,000 psi; is used in all positions, and reverse polarity direct current is required.



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

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

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

There are many types of coatings other than those mentioned here, most of which are usually combinations of these types but for special applications such as hard surfacing, cast iron welding, and for nonferrous metals.

Storage

Electrodes must be kept dry. Moisture destroys the desirable characteristics of the coating and may cause excessive spattering and lead to porosity and cracks in the formation of the welded area. Electrodes exposed to damp air for more than two or three hours should be dried by heating in a suitable oven for two hours at 500°F (260°C).
After they have dried, they should be stored in a moisture-proof container. Bending the electrode can cause the coating to break loose from the core wire. Electrodes should not be used if the core wire is exposed.

Electrodes that have an “R” suffix in the AWS classification have a higher resistance to moisture.

Bare Electrodes

Bare welding electrodes are made of wire compositions required for specific applications.

These electrodes have no coatings other than those required in wire drawing. These wire drawing coatings have some slight stabilizing effect on the arc but are otherwise of no consequence. Bare electrodes are used for welding manganese steel and other purposes where a coated electrode is not required or is undesirable. A diagram of the transfer of metal across the arc of a bare electrode is shown in figure 5-29.

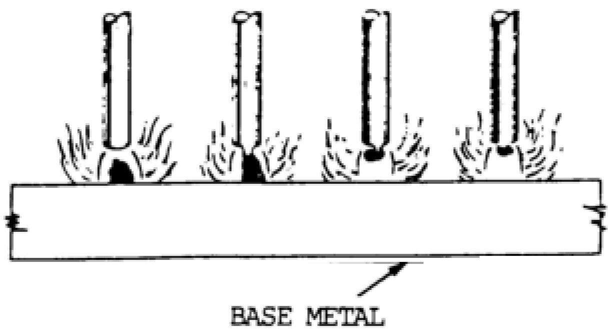


Fig 4.2 diagram of the transfer of metal across the arc of a bare electrode

Molten metal transfer with a bare electrode

Light Coated Electrodes

Light coated welding electrodes have a definite composition.

A light coating has been applied on the surface by washing, dipping, brushing, spraying, tumbling, or wiping. The coatings improve the characteristics of the arc stream. They are listed under the E45 series in the electrode identification system.

The coating generally serves the functions described below:

1. It dissolves or reduces impurities such as oxides, sulfur, and phosphorus.
2. It changes the surface tension of the molten metal so that the globules of metal leaving the end of the electrode are smaller and more frequent. This helps make flow of molten metal more uniform.
3. It increases the arc stability by introducing materials readily ionized (i.e., changed into small particles with an electric charge) into the arc stream.
4. Some of the light coatings may produce a slag. The slag is quite thin and does not act in the same manner as the shielded arc electrode type slag.

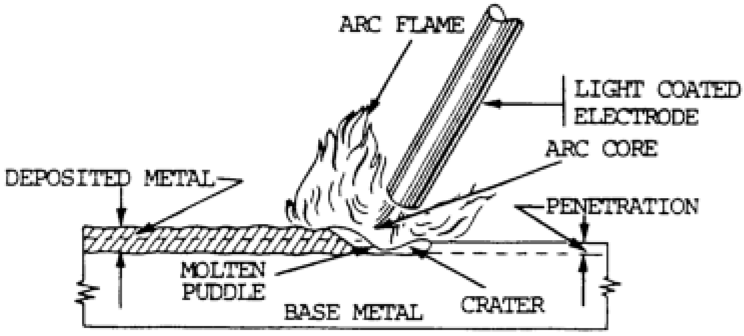


Figure 4.3: Arc Action Obtained With a Light Coated Electrode

Functions of Shielded Arc or Heavy Coated Electrodes

These welding electrodes produce a reducing gas shield around the arc.

This prevents atmospheric oxygen or nitrogen from contaminating the weld metal.

The oxygen readily combines with the molten metal, removing alloying elements and causing porosity.

Nitrogen causes brittleness, low ductility, and in Some cases low strength and poor resistance to corrosion.

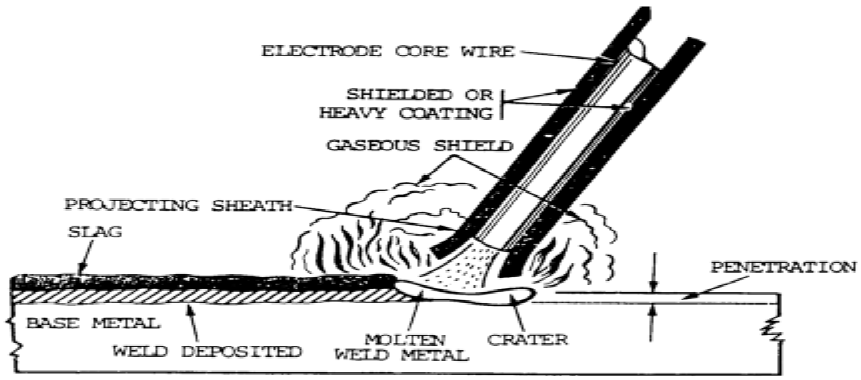
They reduce impurities such as oxides, sulfur, and phosphorus so that these impurities will not impair the weld deposit.

They provide substances to the arc which increases its stability. This eliminates wide fluctuations in the voltage so that the arc can be maintained without excessive spattering.

By reducing the attractive force between the molten metal and the end of the electrodes, or by reducing the surface tension of the molten metal, the vaporized and melted coating causes the molten metal at the end of the electrode to break up into fine, small particles.

The coatings contain silicates which will form a slag over the molten weld and base metal. Since the slag solidifies at a relatively slow rate, it holds the heat and allows the underlying metal to cool and solidify slowly. This slow solidification of the metal eliminates the entrapment of gases within the weld and permits solid impurities to float to the surface. Slow cooling also has an annealing effect on the weld deposit.

The physical characteristics of the weld deposit are modified by incorporating alloying materials in the electrode coating. The fluxing action of the slag will also produce weld metal of better quality and permit welding at higher speeds.



4.4: Arc Action Obtained With A Shielded Arc Electrode

Direct Current Arc Welding Electrodes

The manufacturer's recommendations should be followed when a specific type of welding electrode is being used. In general, direct current shielded arc electrodes are designed either for reverse polarity (electrode positive) or for straight polarity (electrode negative), or both. Many, but not all, of the direct current electrodes can be used with alternating current. Direct current is preferred for many types of covered, nonferrous, bare and alloy steel electrodes. Recommendations from the manufacturer also include the type of base metal for which given electrodes are suited, corrections for poor fit-ups, and other specific conditions.

In most cases, straight polarity electrodes will provide less penetration than reverse polarity electrodes, and for this reason will permit greater welding speed. Good penetration can be obtained from either type with proper welding conditions and arc manipulation.

Alternating Current Arc Welding Electrodes

Coated electrodes, which can be used with either direct or alternating current, are available. Alternating current is more desirable while welding in restricted areas or when using the high currents required for thick sections because it reduces arc blow. Arc blow causes blowholes, slag inclusions, and lack of fusion in the weld.

Alternating current is used in atomic hydrogen welding and in those carbon arc processes that require the use of two carbon electrodes. It permits a uniform rate of welding and electrode consumption. In carbon-arc processes where one carbon electrode is used, direct current straight polarity is recommended, because the electrode will be consumed at a lower rate.

Non-consumable Electrodes

There are two types of nonconsumable welding electrodes.

1. The carbon electrode is a non-filler metal electrode used in arc welding or cutting, consisting of a carbon graphite rod which may or may not be coated with copper or other coatings.
2. The tungsten electrode is defined as a non-filler metal electrode used in arc welding or cutting, made principally of tungsten.

Carbon Electrodes

Electrodes Cutting and Welding Carbon-Graphite Uncoated and Copper Coated.

This specification provides a classification system based on three grades: plain, uncoated, and copper coated. It provides diameter information, length information, and requirements for size tolerances, quality assurance, sampling, and various tests. Applications include carbon arc welding, twin carbon arc welding, carbon cutting, and air carbon arc cutting and gouging.

6010 Electrodes

This type of electrode is often employed for general welding applications that do not call for any special features. They also are used on farm equipment, piping, wrought iron and road equipment. According to Metal Web News, 6011 electrodes create welds with a minimum tensile strength of around 60,000 pounds per square inch (psi). Welders can hold this type of electrode in any position to create a proper weld. 6010 electrodes are designed for use under direct currents (DC). According to Welding Tips and Tricks, 6010 electrodes feature a high cellulose sodium outer coating.

6013 Electrodes

6013 electrodes are relatively easy to use. They create a softer arc that is ideal for use on sheet metal. This type of electrode is often employed for general repair on thinner materials. 6013 electrode welds offer around a 60,000 psi minimum tensile strength, according to Metal Web News. These electrodes can be held in any position and are used under either direct or alternating currents (AC). 6013 electrodes feature a high titania potassium outer coating, according to Welding Tips and T

7018 Electrodes

The 7018 electrode is often referred to as a “low hydrogen electrode” that features a low moisture coating, which reduces the level of hydrogen that seeps into a weld. This type of electrode produces high-quality, crack-resistant weld points with medium penetration. These electrodes must remain dry before use. The minimum weld tensile strength produced by this type of electrode is around 70,000 psi, according to Metal Web News. 7018 electrodes also can be held in any position while welding. 7018 electrodes are engineered to operate under either direct currents or alternating currents. According to Welding Tips and Tricks, this type of electrode features an iron powder, low hydrogen outer coating.

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1) electrode used in arc welding
   a) consumable electrode
   b) non- consumable electrode
   c) portable are welding
   d) all of the above
2) one of the following is welding requirement
   a) select welding machine
   b) select welding current
   c) select proper electrode
   d) all of the above
3) _____ is a filler metal in the form of wire, rod, bore or coated a conduct current between electrode holder & base metal
   a) Cellulose sodium
   b) Electrode
   c) Iron Oxide
   d) Stabilize the arc better
4) Types of electrodes
   a) Bare electrode
   b) Iron Oxide
   c) Coated Oxide
   d) A& C
5) One of the following is coating substance
   a) Cellulose sodium
   b) Cellulose potassium
   c) Iron Oxide
   d) All of the above
6) Welding positions are
   a) Plat position
   b) Vertical position
   c) Over head position
   d) Horizontal position
   e) All of the above
7) Selection of electrode is governed by
   a) Electrode diameter
   b) Properties of base metals
   c) Welding current and polarity
   d) All of the above
8) Most common wieldable metals by arc welding are
   a) Wrought iron b) Cast iron c) Carbon steel d) Alloy steel e) All

Self check answer key

1. Answer Sheet-1

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

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5.1 Assemble and set up welding equipment

Set up welding equipment

* Before starting any arc welding operation

- Make complete inspection of your equipment work area by5-10 minute.
- Check all connection are in good conditions
- Check the work area is free from any obstacle
- Check ground clamp and electrode holders are in a good condition
- Make sure that the welding stations are well ventilated
- Make sure that all safety device for welding are exist
- Set up the current to the required current value base on the material being weld
- Now start to weld

6.1Equipment Setup

To avoid costly mistakes and avoid injury to yourself and others, set up the oxyacetylene equipment and prepare for cutting in a careful and systematic manner.

Take the following steps before attempting to light the torch:

- Secure cylinders so that they cannot be knocked over.
    - ➢ Place in a corner or next to a vertical column; secure with a piece of line.
    - ➢ Never secure to a structural member that is a current conductor.
- Remove protective caps.
- Stand to one side, crack each cylinder valve slightly, and immediately reclose valve.
    - ➢ This blows dirt and other foreign matter out of cylinder valve nozzle.
    - ➢ Do not bleed fuel gas into a confined area; it may ignite.
- Wipe connections with a clean cloth.
- Connect fuel-gas regulator to fuel-gas cylinder and oxygen regulator to oxygen cylinder.
- Snug connection nuts sufficiently with gang wrench to avoid leaks.
- Back off regulator screws to prevent damage to regulators and gauges.
- Open cylinder valves slowly.
    - ➢ Open fuel-gas valve only one-half turn.
    - ➢ Open oxygen valve all the way.

Note: Some fuel-gas cylinders have a hand wheel for opening the fuel-gas valve; others require using a gang wrench or T-handle wrench. Leave any wrench in place while the cylinder is in use so the fuel-gas bottle can be turned off quickly in an emergency.

- Read high-pressure gauge to check contents in each cylinder.
- Connect red hose to fuel-gas regulator (left-hand threads) and green hose to oxygen regulator.

- Purge oxygen hose by turning regulator screw in (clockwise) to between 2 and 5 psig; turn screw out (counterclockwise) to shutoff oxygen.
- Repeat for fuel-gas hose ONLY in a well-ventilated place free from sparks, flames, or possible sources of ignition.
- Connect hoses to torch, red (left-threaded) to fuel, and green to oxy.
- With torch valves closed, turn both regulator screws clockwise to test hose connections for leaks.
- If no leaks are found turn regulator screws counterclockwise to close.
- Open torch valves to drain hose.
- Install correct cutting tip in cutting torch head.
    - ➢ Tighten assembly by hand; snug tighten with gang wrench.
- Adjust working pressures.
    - ➢ Adjust fuel-gas pressure by opening torch needle valve and turning fuel-gas regulator screw clockwise. Adjust regulator to working pressure needed for particular tip size; close torch needle valve.

      - Adjust MAPP gas pressure with torch valves closed.
    - ➢ Adjust oxygen pressure by opening torch needle valve and proceed as with fuel-gas.

To light the torch and adjust the flame, always follow the manufacturer's directions for that particular model of torch. Procedures vary somewhat with different types and, in some cases, even with different models of torches made by the same manufacturer.

In general, the procedure is to open the torch oxygen needle valve a small amount, followed by opening the torch fuel-gas needle valve slightly more. Then use a spark igniter or stationary pilot flame to light the mixture.

CAUTION

NEVER use matches to light the torch; their length requires bringing the hand too close to the tip. Upon igniting, accumulated gas may envelop the hand and result in a severe burn. Also, never light the torch from hot metal.

After checking the fuel-gas adjustment, you can adjust the oxy gas flame to obtain the desired characteristics for the work at hand by further manipulating the oxygen and fuel gas needle valves according to the torch manufacturer's direction.

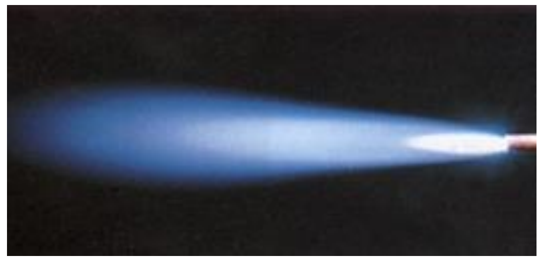
A pure fuel-gas flame is long and bushy with a yellowish color. It takes the oxygen it needs for combustion from the surrounding air and there is not enough oxygen available to burn the fuel gas completely. Consequently, the flame is smoky, sooty, and unsuitable for use.

To set the flame appropriately, you need to increase the amount of oxygen by opening the oxygen needle valve until the flame takes on a bluish white color with a bright inner cone surrounded by a flame envelope of a darker hue. The inner cone is the portion of the flame that develops the required operating temperature.

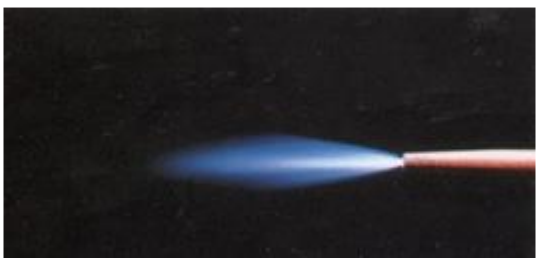
All oxygen processes commonly use one of three types of preheat flames: carburizing, neutral, or oxidizing.

You need to know their characteristics to ensure proper flame adjustment *figure* shows how the three different flames look

Neutral flame



Carburizing flame



Oxidizing flame

Figure 6.1 — Example of carburizing, neutral, and oxidizing flames.

6.2Carburizing Flame

The temperature of a carburizing flame is about 5400°F. It always shows distinct colors; the inner cone is bluish white, the intermediate cone is white, the outer envelope flame is light blue, and the feather at the tip of the inner cone is greenish.

The length of the feather can be used as a basis for judging the degree of carburization. The highly carburizing flame is longer with yellow or white feathers on the inner cone; the slightly carburizing flame has a shorter feather on the inner cone and becomes whiter.

Strongly carburizing flames are not used in cutting low-carbon steels because the additional carbon they add causes brittleness and hardness. However, these flames

are ideal for cutting cast iron; the additional carbon poses no problem, and the flame adds more heat to the metal because of its size.
Slightly carburizing flames are ideal for cutting steels and other ferrous metals that produce a large amount of slag. Although a neutral flame is best for most cutting, a slightly carburizing flame is ideal for producing a lot of heat down inside the kerf. It makes reasonably smooth cuts and reduces the amount of slag clinging to the bottom of the cut.

6.3Neutral Flame

The temperature of a neutral flame is about 5600°F. It is the most common preheat flame for oxygas cutting. The carburizing flame becomes neutral when you add additional oxygen. The feather will disappear from the inner flame cone, and all that will be left is the dark blue inner flame and the lighter blue outer cone.

The neutral flame will not oxidize or add carbon to the metal you are cutting. In actuality, a neutral flame acts like the inert gases that are used in TIG and MIG welding to protect the weld from the atmosphere. When you focus a neutral preheat flame on a single spot on the metal until it melts, it forms a clear-looking molten puddle that lies very quietly under the flame.

6.4Oxidizing Flame

The temperature of an oxidizing flame is about 6000°F. When you add a little more oxygen to the preheat flame, it will quickly become shorter. The flame will start to neck down at the base next to the flame port, and the inner flame cone changes from dark blue to light blue. Oxidizing flames are much easier to look at because they are less radiant than neutral flames.

The oxidizing flame is rarely used for conventional cutting since it produces excessive slag and does not leave square-cut edges. Oxidizing flames are used in conjunction with cutting machines that have a high-low oxygen valve. The machine starts the cut with an oxidizing flame then automatically reverts to a neutral flame.

The oxidizing flame gives you fast starts when using high-speed cutting machines and is ideal for piercing holes in plate. They are used also in cutting metal underwater where the only source of oxygen for the torch is supplied from the surface

Direction I: choose the best answer to the following questions. Use the Answer sheet provided in the next page:

1. Which of the following is also called "gas welding"?
a) Oxy fuel gas welding
b) Metallic welding
c) Arc welding
d) Fuel gas welding
View Answer

2. How many types of flames are there in welding?
a) 1
b) 2
c) 3
d) 4

3. In which of the following type of flame, oxygen is of same proportion with acetylene?
a) Neutral flame
b) Oxidizing flame
c) Carburizing flame
d) Both oxidizing flame and carburizing flame.

4. In which of the following type of flame, oxygen is in excess proportion with acetylene?
a) Neutral flame
b) Oxidizing flame
c) Carburizing flame
d) Both oxidizing flame and carburizing flame

5. In which of the following type of flame, oxygen is deficient in proportion with acetylene?
a) Neutral flame
b) Oxidizing flame
c) Carburizing flame
d) Both oxidizing flame and carburizing flame

6. Which of the following flame is harmful to steel?
a) Neutral flame
b) Oxidizing flame
c) Carburizing flame
d) Both oxidizing flame and carburizing flame

7. For brazing, soldering and flame hardening which of the following flame is used?
a) Neutral flame
b) Oxidizing flame
c) Carburizing flame
d) Both oxidizing flame and carburizing flame

8. The inner cone of the flame in welding has the following nature?
a) Highest temperature
b) Coldest temperature
c) Moderate temperature
d) Uncertain

9. The oxy acetylene gas welding is a type of?
a) Endothermic reaction
b) Exothermic reaction
c) Neutral reaction
d) Both endothermic reaction and exothermic reaction

10. The chemical formula of acetylene is?
a) C_2H_4
b) C_2H_6
c) C_2H_5OH
d) C_2H_2

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = ___________
Rating: ____________

Name: ___________________________ Date: ________________

Answer Questions

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Information Sheet-7	Providing braces, stiffeners, rails and other jigs

7.1 Introduction

The best welding fixtures and jigs on the market today reduce welding time, simplify welding jobs, streamline manufacturing processes, and ultimately minimize production costs. Modern equipment also is ergonomic and designed to minimize effort.

While a jig is somewhat similar to a welding fixture, a fixture allows for both tool and work piece to be moved together. Some jigs are attached to welding tables and have the function of a frame-welding fixture; these may be known as frame welding jigs. The ergonomic design of all jigs minimizes the work needed to complete a task

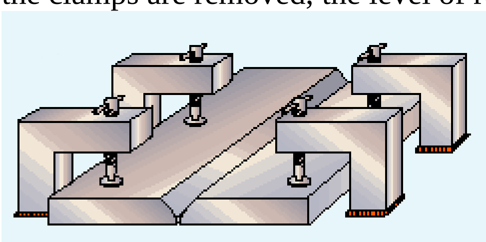
7.2 Welding jigs and fixtures

Jigs and fixtures are used to locate the parts and to ensure that dimensional accuracy is maintained whilst welding. They can be of a relatively simple construction, as shown in *Fig 3a*, but the welding engineer will need to ensure that the finished fabrication can be removed easily after welding.

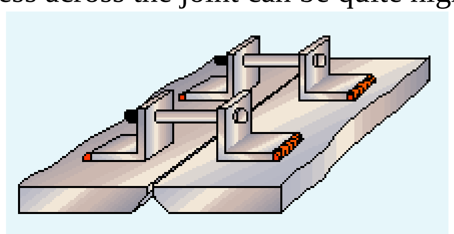
7.3 Flexible clamps

A flexible clamp (Fig *3b*) can be effective not only in applying restraint but also in setting up and maintaining the joint gap (it can also be used to close a gap that is too wide).

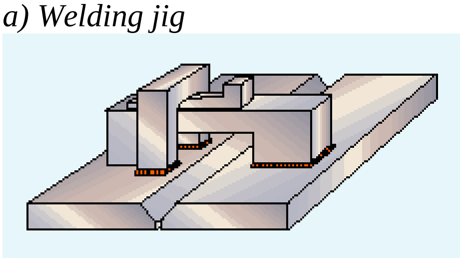
A disadvantage is that, as the restraining forces in the clamps are transferred into the joint when the clamps are removed, the level of residual stress across the joint can be quite high.



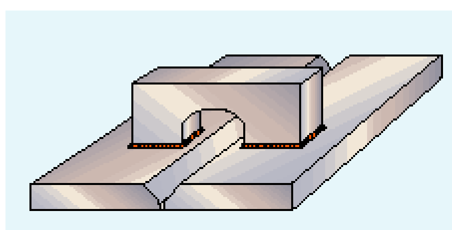
a) Welding jig



b) Flexible clamps



c) Strong backs with wedges



d) Fully welded strong backs

Fig. 7.1 Restraint techniques to prevent distortion

7.4Strong backs (and wedges)

Strong backs are a popular means of applying restraint especially for site work. Wedged strong backs, *Fig.3c*, will prevent angular distortion in plate and help to prevent peaking in welding cylindrical shells. As these types of strong back will allow transverse shrinkage, the risk of cracking will be greatly reduced compared with fully welded strong backs.

Fully welded strong backs (welded on both sides of the joint) *Fig 3d*, will minimize both angular distortion and transverse shrinkage. As significant stresses can be generated across the weld, which will increase any tendency for cracking, care should be taken in the use of this type of strong back.

7.5Stiffening

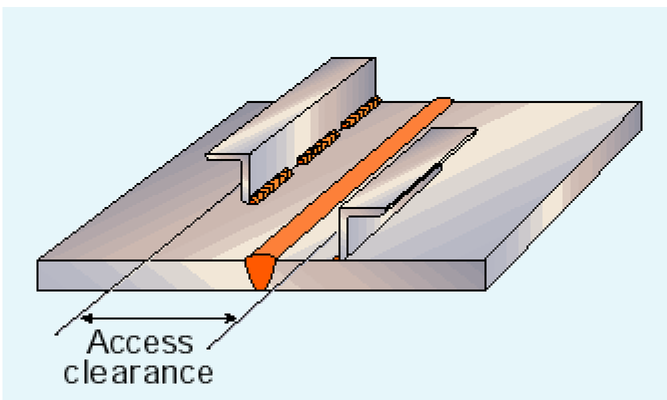


Fig. 7.2. Longitudinal stiffeners prevent bowing in butt welded thin plate joints

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 (Fig. 3) 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.

7.6Fixtures for Railing Welding Fixtures

A well-designed fixture for railing welding (**Fig.4**) can cut production time significantly for banisters, straight railings, handrails, and all other ornaments and railing parts. It should be made from carbon steel, stainless steel, or aluminum, depending on which type of metal the manufacturer prefers.

To streamline welding and make production projects as simple and seamless as possible, the various bar elements for railings ideally should be placed on the frame according to how wide they are. In a design where this is possible, only the distance between upright members and the number of similar bar elements need to be entered into the input display of the machine.

It should be possible to clamp the horizontal members of the railing, including the handrail or banisters, so that they can be positioned individually along the shorter X axis, and then shifted together along the longer Y axis as a single unit. Once everything is clamped into place, the fixture can be tilted and swung into the optimum welding position to make the procedure as quick and easy as possible.

A top-of-the-range rail welding fixture has holders for handrails and belts that are made from stainless steel to conform to the demands of high-quality stainless steel railings

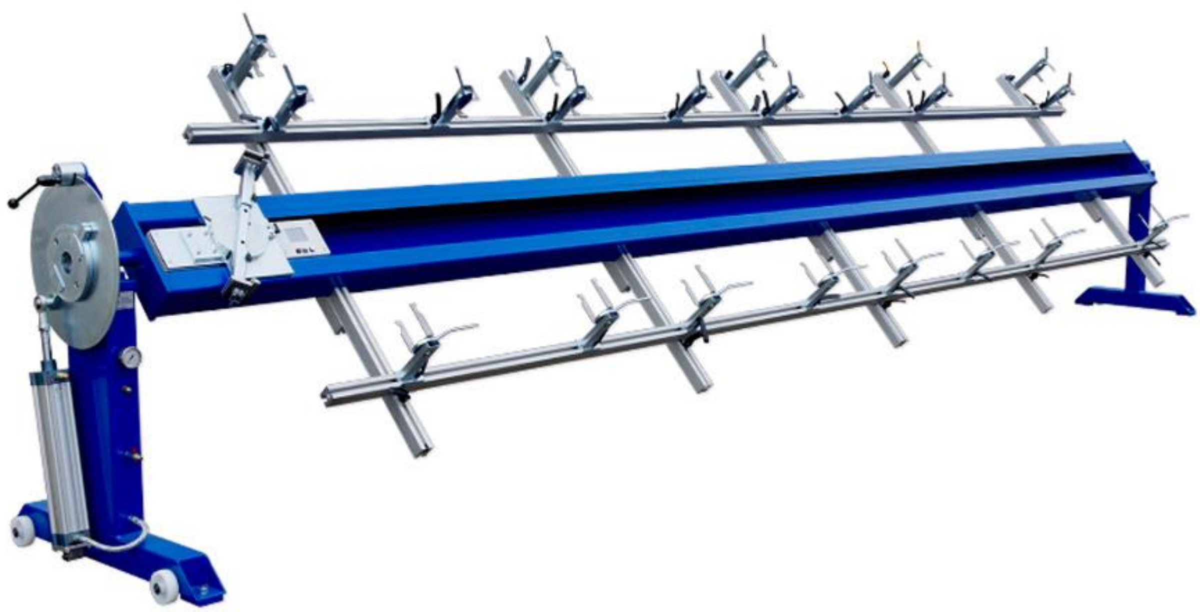


Fig. 7.3 welding rail

Self-Check -7	Written Test

Direction I: choose the best answer to the following questions. Use the Answer sheet provided in the next page:

1. With the use of Jigs and fixture total cost of production
   a) Increases
   b) Decreases
   c) Remains same
   d) Jigs are not used in any production process
2. With the use of Jigs and fixture rate of production will
   a) Increase
   b) Decrease
   c) Remains same
   d) Jigs are not used in any production process
3. Jigs and fixture increases the accuracy of the parts.
   a) True
   b) False
4. Jigs And fixture are used to provide interchangeability.
   a) True
   b) False
5. With the use of Jigs and fixture quality control expenses will
   a) Reduce
   b) Increases
   c) Jigs and fixture are not used in any production process
   d) None of the mentioned

Answer Sheet-1

Score = ___________

Rating: ____________

Name: ___________________________ Date: ________________

Short Answer Questions

1.
2.
3.
4.
5.

8.1Effect of wind speed on weld profile

Examination of welds made under different wind speeds indicates that wind acting on the molten weld pool results in ripples in the welds made under high wind speeds. The effect is most noticeable for winds of 35 mph (56 kph). In addition, the high wind caused the arc to behave erratically. In the pipeline fabrication, the weld failure can be initiated from ripples on the weld surface, which underscores the importance of maintaining the weld profile.

In all cases, the wind direction was perpendicular to the longitudinal axis of the weld. High wind speed did not cause any significant profile skew in the sections examined. The sensitivity of wind direction on the weld was not examined; however, it is hypothesized that head wind or tail wind in the direction of the welding axis may have a greater effect on the formation of ripples and a lesser effect on concavity. This hypothesis should be verified through additional experimentation.

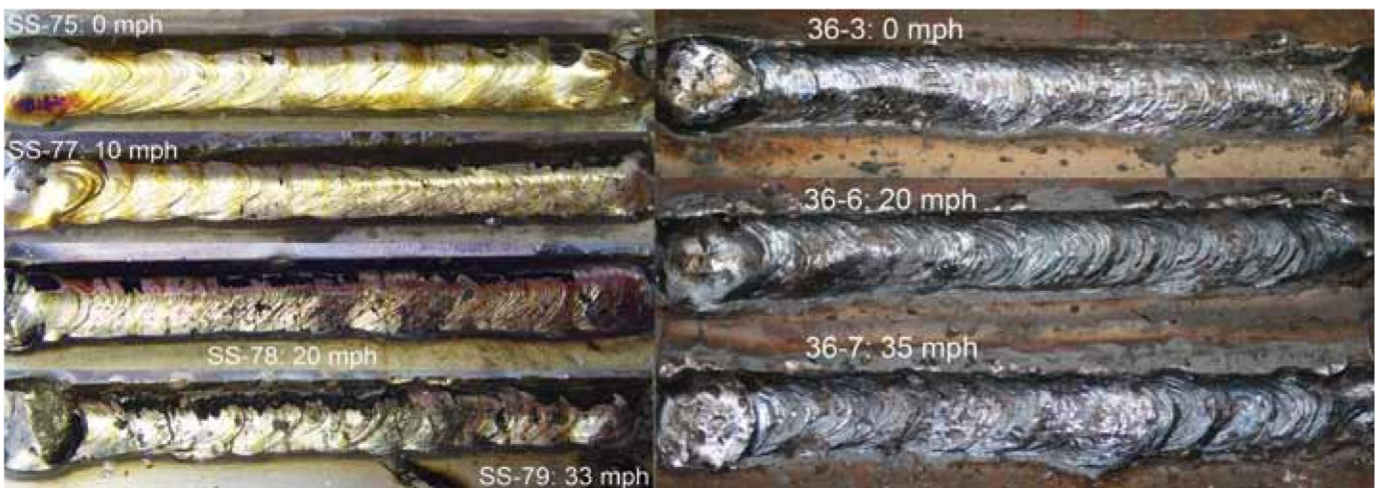


Fig8.1 effect of wind speed on weld profile

- Negative pressure caused by wind blowing over and around plate surfaces provides suction at the root of the joint, trapping slag.
- At higher speeds, the wind may push the slag ahead of the molten weld metal pool, trapping the slag under the advancing weld bead.
- Higher wind speeds decrease the welding arc stability, which influences the uniformity of the molten weld metal pool and results in slag inclusions.

8.2Protecting weld materials from draft

When welding with a gas-shielded welding process, the area in which welding is being done shall be protected from drafts which can cause loss of the gas shield. Wind velocities in excess of 5 mph are high enough for this to happen, resulting in surface oxidation of the weld metal, oxide contamination in the deposit, porosity, and loss of mechanical properties. The use of tent-like enclosures is recommended in unsheltered areas.

9.1Distortion prevention

Distortion could often be prevented at the design stage, for example, by placing the welds about the neutral axis, reducing the amount of welding and depositing the weld metal using a balanced welding technique. In designs where this is not possible, distortion may be reduced or prevented by one of the following methods:

- pre-setting of parts
- pre-bending of parts
- use of restraint

The technique chosen will be influenced by the size and complexity of the component, assembly, the cost of any restraining equipment and the need to limit residual stresses.

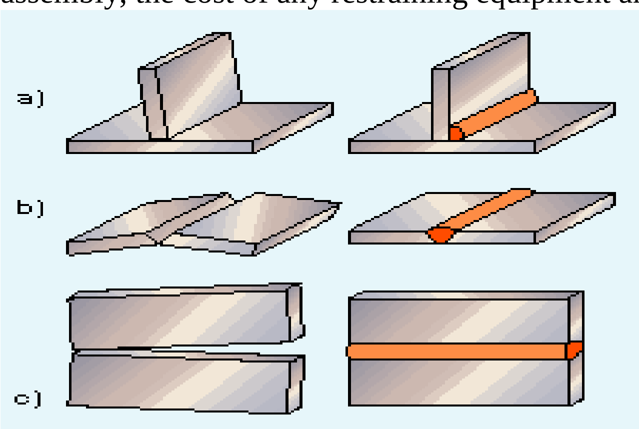


Fig.9.1 Pre-setting of parts to produce correct alignment after welding:

a. Pre-setting of fillet joint to prevent angular distortion;
b. Pre-setting of butt joint to prevent angular distortion;
c. Tapered gap to prevent closure

9.2Pre-setting of parts

The parts are pre-set and left free to move during welding (see *Fig 1*). In practice, the parts are pre-set by a pre-determined amount so that distortion occurring during welding is used to achieve overall alignment and dimensional control.

The main advantages compared with the use of restraint are that there is no expensive equipment needed and there will be lower residual stress in the structure.

Unfortunately, as it is difficult to predict the amount of pre-setting needed to accommodate shrinkage, a number of trial welds will be required. For example, when MMA or MIG welding butt joints, the joint gap will normally close ahead of welding; when submerged arc welding; the joint may open up during welding. When carrying out trial welds, it is also essential that the test structure is reasonably representative of the full size structure in order to generate the level of distortion likely to occur in practice. For these reasons, pre-setting is a technique more suitable for simple components or assemblies.

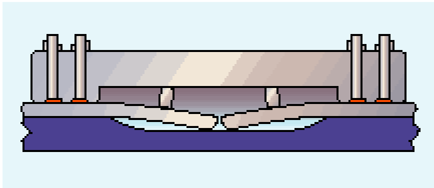


Fig.9.2 Pre-bending, using strong backs and wedges, to accommodate angular distortion in thin plate

9.3Pre-bending of parts

Pre-bending, or pre-springing the parts before welding is a technique used to pre-stress the assembly to counteract shrinkage during welding. As shown in *Fig 2*, pre-bending by means of strong backs and wedges can be used to pre-set a seam before welding to compensate for angular distortion. Releasing the wedges after welding will allow the parts to move back into alignment.

The main photograph shows the diagonal bracings and Centre jack used to pre-bend the fixture, not the component. This counteracts the distortion introduced though out-of-balance welding.

9.4Use of restraint

Because of the difficulty in applying pre-setting and pre-bending, restraint is the more widely practiced technique. The basic principle is that the parts are placed in position, and held under restraint to minimize any movement during welding. When removing the component from the restraining equipment, a relatively small amount of movement will occur due to locked-in stresses. Either applying a small amount of pre-set or stress relieving before removing the restraint can cure this.

When welding assemblies, all the component parts should be held in the correct position until completion of welding and a suitably balanced fabrication sequence used to minimize distortion.

Welding with restraint will generate additional residual stresses in the weld, which may cause cracking. When welding susceptible materials, a suitable welding sequence and the use of preheating will reduce this risk.

Restraint is relatively simple to apply using clamps, jigs and fixtures to hold the parts during welding.

9.5Best practice

Adopting the following assembly techniques will help to control distortion:

- Pre-set parts so that welding distortion will achieve overall alignment and dimensional control with minimum residual stress.
- Pre-bend joint edges to counteract distortion and achieve alignment and dimensional control with minimum residual stress.
- Apply restraint during welding by using jigs and fixtures, flexible clamps, strong backs and tack welding but consider the risk of cracking which can be quite significant, especially for fully welded strong backs.
- Use an approved procedure for welding and removal of welds for restraint techniques, which may need preheat to avoid forming imperfections in the component surface.

Operation Sheet 1	Preparing welding equipment, Materials and consumables

Operation title: **-** set up oxyacetylene welding equipment
Purpose: **-** to prepare oxyacetylene welding equipment
Condition for the operation: **-** welding work shop
Equipment: -

- Oxygen cylinder
- Acetylene cylinder
- Regulators
- Hoses
- Striker

Tools: - screw driver, plier, and spanner
Procedure: -

Before you attempt to light the torch, follow these checks:

Stap1. Make sure regulator pressure adjustment screws are backed out
Stap2. Make sure torch valves are closed!
Stap3. Stand away from front of regulator
Stap4. Separately and slowly open the oxygen and acetylene cylinder valves
Stap5. Adjust regulator p/a screws to tip pressure settings
Stap6. Open/close torch valves separately and fine tune pressure settings on regulators
Stap7. Depress cutting lever and adjust pressure if necessary

Lighting and adjusting the torch (with a positive/equal pressure mixer):

1. Separately purge both oxygen and fuel gas lines
2. Open fuel gas valve 1/2 turn
3. Ignite flame with striker
4. Increase fuel gas flow until flame leaves end of tip and no smoke is present
5. Decrease until flame goes back to tip
6. Open oxygen valve and adjust to neutral flame
7. Depress oxygen lever and make necessary adjustments

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

Stap1. Close oxygen torch valve
Stap2. Close fuel gas torch valve

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

Stap1. Close oxygen and fuel gas cylinder valves
Stap2. Separately purge oxygen and fuel gas lines
Stap3. Make sure all regulator gauges read 0
Stap4. Back out regulator pressure adjustment screws

Precautions: -

- Follow basic safety rules

LAP Test	Practical Demonstration

Name: ______________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Given necessary equipment, tools and materials you are required to perform the following tasks within3hr hour

Task1. Prepare material according to the drawing

Task2. Fix the work piece

Task3. Set up welding machine

Task4. Tack weld

Task5. Finish weld

Task6. Clean the weld

Equipment: -

- SMAW welding machine

Tools: - chip hammer, steel rule, hacksaw, wire brush, scriber, fixing jig
Materials: -20x20x1.5mm square pipe

Instruction Sheet 3	Learning Guide 28: Set-up pre heating tools/ equipment

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

- Understanding appropriate pre-heating equipment
- Operating pre-heating equipment

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 –

- Understand appropriate pre-heating equipment
- Operate pre-heating equipment

Learning Instructions:

15. Read the specific objectives of this Learning Guide.
16. Follow the instructions described in number 3 to 20.
17. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
18. Accomplish the “Self-check 1” in page __.
19. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
20. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1
21. Submit your accomplished Self-check. This will form part of your training portfolio.
22. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
23. Accomplish the “Self-check 2” in page __.
24. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).
25. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
26. Accomplish the “Self-check 3” in page __.

27. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).
28. If you earned a satisfactory evaluation proceed to "Operation Sheet 1" in page _. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to for each Learning Act

Information Sheet-1	Understanding appropriate pre-heating equipment

1.1Introduction

A crucial step in many welding applications, preheating slows the rate of cooling in a finished weld, lowers the amount of hydrogen in it, and reduces the risk of cracking. Artificially introducing heat into the base metal — by means of an external heat source — adds a step to the welding process; however, it can save you time and money in the long term by reducing the potential for a failed weld that requires rework.

You have numerous methods for preheating the base material. Each has benefits and drawbacks. The best choice for a specific application depends on several factors, including any code requirements that may apply. Consider these tips and best practices that contribute to proper preheating and a high-quality weld.

1.2 Why Is Preheating Important?

Preheating minimizes the temperature difference between the welding arc and the base material. This benefits the weldment in several ways.

- It helps to lessen shrinkage stresses that can lead to cracking and distortion. Because hot materials expand and cool ones contract, a large temperature variance between the molten weld pool and the relatively cool base material can result in internal stresses as the weldment tries to normalize those temperature differences. These internal stresses increase the risk of cracking and distortion.
- Proper preheating helps to slow the cooling rate of the finished weld and reduce hardness in the heat-affected zone (HAZ), which creates a weld that is less brittle and more ductile. These characteristics are especially important for materials more susceptible to hardness at elevated temperatures, such as cast iron, medium- and high-carbon steel, or high- carbon-equivalency steel. Slowing the cooling rate also allows hydrogen to escape the weld puddle as it hardens to help minimize cracking.
- Preheating introduces the necessary heat into the weld area to ensure proper penetration. This benefits thick materials and those that conduct heat quickly. By preheating, you can use less heat in the welding arc and still achieve optimal penetration, because the base material starts out at an elevated temperature.

1.3 When Should You Preheat?

Preheating is especially important when welding:

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

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

2.1 Operating pre-heating equipment

Preheating is an important preparatory operation welding jobs. As the name implies, it is the process of raising the temperature of a part before welding it. This preheat temperature has to be maintained throughout the welding procedure. In some cases, it might be necessary to continue heating the part during welding, but sometimes the heat input from the welding itself maintains that temperature. The inter pass temperature, which is the base metal temperature maintained between the first and last welding passes, should not fall below the preheat temperature.

Preheat is recommended for certain jobs for several reasons. Among these is that it helps stave off moisture from the base metal and weld, which in turn makes the completed part less susceptible to hydrogen cracking. It also reduces shrinking stresses in both the base metal and the weld joint. Preheating helps ensure that the weld has the mechanical properties it was designed to achieve.

Essentially three methods commonly are used to preheat joints: propane (gas) torch, induction heating, and electrical resistance heating.

2.2 Torch Heating

“Torch heating is certainly the most portable of the three methods,” said Scott Fong, owner and general manager of KASI Technologies Inc., an Edmonton company that specializes in renting industrial heating, welding, and bolting equipment. “Basically, torch heating is like using a big barbecue lighter. It’s just a torch and you simply monitor its temperature with temperature-indicating sticks. Once you see the sticks melt, you know you’ve reached the minimum preheat temperature and you start welding.”

While Fong appreciates the portability and affordability of this method, he also notes that it is, by its very nature, not as accurate as the other technologies available.

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

2.3 **Induction Heating**

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

"The equipment used for induction is considerably more expensive than that used for electrical resistance heating," said Fong. "However it does get your steel hotter quicker. It still offers you much more control than what you achieve with a torch."

The induction method of preheating can use either a liquid-cooled braided hose or an air-cooled premade blanket wrapped around the material to be heated to create a magnetic field. The magnetic field excites the molecules in the material, which creates heat that radiates from the center of the material outward in all directions.

With an induction heating system, you attach a thermocouple to the weld. The thermocouple senses the temperature of the steel and sends a signal back to the controller on the induction machine. Once the steel reaches the preheat temperature, it will maintain that temperature until the controller is adjusted.

"It is very quick," said Fong. "It has its ideal applications. For instance, when a shop is heating very thick sections of pipe and rotating them, this can be a good solution. Its limitation is that an induction machine can be used to heat just one weld joint at a time, and it has only a single point of control."

2.4 **Electrical Resistance Heating**

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

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

"It allows you more control, in the sense that you can add more controlling thermocouples," said Fong. "For materials like P91 alloy steel, where you need to tightly monitor your maximum inter pass temperature and your preheat temperature, the electrical resistance method gives you more control over that. P91 is becoming widely used in power plants and other high-temperature applications. So in circumstances where you are using this type of material, using electrical resistance allows you to control each 120 sq. in. of steel. It is also your most effective method of controlling maximum inter pass."

Fong also noted that the equipment is simpler and more durable for field applications.

"It is a little slower with respect to actually setup, but when you are welding thick sections, that speed isn't as big a concern because you can prepare for more welds at once," he explained.

"Preheat time could also be a half hour compared to five minutes. That depends on the power available and the setups, so it is harder to quantify."

Ovens

- **How it works:** Ovens used for welding preheat use convection heating. The entire part is placed inside the oven for preheating.
- **Pros:** Uniform heating is possible since the entire part is inside the oven. It is also a good option when an entire large part must be heated, or when the operation needs to do batch heating of many parts at once.
- **Cons:** Ovens can be quite large and require connection to an electrical outlet. They are often permanently installed in one location and do not offer mobility. As a result, parts must be brought to the oven for preheating, which can be difficult when very large parts are involved. These systems also typically require a substantial electrical connection and system, which adds expense. In addition, the oven may have to be preheated for several hours before it is used, and it can put out enough heat to warm up the area around the oven, negatively affecting worker comfort. Outsourcing oven preheating causes a loss of control over the schedule and timeline

2.5 Considerations for Preheating

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

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

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

Preheat measuring often is done with Tempilstik®s, infrared thermometers, or other heat-measuring devices. Generally, the preheat temperature should be measured at least 3 inches from the joint. The preheat temperature should be verified directly before welding begins.

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

Self-Check -2	Written Test

Direction I: choose the correct answer to the following questions. Use the Answer sheet provided in the next page:

1. Post weld heat treatment of a carbon steel weldment will not result in
   a. improvement of ductility
   b. reduction of hardness
   c. minimizing distortion
   d. reduction of residual stresses
2. The welding heat input during shielded metal arc welding does not depend on
   a. extent of weaving of the electrode
   b. employing a low welding speed
   c. employing a low current level
   d. preheating the job
3. Select the false statement on carbon steels
   a. After post weld heat treatment, the ductility of the material will increase
   b. The peak temperature for post weld heat treatment of low alloy steel is generally higher than that for carbon steel
   c. The heating and cooling rates do not influence the effectiveness of post weld heat treatment
   d. The soaking time is given for equalization of temperature across the thickness
4. After post weld heat treatment of shielded metal arc welded component,
   a. Both hardness of the weld metal and ductility increase
   b. Both hardness and ductility of the weld metal decrease
   c. Hardness of the weld metal increases while the ductility decreases
   d. Hardness of the weld metal decreases while the ductility increases
5.

Answer Sheet-1

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Answer

1. .
2. .
3. .
4. .
5. ,

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

- Performing tack welding
- Inspecting tack weld
- Tacking root
- Installing backing plate, stiffener and running plate
- Making joints free from rust, paints, grease and other foreign materials prior to fit up or tacking.

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 tack welding
- Inspect tack weld
- Tack root
- Install backing plate, stiffener and running plate
- Make joints free from rust, paints, grease and other foreign materials prior to fit up or tacking.

Learning Instructions:

29. Read the specific objectives of this Learning Guide.
30. Follow the instructions described in number 3 to 20.
31. Read the information written in the "Information Sheets 1". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
32. Accomplish the "Self-check 1" in page __.
33. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
34. If you earned a satisfactory evaluation proceed to "Information Sheet 2". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1
35. Submit your accomplished Self-check. This will form part of your training portfolio.
36. Read the information written in the "Information Sheet 2". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
37. Accomplish the "Self-check 2" in page __.
38. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).

39. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.

40. Accomplish the “Self-check 3” in page __.

41. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).

42. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to for each Learning Act

Information Sheet-1	Performing tack welding

1.1 How to perform tack welding successfully

After items to be welded together have been positioned as required, generally by clamping them on suitable fixtures, tack welds are used as a *temporary* means to hold the components in the proper location, alignment, and distance apart, until final welding can be completed.
In short-production-run manual welding operations, tack welding can be used to set up the work pieces without using fixtures. Typically, tack welds are short welds. In any construction, several tack welds are made at some distance from each other to hold edges together.
An advantage of this *provisional* assembly procedure is that if the alignment for final welding is found to be incorrect, the parts can be disassembled easily, realigned, and tack welded again.

In general, the same process that is used for the final weld performs tack welding. For example, aluminum-alloy assemblies to be joined by friction stir welding are tack-welded by the same process using a small tool developed for this purpose. On the other hand, electron beam tack welds, created with reduced power, are used to supplement or replace fixturing and to maintain the correct shape and dimensions during final electron beam welding.

If the final welding is performed while the elements are still clamped in a fixture, tack welding must keep the elements in place and resist considerable stresses, not sufficiently contrasted by clamping devices that tend to separate the components

1.2 Why Are Tack -Welds Important?

The temporary nature of tack welds may give the false impression that the quality of these auxiliary joining aids is not as important as that of final weld and that this operation does not have to be properly programmed, performed, and inspected. This is not true.

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

1.3 Defective Tack Welding Risks

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

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

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

Hard, brittle, and crack-sensitive microstructures can be formed in the heat-affected zone (HAZ) if the metal is rapidly quenched. In this case, even removing the whole tack weld by grinding may leave dangerous, invisible cracks in the base metal.

The brittle metal can crack during solidification of the weld metal or when stressed. Under bead, cracks cannot be readily detected by visual inspection, and more thorough nondestructive tests may not be performed if they are deemed unimportant for such limited welds. However, these small cracks can cause the whole structure to fail.

1.4 Controlling Tack Weld Quality

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

The requirements are applicable for any welding process used.

1.5 Distortion Control Procedures

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

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

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

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

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

1.6 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.

1.7 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.

2.1 Inspection of the Pipe In The 6G Fixed Position

Once the pipes tacked up,

- Put them in the arm that holds the pipe in place.
- Took a level and set the pipe at 45 degrees.
- Set the height of the pipe to where you want to weld. It is preferable to weld the bottom half of the pipe that gives you a more stability then standing.
- Once everything is in place tighten the arm

Checking the 6G pipe test to make sure it is at a 45 degrees with a magnetic level. set the height to what was the best position .

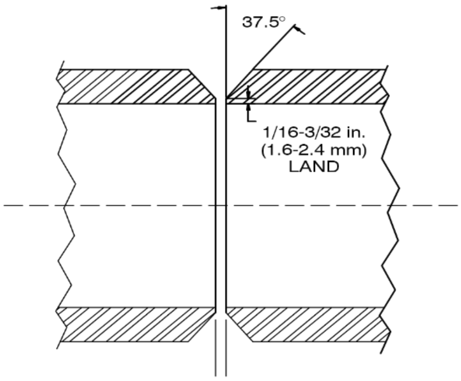
Fig 1.1 Checking the 6G pipe test to make sure it is at a 45 degrees with a magnetic level

Sheet Information -3	Tacking root

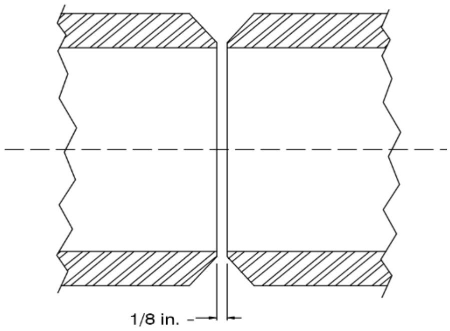
3.1 Tacking the root

Tack the pipe with the RMD process, making tacks (in this order) at the 12-, 6-, 3-, and 9-o'clock positions. Remove the filler metal spacer after making the first tack, then check the gap with a tool designed for that purpose. Tacks on smaller diameter pipe can be 1/4- to 1/2-in. long. Tack on larger pipe may be 1 in. or longer. Note that tack welds will shrink during cooling, causing the gap to close up. In areas with less than a 1/8-in. gap, grind the joint using a 3/32-in. cutting wheel to open the root. Finish preparing the pass by grinding each tack weld to a featheredge to ensure that the root pass consumes the tack weld.

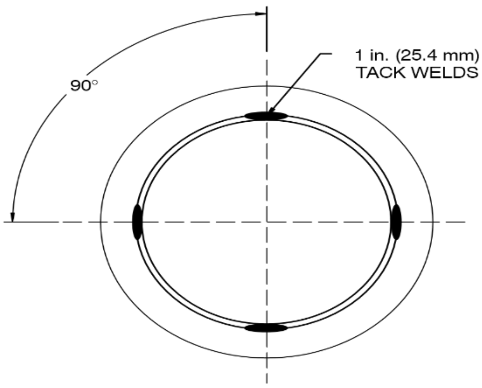
1. Bevel pipe end to 37.5° (standard pipe bevel)leaving a 1/16 to 3/32 in. (1.6 to 2.4 mm) land.



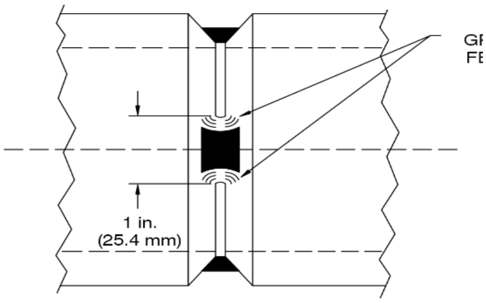
2. Align pipe ends together leaving a minimum of1/8 (3.2 mm) gap.



3. Tack pipe ends together in four locations approximately 90° apart and 1 in. (25.4 mm) long on pipe that is 6 in. (152.4 mm) or larger diameter. Use appropriate sized tack welds on smaller pipe.



4. Grind each end of the tack weld to a feather ed edge).



Self-Check -1	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1.
2.
3.
4.
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Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

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Information Sheet-4	Making joints free from rust, paints, grease and other foreign materials prior to fit up or tacking

4.1 Cleaning joints prior to fit up tackling

Initial cleaning shall be performed using the methods described in the Welding Procedure Specification. Surfaces to be welded shall be free of grease, oil, paint, rust mill scale and cutting oxides for at least 1/2 inch along the pipe from the end preparation bevel.
The surfaces to be welded and the inside and outside surfaces of the base metal shall be cleared of all contamination for one inch back from the bevel before the pipe is aligned and tack welded. Special cleaning methods shall be used when specified in the Welding Procedure Specification.
Remove grease, oil and cutting fluid using appropriate solvents. After removing grease, oil or cutting fluid residue, remove paint, varnish, rust, dirt or oxide using a wire brush or grinding wheel. Paint, which is designed to be welded over, such as “Deoxaluminite”, may be welded over without removal. Brushing with a power wire brush to remove excess build-up (i.e., runs) of weld able coatings is recommended.
When wire-brushing stainless steel, use only austenitic stainless steel wire brushes. Brushes for use on stainless steel or other corrosion-resistant metals should be segregated and not be used on carbon or low alloy steel. These ordinary steel will contaminate the brush and result in surface rusting of the corrosion-resistant metal if the brush is used on corrosion-resistant metals.
Interpass cleaning shall be done using the methods described in the Welding Procedure Specification. All slag, silica deposits and other residual deposits from the welding process on the surface of the weld and the surrounding base metal shall be removed. The weld surface is inspected and ground as necessary. After each pass to be sure that the contour of the weld is sound and that the geometry is suitable for depositing the next layer of weld metal.
The completed weld shall be cleaned using the method described in the Welding Procedure Specification for interpass cleaning.

Self-Check -4	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1.
2.
3.
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Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

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

- Performing root gap
- performing an alignment
- Inspecting fitted materials

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 –

- Performing root gap
- perform an alignment
- Inspect fitted materials

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 20.
3. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the “Self-check 1” in page __.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1
7. Submit your accomplished Self-check. This will form part of your training portfolio.
8. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
9. Accomplish the “Self-check 2” in page __.
10. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).
11. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
12. Accomplish the “Self-check 3” in page __.
13. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).

14. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to for each Learning Activities.

1.1 **Performing root gap**

Proper part fit-up ensures that the joint is set uniformly from start to end, resulting in weld consistency throughout the part. It helps prevent problems with lack of penetration or too much penetration, issues that can decrease the service life of the finished weld.

Part fit-up involves several key steps, including matching the inside diameter (ID) of the two pieces of pipe to be welded and making sure you have a proper gap between the pipes for the root pass.

To match the pipes' IDs, first take measurements to ensure everything will line up properly, then do some dry runs before actually attaching the pipe with tack welds to establish the gap. The IDs should be as close as possible to perfectly aligned. If the IDs are not aligned, use a grinder on the inside of the pipe to match up the diameters. Mismatched IDs are more common with large-diameter pipes.

A welder inspects the consistency of the inside diameter, ensuring the IDs are consistent between the two pipes. Mismatched pipe IDs can cause various welding defects.

Establishing the gap, or root opening, comes next. The welding process being used and the qualified weld procedures determine what type of land the root face needs. Some welds, especially for gas tungsten arc welding (GTAW) and gas metal arc welding (GMAW), may require a 371/2-degree bevel with a knife edge or a 1/16-in. land for easier fusion of the root pass. Shielded metal arc welding (stick, or SMAW), which has a stiffer arc (that is, more forceful and penetrating), often requires a heavier land. The land on the root face can range from a knife edge up to 1/8 in. in some applications.

Qualified procedures should specify the proper width of the root gap, which depends on the welding process, joint geometry, and material type and thickness. The gap may be as tight as 1/16 in. or up to 5/32 in. SMAW typically requires a tighter gap, while GMAW is more forgiving and allows a larger gap. The root gap should be large enough to allow the molten weld pool to fill it, but small enough so that the weld puddle doesn't fall through.

The root gap should be uniform from beginning to end. Inconsistent gaps will affect quality and consistency throughout the entire weld. To measure and ensure proper gap fit-up, use a gap rod or a piece of filler rod that matches your desired gap size.

Once you establish a consistent gap, tack the pipes together for welding. On a large pipe, tack welds may be 1 in. long or even longer; on a small pipe, they may be between ¼ and ½ in. long. The number of tacks needed depends on the pipe diameter. Small pipes often can be welded with three tacks, while larger pipes may require four or more. The more tacks used on larger-diameter pipes, the less likely it is the gaps will shrink as they cool after welding, causing the joint to close up. No matter how many tacks are used, be sure they are evenly spaced.

Also make sure the tacks are clean on the inside. Whether tacks are cut out during welding is a matter of operator preference. They can be left in and feathered into the weld. In this case, grind each tack to a feathered edge (that is, with a smooth connection between the tack weld bead and the joint wall) before performing your root pass weld. This will ensure that you consume the tacks when completing the root pass. After welding, take care to inspect the tacks to ensure there are no defects or inclusions.

1.2 Common Mistakes

Spending time and money on rework caused by weld failure or poor aesthetics is the consequence of sloppy weld preparation. To get the best results, avoid these common mistakes:

- Rushing part fit-up can result in part misalignment. It's common to see a bevel with a too steep angle, which results in poor base metal penetration.
- Establishing too much land when pipe SMAW can make it difficult to get proper penetration in the root pass. In general, don't exceed a 1/8-in. land when stick welding.
- Closing the root gap too much is a common mistake when welding large pieces of pipe, such as those 24 to 30 in. in diameter. In laying down the root pass, if you close in on the root too much, the gap will start to shrink. In applications that start off with a tight gap, closing the gap too much may require cutting it open again to complete the root pass. This is non-value-added time that requires extra labor, wastes consumables, and increases costs.
- Not properly cleaning off lubricating oil, dirt, paint, or lacquer from the base material can result in hydrogen inclusions and cracking. Improper cleaning practices can also cause porosity. Using a grinder or buffing wheel is the fastest way to properly clean the weld area. Make sure to clean the joint itself and the entire area 1 to 2 in. back from the joint to prevent foreign materials from creeping into the weld.
- Not following the weld preparation requirements set out in the welding procedure specification (WPS) may seem like a time-saving opportunity, but it can lead to significant time and money spent later in rework and failed welds. Before starting the process, get familiar with the WPS for the application. It typically specifies the proper bevel angle, land size, root gap, and other factors.

Information Sheet-2	Performing an alignment

2.1 Performing an alignment

You must carefully prepare pipe joints for welding if you want good results. Clean the weld edges or surfaces of all loose scale, slag, rust, paint, oil, and other foreign matter. Ensure that the joint surfaces are smooth and uniform. Remove the slag from flame-cut edges; however, it is not necessary to remove the temper color.

When you prepare joints for welding, remember that bevels must be cut accurately. Bevels can be made by machining, grinding, or using a gas-cutting torch. In fieldwork, the welding operator usually must make the bevel cuts with a gas torch. When you are beveling, cut away as little metal as possible to allow for complete fusion and penetration. Proper beveling reduces the amount of filler metal required which, in turn, reduces time and expense. In addition, it also means less strain in the weld and a better job of design and welding.

Align the piping before welding and maintain it in alignment during the welding operation. The maximum alignment tolerance is 20 percent of the pipe thickness. To ensure proper initial alignment, you should use clamps or jigs as holding devices. Apiece of angle iron makes a good jig for a small-diameter pipe (fig. 5.1), while a section of channel or I-beam is more suitable for larger diameter pipe.

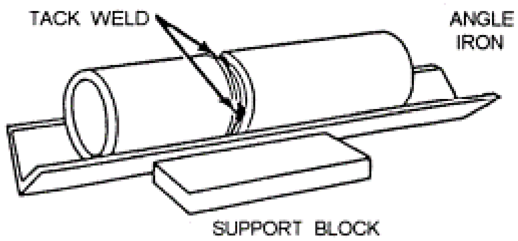

Figure 2.1.—Angle iron jig.

Components to be welded shall be aligned and spaced as per the requirements laid down in applicable code. Special care must be taken to ensure proper fitting and alignment when the welding is performed by GT AW process. Flame heating for adjustment and correction of ends is not permitted unless specifically approved by the Engineer-in-Charge.

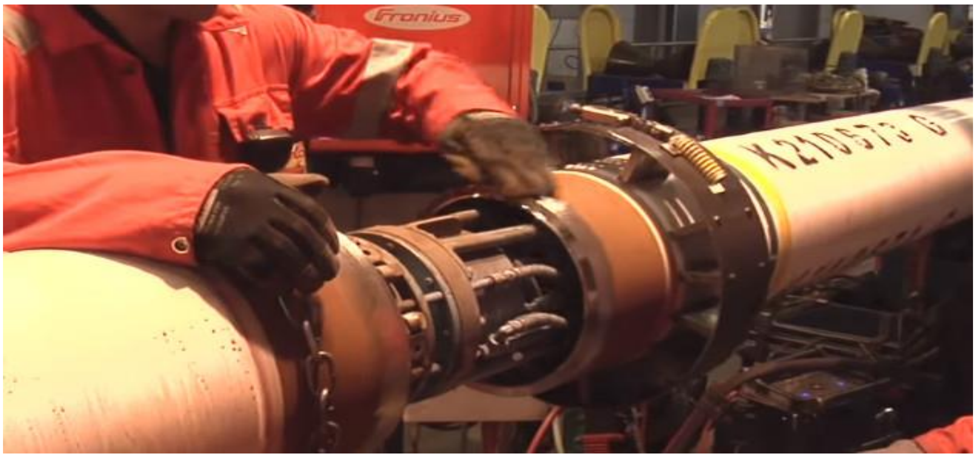

Fig.2.2 Internal Clamps for Pipe Alignment

A wire spacer of suitable diameter may be used for maintaining the weld root opening while tacking, but it must be removed after tack welding and before laying the root bead.

For pipes of wall thickness 5 mm and above, the ends to be welded shall be secured in position with the aid of couplers, yokes and ‘C’ clamps, to maintain perfect alignment. Yokes shall be detached after the completion of weld, without causing any surface irregularity. Any irregularity caused on the pipe surface must be suitably repaired to the satisfaction of the Engineer-in-Charge.

Fig.2.3 Internal Flange Alignment Tool

2.2 **Tack Welding**

Tack welds, for maintaining the alignment, of pipe joints shall be made only by qualified welders using approved Welding Procedure Specification. Since the tack welds become part of the final weldment they shall be executed carefully and shall be free from defects. Defective tack welds must be removed prior to the actual welding of the joints.

1. **3 tacks – for 2 1/2″ and smaller dia. pipes.**
2. **4 tacks – for 3″ to 12″ dia. pipes.**
3. **6 tacks – for 14″ and larger dia. Pipes**

Self-Check -5	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. What is the importance of proper part fit up?
2. What is the result of rushing part fit up?
3. What are the common mistakes in part fit up?
4. What are the benefits of proper beveling?
5. How can you prepare bevel?

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

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

- Understanding welding symbols
- Understanding pipe welding position
- Performing root pass
- Cleaning root pass
- Performing subsequent filling passes
- Performing capping
- Ensuring weld deposit
- Welding materials using SMAW and Oxyacetylene process
- Cleaning and freeing joints from discontinuities.
- Cleaning welds
- Making welded parts free from weld defects or porosity

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 –

- Understand welding symbols
- Understand pipe welding position
- Perform root pass
- Clean root pass
- Perform subsequent filling passes
- Perform capping
- Ensure weld deposit
- Weld materials using SMAW and Oxyacetylene process
- Clean and freeing joints from discontinuities.
- Clean welds
- Make welded parts free from weld defects or porosity

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
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7. Submit your accomplished Self-check. This will form part of your training portfolio.
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11. Read the information written in the "Information Sheets 3 and 4". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
12. Accomplish the "Self-check 3" in page __.
13. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).
14. If you earned a satisfactory evaluation proceed to "Operation Sheet 1" in page _. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to for each Learning Act

Information Sheet-1	Understanding pipe welding position

1.1 Introduction

Weld symbols have been used for many years and are a simple way of communicating design office details to a number of different industrial shop floor personnel such as welders, supervisors, and inspectors. Subcontractors are often required to interpret weld symbols on engineering drawings, from perhaps the main contractor or client to determine the type of weld needed. It is essential that everyone should have a full understanding of weld symbol requirements to ensure that the initial design requirement is met.

There are a number of standards, which relate to weld symbols, including British, European, International and American (American Welding Society) standards. Most of the details are often similar or, indeed, the same, but it is essential that everyone concerned knows the standard to be used. One of the first requirements therefore is:

1.2 Which Standard?

The UK has traditionally used BS 499 Part 2. BS EN 22553, however, in many welding and fabrication organizations there will be old drawings used that make reference to out of date standards such as BS 499 Pt 2 has now superseded this standard.

BS EN 22553 is almost identical to the original ISO 2553 standard on which it was based. Therefore, we can say, for at least this article's scope, there are no significant differences, but it is essential that the reader consult the specific standard. The American system is also similar in many respects but will not be covered here.

1.3 Basic Requirements

All the standards have the same requirements in relation to the following items:

- Arrow line and arrow head
- Reference line

The arrow line can be at any angle (except 180 degrees) and can point up or down. The arrow head must touch the surfaces of the components to be joined and the location of the weld. Any intended edge preparation (i.e. for a groove weld) or weldment is not shown as an actual cross- sectional representation, but is replaced by a line. The arrow also points to the component to be prepared with single prepared components.

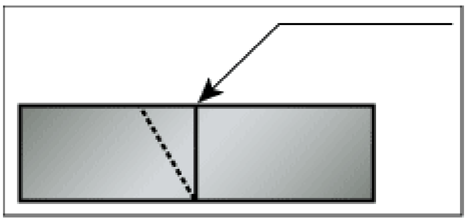

Fig. 1.1

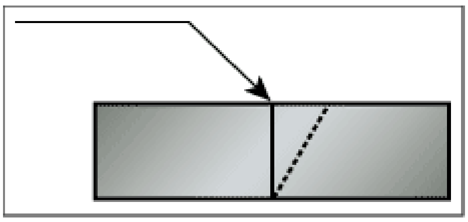

Fig. 1.2

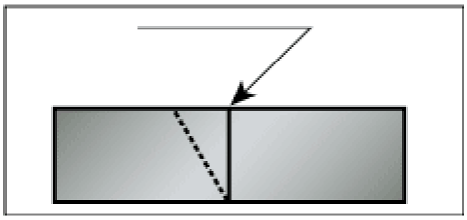

Fig.1.3

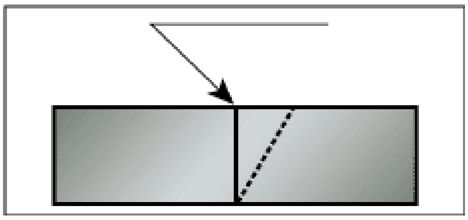

Fig. 4.

Symbol types

To the basic set-up of the arrow and reference line, the design draughts person can apply the appropriate symbol, or symbols for more complex situations.

The symbols, in particular for arc and gas welding, are often shown as cross-sectional representations of either a joint design or a completed weld. Simple, single edge preparations are shown in *Fig. 5*.

For resistance welding, a spot weld and seam weld are shown in *Fig. 6:*

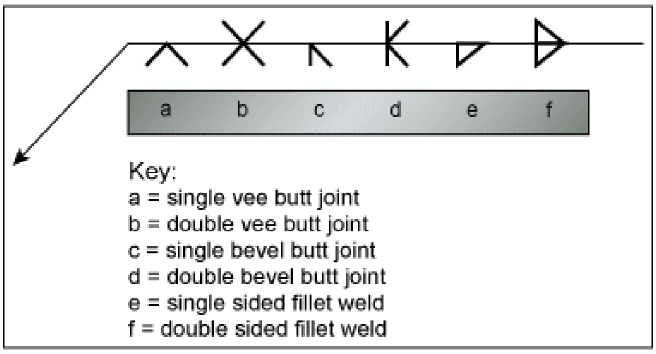

Fig. 1.5

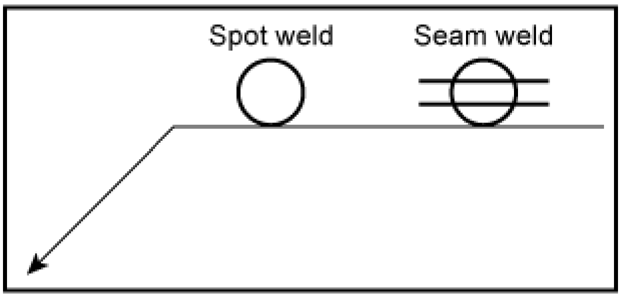

Fig.1.6

1.4 Joint and/or weld shape

The above examples can be interpreted as either the joint details alone or the completed weld, however, for a finished weld it is normal to find that an appropriate weld shape is specified. Using the examples above, there are a number of options and methods to specify an appropriate weld shape or finish.

Butt welded configurations would normally be shown as a convex profile (Fig.7 'a', 'd' and 'f') or as a dressed-off weld as shown in 'b' and 'c'. Fillet weld symbols are always shown as a 'mitre' fillet weld (a right-angled triangle) and a convex or concave profile can be superimposed over the original symbol's mitre shape. See *Fig. 7*.

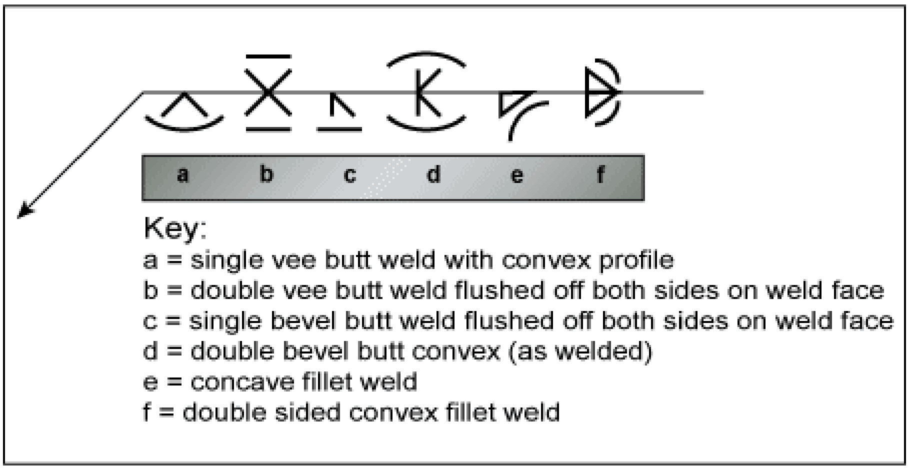

Fig. 1.7

As previously mentioned, it is essential that all concerned in any project are aware of which standard is being applied.

1.5 Weld sizing

In order that the correct size of weld can be applied, it is common to find numbers to either the left or to the right of the symbol.

For fillet welds, numbers to the left of the symbol indicate the design throat thickness, leg length (leg size), or both design throat thickness and leg length requirements. Generally, but not in all cases, fillet welds are of equal legs. *Figure 8* gives examples of symbols used in different standards.

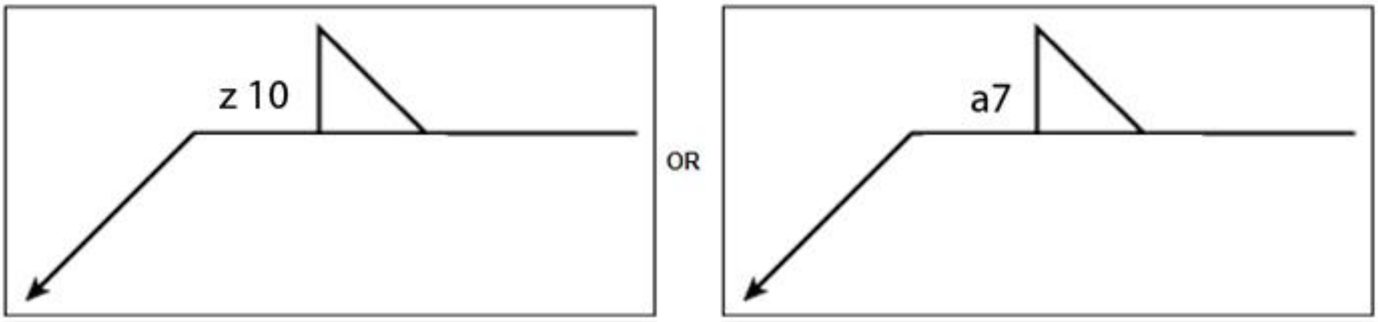

Fig.1.8

For fillet welds:

Superseded BS499 Pt 2 gives

a = design throat thickness
b = leg length

ISO 2553/EN 22553 requirements

a = design throat thickness
z = leg length
s = penetration throat thickness

For butt joints and welds, an S with a number to the left of a symbol refers to the depth of penetration as shown in *Fig.9*.

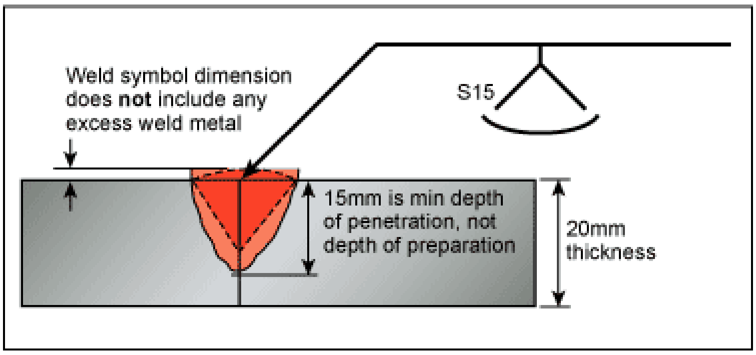

Fig.1.9

When there are no specific dimensional requirements specified for butt welds on a drawing using weld symbols, it would normally be assumed that the requirement is for a full penetration butt weld (*Fig.10*).

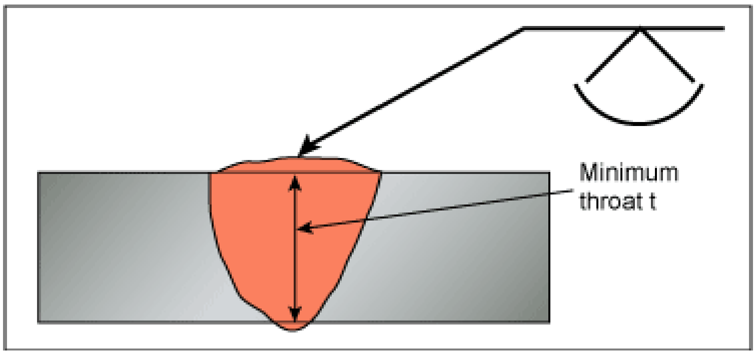

Fig.1.10

Numbers to the right of a symbol or symbols relate to the longitudinal dimension of welds, *eg* for fillets, the number of welds, weld length and weld spacing for non-continuous welds (e.g. intermittent fillet welds), as *Fig.11*.

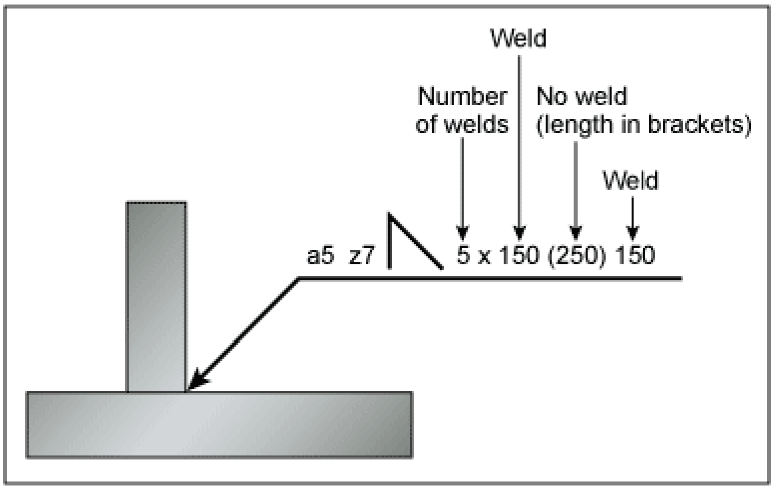

Fig.1.11

On fillet welded joints made from both sides, a staggered weld can be shown by placing a 'Z' through the reference line (*Fig.12*).

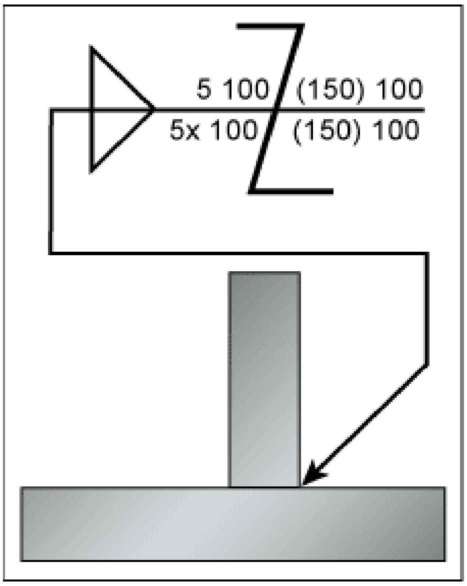

Fig.1.12

1.6 Supplementary Symbols

Weld symbols indicate the type of preparation to use or the weld type. However, there may still be occasions where other information is required. The basic information can therefore be added to in order to provide further details as shown in *Figs.13, 14 and 15*. The tail of the weld symbol is the place for supplementary information on the weld.

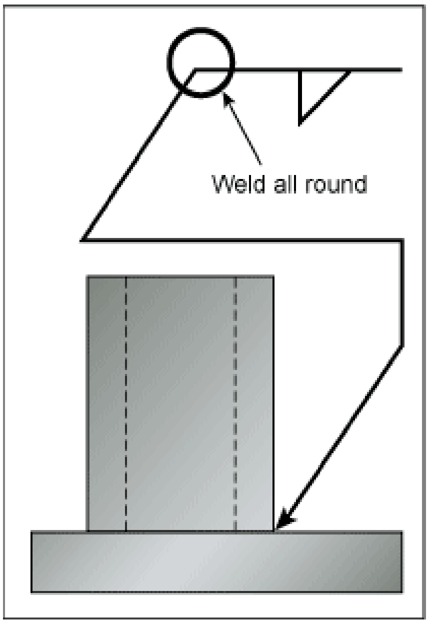

Fig.1.13

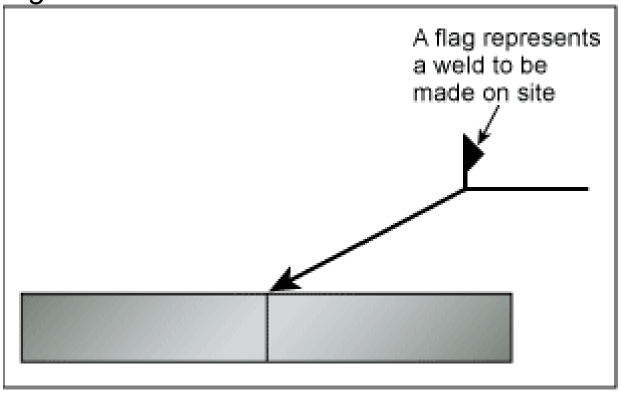

Fig.1.14

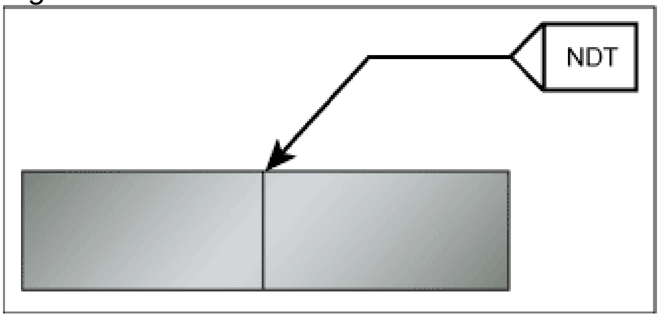

Fig.1.15

Weld all Round

For a rectangular hollow section (RHS) welded to a plate, for example:

Weld in the Field or on Site

The box attached to the arrow can be used to contain, or point to, other information.

Welding Process Type

ISO 4063 gives welding processes specific reference numbers. As shown in *Fig.16* the appropriate process number is placed in the tail of the arrow. Other processes are given a unique number

Fig.1.16

There are a number of additional symbols given in the standards (*eg* ISO 22553) which refer to additional welding or joint requirements. *Figure 17* shows the requirement for a sealing run.

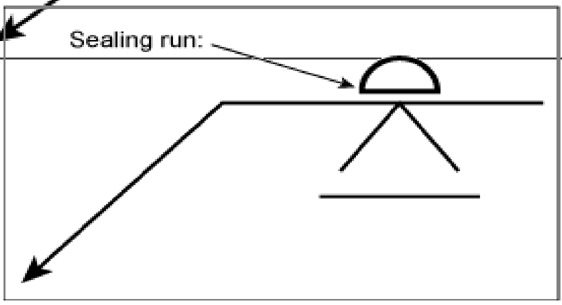

Fig.1.17

1.7 Compound Joints/Welds

A compound weld could be a 'T' butt weld which requires fillet welds to be added to increase the throat thickness as shown in *Fig.18*.

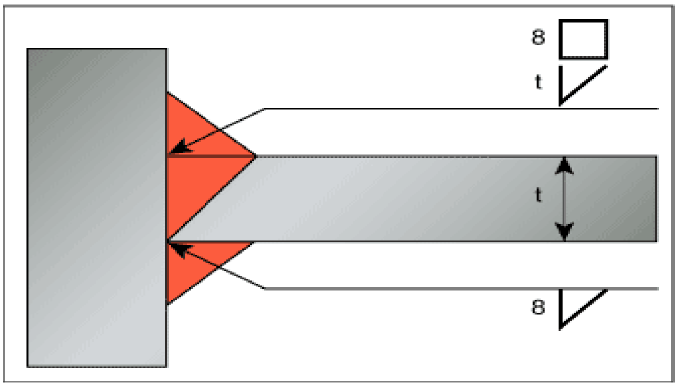

Fig1..18

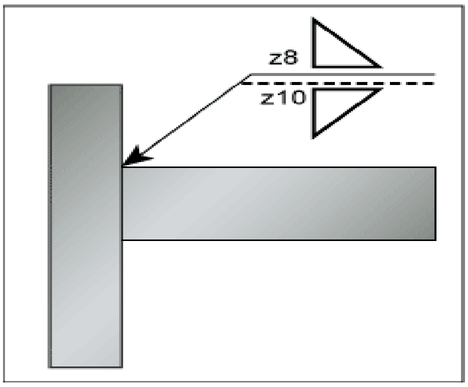

Fig.1.19

1.8 The Broken Reference Line

The main feature that distinguishes weld symbol standards is that for ISO 2553 and BS EN 22553, there is an additional feature of a broken reference line.

This method is used when a weldment or weld preparation needs to be specified on the 'other side' of the arrow as shown in *Fig.19*.

Any symbol that is used to show a joint or weld type feature on the other side of the arrow line is always placed on a dotted line.

BS 499 and AWS require symbols to be placed above the reference line (which indicate the other side) or below the reference line (indicating the arrow side of the joint).

Self-Check -5	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. Using a sketch show the types of weld symbol
2. Describe arrow line and arrow head in weld symbol

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = ___________
Rating: ____________

Name: ___________________________ Date: ________________

Short Answer Questions

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3.1 Pipe Welding Positions

Your welding position can be determined by the position of your pipe. There are fixed and rotating pipes that are fixed or inclined, horizontal or vertical.

1G Rolled

To weld in the 1G rolled position, start your arc in the center of your tack. Your gun should be perpendicular to your pipe with a 5 to 10 degree drag angle. Your stick out should not exceed 5/8 inch.

Your weld position should be in the center of the puddle as your pipe rolls away from you. Drag your welder. You do not want to weave for this position unless your gap is larger than 3/16 inch and requires a sidewall bridge.

The **2G** position is fixed, which means that the pipe cannot be turned as you weld. In this case, the pipe is placed on its base, which makes it much sturdier and more stable to weld.

5G Fixed

The **5G** position is similar to 1G in that the pipe is placed horizontally, except that it is fixed and cannot move. This will require you weld in a variety of different positions, including overhead. Vertical up and vertical down directions

For this position, you are going to start welding the arc in the center of a tack weld with a 5 to 10 degree drag angle and the same stick out length. This time, you want to move your electrode back and forth across the gap with a half-moon position, where the moon faces down.

Gravity will begin pushing the puddle down the joint. Once this happens, stop weaving and direct the electrode back to the center of your weld puddle. Use a slight side-to-side position at the bottom. End your bead on the feathered tack weld. Otherwise, you will end up with a pinhole at the end of your weld.

Make sure that you grind out the end of your weld before you resume. Once you complete the root pass, you will also need to grind out your starts and stops before making fill passes.

The **6G** position is the most challenging because it involves the pipe being fixed at a 45º angle. This requires welding in all positions and incorporates the ‘good’ and ‘bad’ sides.

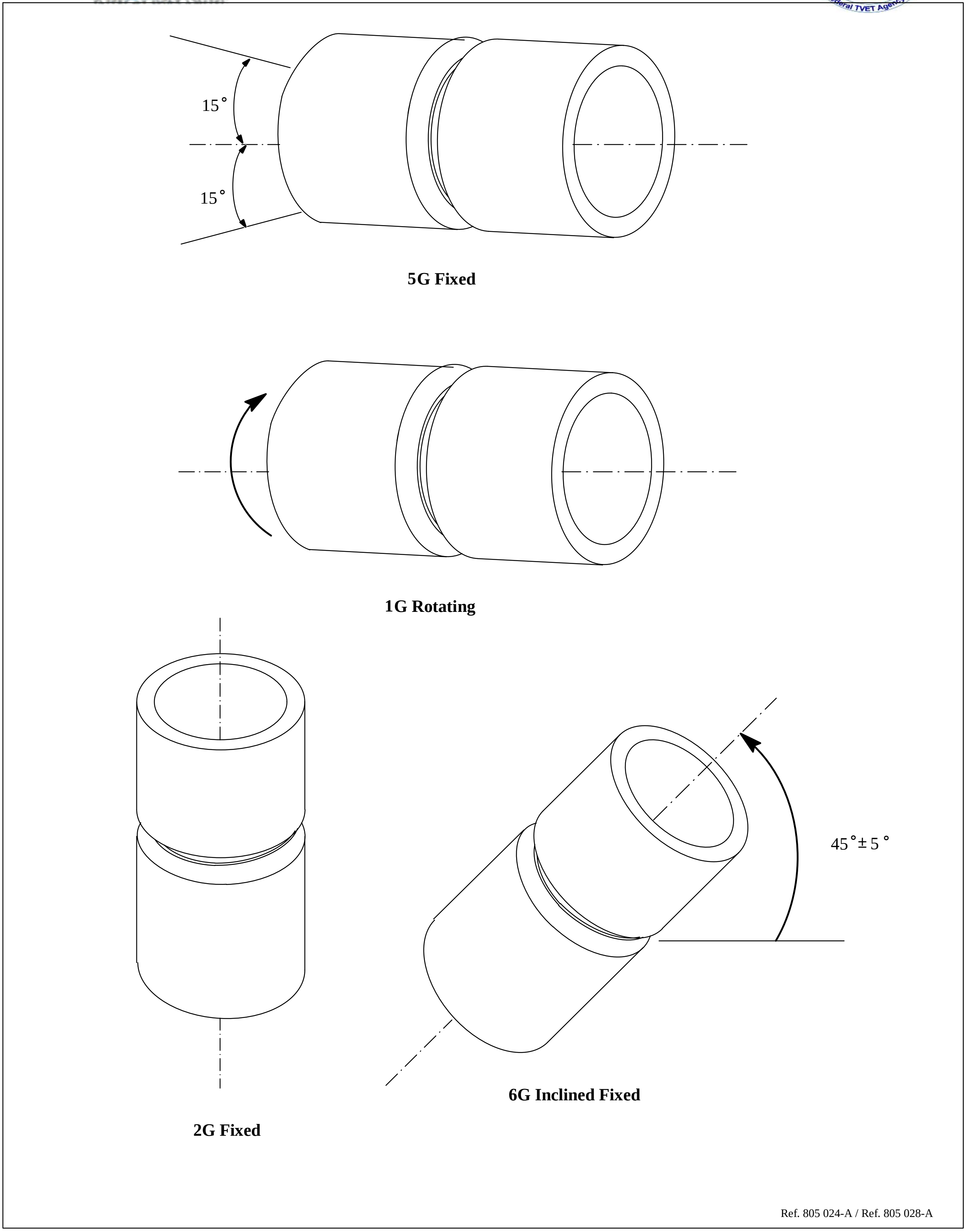

Figure 2.1. Pipe Positions

Self-Check -1	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1.
2.
3.
4.
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Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

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Information Sheet-3	Performing root pass

3.1 Performing root pass

Set welding amperage to fall within the WPS and then match personal preferences. Typical starting points are 80 to 90 A for a 1⁄8-in. electrode and 105 to 115 A for a 5⁄32-in. electrode. Strike the arc on a tack weld at the top of the pipe, holding the rod perpendicular to the pipe. The operator will clearly hear the arc when it penetrates through the pipe, and a small “keyhole” will open behind the electrode. At this point, tilt the electrode and start traveling toward the bottom of the pipe, holding a 5- to 15-deg drag angle and moving in a straight line (e.g., no weave).

Very little arc light will be visible on the outside of the pipe. Experienced pipe welders know how to read the keyhole and make one of four adjustments to control keyhole size, which should roughly match root-opening width. If the operator does not see a keyhole, that indicates insufficient penetration. To correct the situation, the operator can do one or more of the following:

1. Increase amperage, typically done on the fly by a welder’s helper with a remote amperage control.
2. Hold a longer arc, which increases voltage and overall heat input.
3. Use more of a drag angle, which pushes more heat back into the joint.
4. Reduce travel speed.

If the keyhole is too large, the operator can make one or more of the following corrections:

1. Reduce amperage.
2. Increase travel speed until the keyhole reaches the correct size.
3. Decrease arc length to lower voltage and “cool” the weld pool.
4. Hold the electrode more perpendicular.

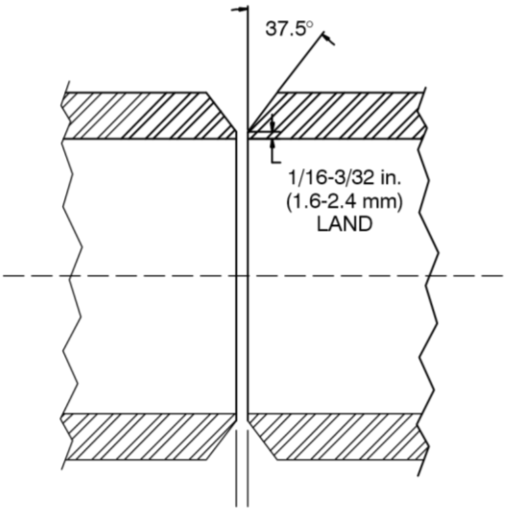
Beginners typically need to put more pressure on the electrode than they think (“bury the rod” is a common instruction). Sometimes the right amount of pressure can cause the rod to bend a little bit, especially with a smaller diameter electrode and a narrow root opening.

There are two problems operators may encounter on a root pass. One problem is the arc may wander to one side, and this can be caused by a concentricity problem with the electrode coating. In SMAW, the coating crater, or the cup-like formation of the coating that extends beyond the melting core wire, performs the function of concentrating and directing the arc. Concentration and direction of the arc stream is attained by having a coating crater, somewhat similar to the nozzle on a water hose, directing the flow of weld metal. When the coating is not concentric to the core wire, the poor arc direction causes inconsistent weld beads, poor shielding, and incomplete penetration. The electrode melts off unevenly, leaving a projection on the side where the coating is the heaviest. This condition is often referred to as “fingernailing.”

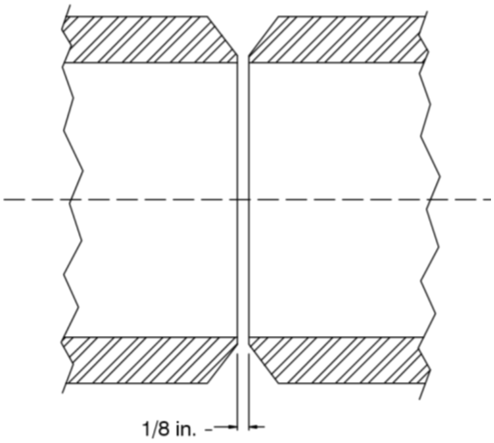
To counteract fingernailing, push the thin side of the electrode further into the groove to direct the arc force into the joint. The second problem, which has a similar solution, is arc blow, where magnetic forces try to push the arc toward one side of the joint. If this occurs, push the electrode toward the opposite side of the joint and try to create a more even melt-off rate. Arc blow can be caused by poor grounding. Make sure the pipe is well grounded; repositioning the ground clamp can solve the problem.

3.2 Open Root Joint Preparation

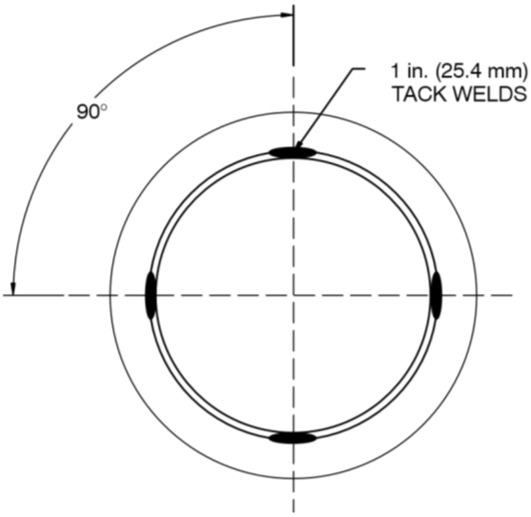
1. Bevel pipe end to 37.5° (standard pipe bevel)leaving a 1/16 to 3/32 in. (1.6 to 2.4 mm) land.



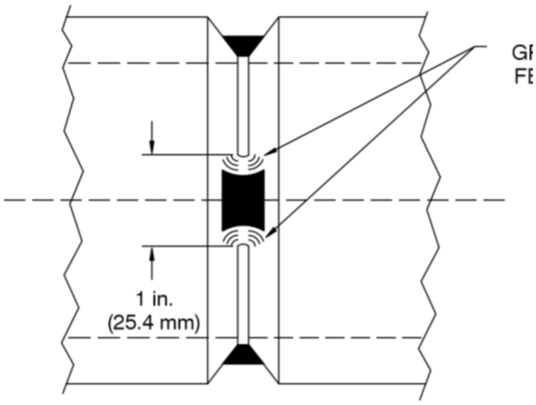
2. Align pipe ends together leaving a minimum of1/8 (3.2 mm) gap.



3. Tack pipe ends together in four locations approximately 90° apart and 1 in. (25.4 mm) long on pipe that is 6 in. (152.4 mm) or larger diameter. Use appropriate sized tack welds on smaller pipe.

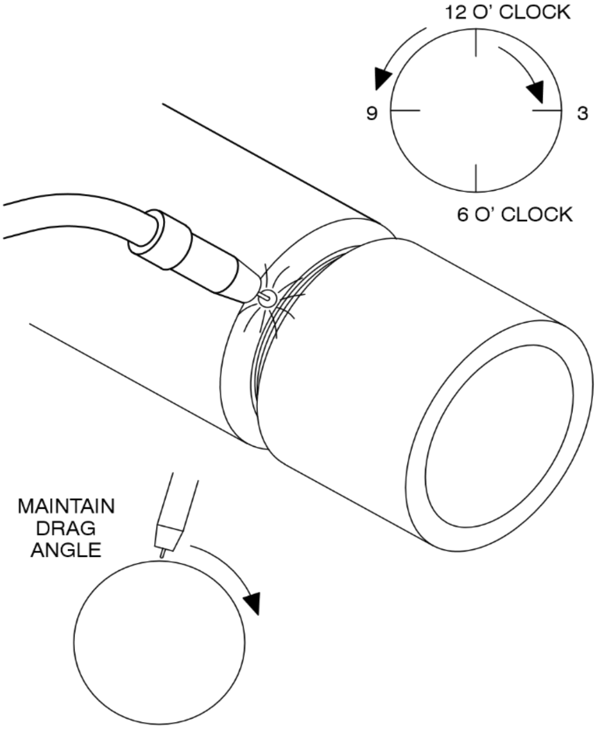


4. Grind each end of the tack weld to a feather ed edge).

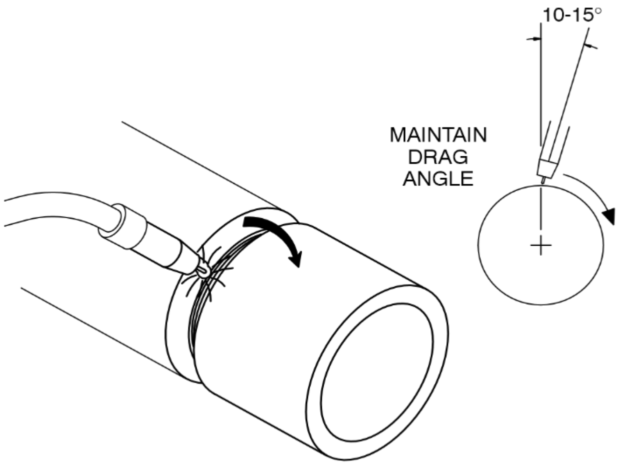


3.3 5G Welding Technique Recommendations

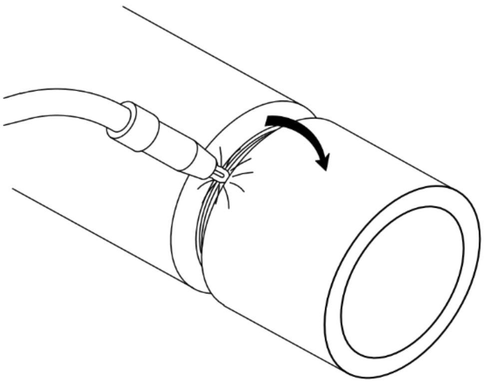
1. Start arc on sidewall or in center of tack weld, not in the gap.



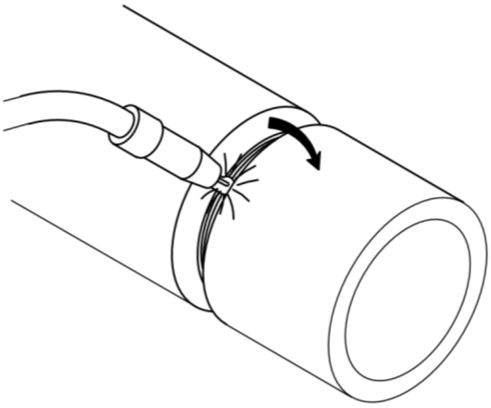
2. After puddle is established, maintain the arc on the center of the puddle with a 1/2 to 5/8 in. (12.7 to 15.9 mm) tip to work distance.



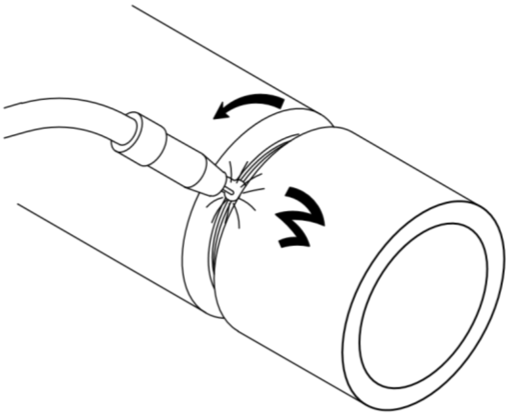
3. Move across the gap.



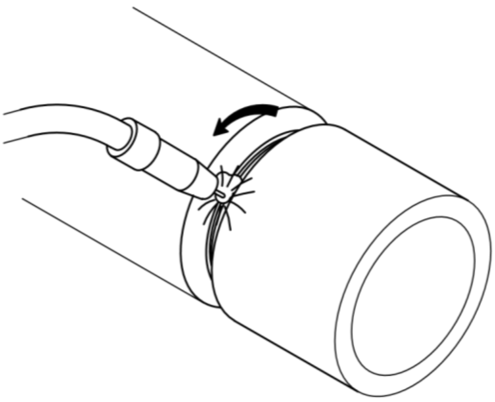
4. Move slightly up the sidewall.



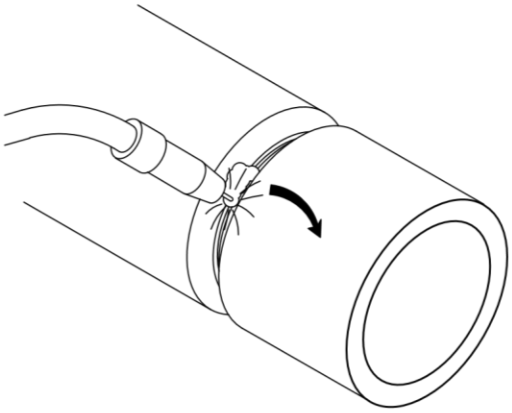
5. Stay in the puddle and move the electrode back across the gap. Move the electrode down the joint in a half-moon motion.



6. Continue moving back and forth (weaving) across the gap until reaching the 1 o'clock position.

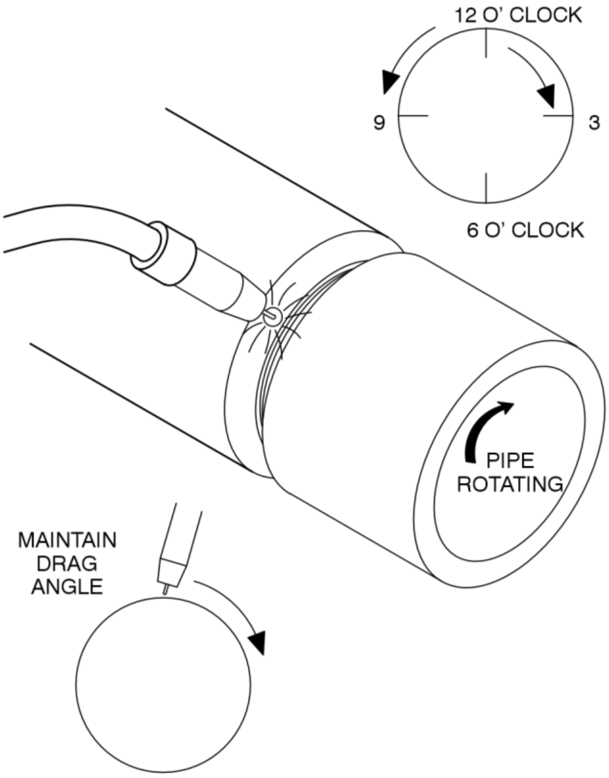


7. At the 1 o'clock position, stop weaving. Concentrate the arc on the center of the weld puddle and move down the pipe joint until the 5 o'clock position.

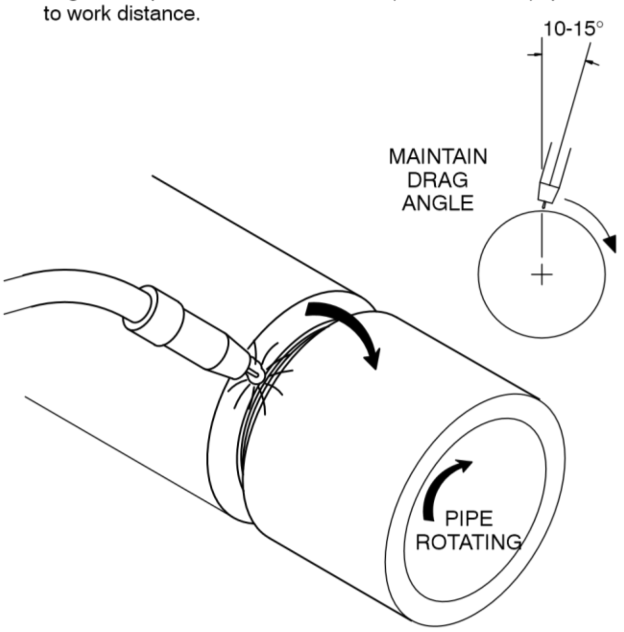


3.4 1G Welding Technique Recommendations

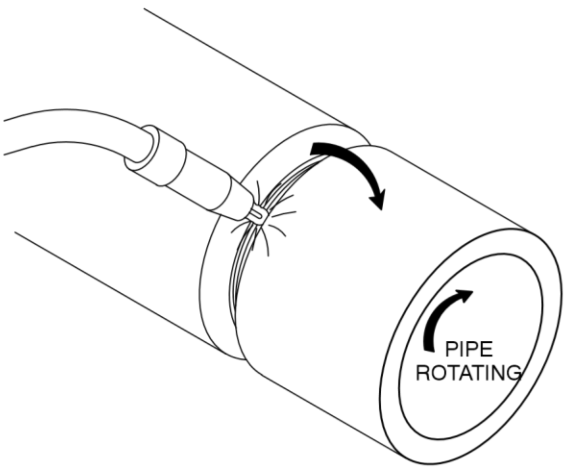
1. Start arc on sidewall or in center of tack weld, not in the gap.



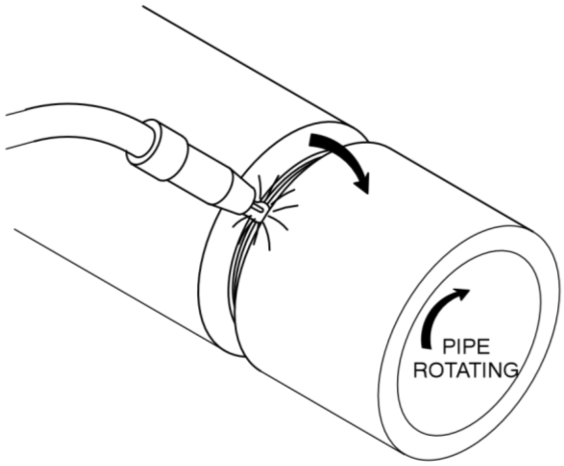
2. After puddle is established, maintain the arc on the leading edge of the puddle with a 1/4 to 1/2 in. (6.4 to 12.7 mm) tip to work distance.



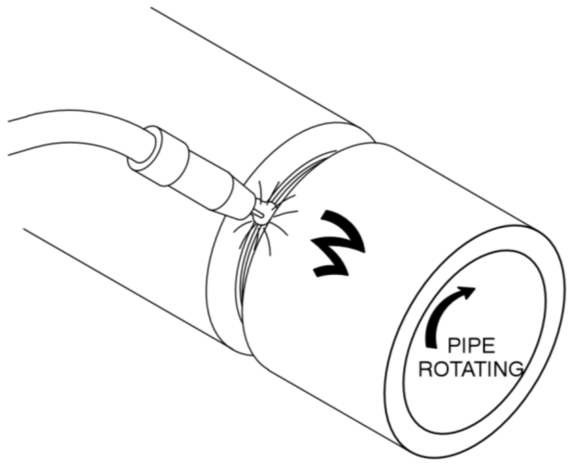
3. Move across the gap. Watch the puddle, not the arc.



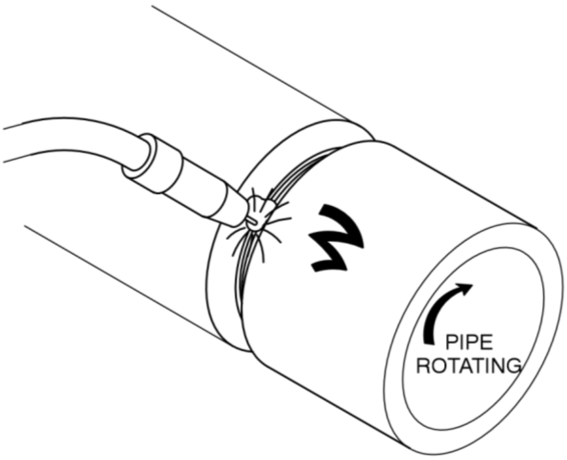
4. Move slightly up the sidewall. Keep the electrode near the top of the pipe joint.



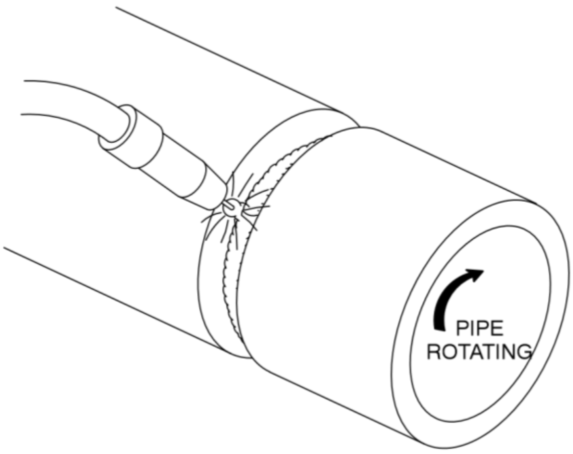
5. Stay on the leading edge of the puddle and move the electrode back across the gap. Move the electrode in a half-moon motion.



6. Continue moving back and forth (weaving) across the gap. Be sure pipe rotates at a constant speed. Maintain a steady arc length.



7. DO NOT stop welding in the root. This may cause pinholes. Fill the crater by welding into the previous weld start. Use a short arc length to control heat.
Be sure to grind the weld at the stop position to ensure any pinhole is removed and weld is feathered.



8. When root weld is complete, remove excess silicon with a wire wheel or with light grinding. Also, grind any high spots on root pass to make it uniform in height.

Self-Check -1	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1.
2.
3.
4.
5.

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = ___________
Rating: ____________

Name: ___________________________ Date: ________________

Short Answer Questions

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Information Sheet-4	Cleaning root passes

Root pass cleaning

Following the root pass, it is necessary to grind the weld to ensure proper penetration for the next pass or hot pass. This can be done using a 1/8-inch grinding wheel along the root pass, which helps create a flat or u-shape at the bottom of the weld.

With subsequent welds laid down after the hot pass, use a wire brush to clean away any imperfections or slag. This prepares the metal for each weld layer. A narrow-faced wire wheel works well for this. If the v-groove of the weld joint is wider, such as filler passes with larger-diameter pipes, choose a brush with a wider face that is designed to clean larger areas.

When two welders work on opposite sides of the pipe on larger-diameter pipes, the starting and stopping points for each welder are typically at the 12 o'clock and 6 o'clock positions. The point where the welds join and overlap is called the button. While this area can be more difficult to clean, avoid banging the wire wheel on the button, as this will damage the wires. Use normal pressure and allow the brush more dwell time to clean this area.

The same wire wheel used for interpass cleaning can also be used to clean the weld and remove any slag from the cap pass.

Some wire wheels use a dual-hex nut design that simplifies periodic flipping of the wheel to help promote the self-sharpening ability of the wire tips. Choosing a wheel with this design helps deliver maximum cleaning action, long life, and safer use.

An encapsulated stringer bead wheel is another option for cleaning between weld passes. Only the wire tips are exposed from the encapsulation. These brushes offer several advantages, including longer product life and aggressive cleaning action. Moreover, because there are no long wires outside of the encapsulation, long wire breakage is eliminated.

Be aware that the operator has less flexibility with an encapsulated wire brush because of the short trim length of the wires. When choosing this option, look for an encapsulated wheel that uses a heat-stabilized encapsulation that gradually wears away to expose a consistent short trim. This makes it suitable for cleaning hot welds without overheating.

5.1Hot Pass

The hot pass is defined as the 2nd to 3rd pass on the pipe that is done to cover the root weld. If done right the hot pass will turn a flat root penetration surface to a convex one. If your root weld does not have enough penetration or even some suck, back a good hot pass can fix that!
The way a hot pass gives the root better penetration comes from welding hot and making sure the toe of the weld heat up the outsides of the pipe bevel. When the pipe cools and shrinks the root is forced to protrude on the inside of the pipe and become convex.

5.2Fill Pass

The fill pass should nearly fill the groove. If a bead sequence is necessary, an alternating pattern should be used from face to face of the joint. The location of each bead should have an adequate, uniform lap for each subsequent weld bead. If a narrow cavity should develop between weld beads or between the face of the joint and the weld bead it may result in a lack of fusion or contamination (slag). If possible, grind the area to eliminate the cavity and improve the lap weld before making the next weld.

5.3Cap Pass

The cap weld should completely fill the top of the joint with the least amount of excessive build-up beyond the top surface of the pipe. Grinding may be necessary to improve the weld bead shape and remove any contamination before making the final cap pass.

5.4Hot Pass Welding Technique and Rod Angles

Hot pass or filler pass was done using a weave with a 3/32 E7018 electrode. The technique is to hold the sides until the toe of the weld washed into the bevel. The upper part of the bevel is held about 2 seconds and the bottom is held for about 1 second. This is the easiest part of the welding technique.

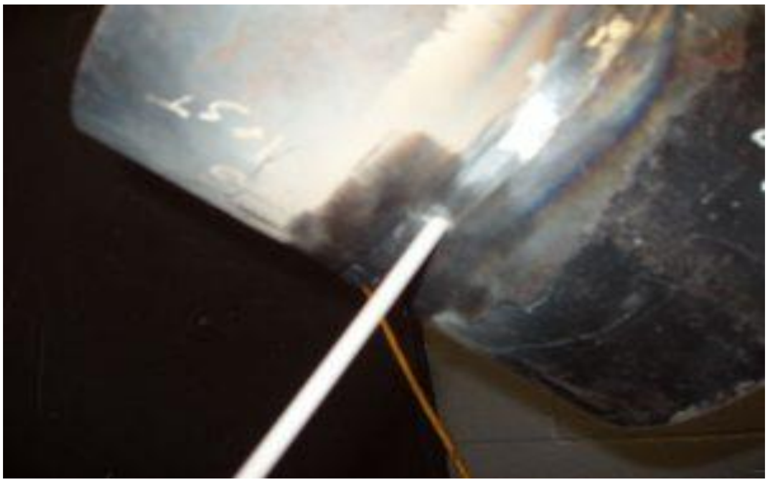

Fig5.1The rod to the hot pass. Hold this side and then move to the other side after about a second.

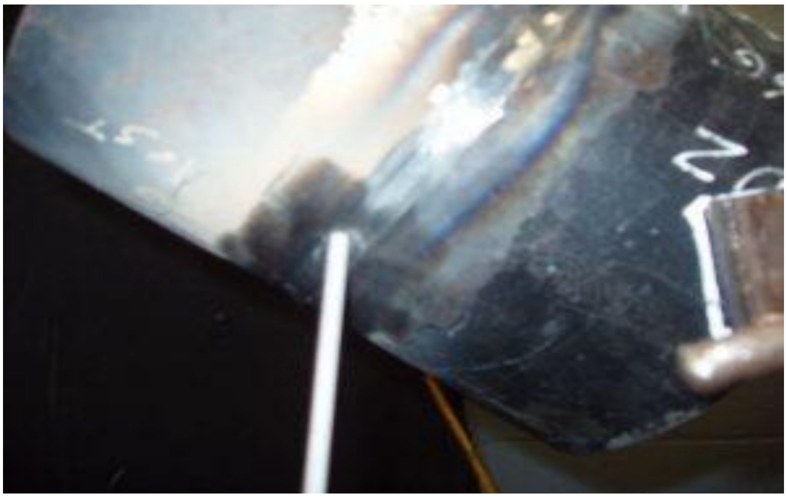

Fig5.2 the angle used to get the other side of the weld joint. The angle is same all around the pipe no matter what position. Just point the rod to the center of the pipe in the flat, horizontal, vertical and overhead positions.

5.5 How to Do a Hot Pass in the 6G Position

Before putting in the hot pass grind down the roots surface. When it comes to welding certifications, some inspectors **do not allow grinding** at all but with the E6010 root, they usually allow to grind down the root. Most of the time everyone piggybacks there tacks, so you will have a few lumps on the outside of the root from the restarts. When it comes to grinding down the roots surface on critical joints, it is always allowed.

Grind the E6010 root pass to make sure no slag was on the surface.

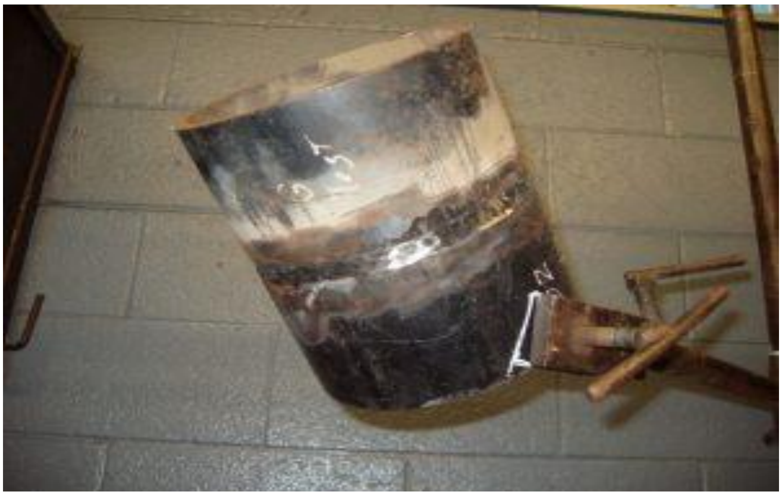

Fig5.3 a side view of the ground down root pass.

Fig5.4Top of the ground down root and this will be the base for the hot pass.

Below are the pictures of hot pass. Use a weaving technique for your weld holding the sides just like the above pictures of the electrode angles. As you can see, the bevel is mostly filled and there is no slag on the edges of the bevel. When putting in a filer pass the slag should come off easily! If not, that means you are not holding the sides long enough and there is a possibility of slag inclusions.

Fig5.5Side view of the hot pass

Self-Check -5	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

Explain the following terms

1. Root pass
2. Hot pass
3. Fill pass
4. Cap pass

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

5. Answer Sheet-1

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

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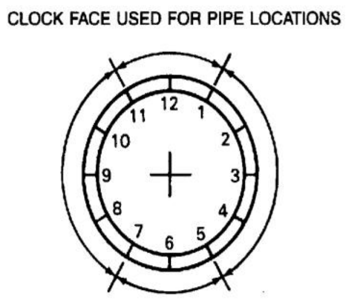
6.1Fill and Cap

For the fill and cap passes, operators will usually step up to the largest electrode allowed, often a 3⁄16-in. to provide greater deposition and to help create a wider pool. In fact, a cap made in a single pass is often called a "pool cap."

For the first fill pass, use a weave to ensure tie-in with the pipe wall. Moving the electrode side to side and creating an upside-down U shape is common, as is holding a longer arc than for the previous passes. Combined with a proper drag angle, these techniques prevent the center of the pool from sagging.

Because one of the most common defects is insufficient fill, "stripper passes" may need to be added to build up the weld metal so that it is flush or almost flush with the top of the joint. The spots between the 2 and 5 and 7–10 o'clock positions are notorious for having low spots in the center, and adding a stripper pass in this area may be necessary.

The cap pass should bring the weld metal up to the point where the cap is flush to no higher than 1⁄16 in. above the pipe surface. Without the need to tie-in to the pipe wall, lower currents may be used than for the fill pass(es).



ROOT BEND TROUBLESHOOTING GUIDE

TO ELIMINATE	CURRENT	ROOT OPENING	ROOT FACE	PIPE WALL OFFSET	BEVEL ANGLE
INTERNAL UNDERCUT	DEC.	DEC.	INC.	DEC.	DEC.
INCOMPLETE FUSION	INC.	INC.	DEC.	DEC.	INC.
CRACKING	DEC.	—	DEC.	DEC	INC.

DEC. = DECREASE INC. = INCREASE

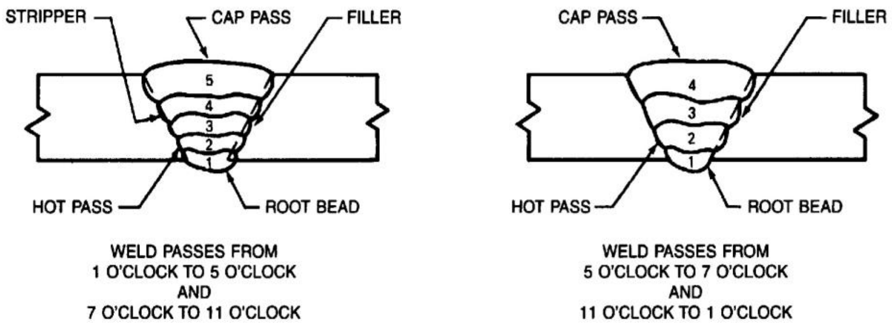


Fig6.1 pass sequence

Self-Check -5	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

Explain the following terms

1. Root pass
2. Hot pass
3. Fill pass
4. Cap pass

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

5. Answer Sheet-1

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

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7.1Welding materials using SMAW and Oxyacetylene process

When welding materials the arc shall be struck on the face of the bevel or on previously deposited weld metal, not on the external surface of the pipe. When continuing the same bead around the pipe, it is preferred that the arc be struck on metal about 3/8" ahead of the previous bead then drawn back on to the previous bead before continuing forward progress.

The welder shall visually inspect each weld bead for defects. Any defects, including significant slag and porosity and all cracks are removed by grinding or by carbon arc gouging following by grinding.

Beads not more than 3/4 inches wide are permitted for any welding process when the WPS permits weaving. When stringer beads are required by the WPS, the weld shall be made without significant motion of the electrode transverse to the direction of travel.

Prior to depositing the next weld bead, any weld metal build-up which may have been left at any weld stop or re-start locations shall be ground to blend uniformly with the surrounding deposit and base metal contour.

7.2Welding from Two Sides

When the inside surface of a weld is accessible, it shall be visual examined by the welder for full fusion, adequate penetration, convexity and concavity. Any defects shall be removed by grinding to sound metal and welded from the inside, if necessary, to bring the weld metal flush with the surrounding base metal. On joints that are designed to be welded from both sides, the root pass shall be ground or carbon-arc gouged and ground to sound metal before depositing weld metal from the inside surface

The inside surface of a production joint may be back gouged using methods given in the Welding Procedure Specification and welded from the inside of the pipe, as necessary. Before welding the inside surface, that surface shall be visually inspected for defects, and additional grinding shall be done as needed to reach sound metal. When the WPS indicates that back gouging is “none,” it means that the procedure is not intended for use with back welding; in these cases, use a WPS, which allows back welding to make repairs from the second side.

Self-Check -7	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

Explain the following terms

1. Root pass
2. Hot pass
3. Fill pass
4. Cap pass

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

5. Answer Sheet-1

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

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Information Sheet-8	Cleaning and freeing joints from discontinuities.

8.1Cleaning the Pipe

Base material condition can vary greatly when pipes arrive on the jobsite. There is typically some rust on the pipe — how much depends on the length of time since manufacturing and the pipe storage conditions. The more time that passes between manufacturing of the pipe and preparing it for welding, the greater the chances more rust has accumulated.
If the pipe has only light surface rust, it requires a different conditioning product than if it has heavier rust.

Wire Brushes and Wheels: Light surface rust can typically be removed with a hand wire brush or wheel. Wire brushes efficiently remove loose material on the surface of the pipe without changing the base metal.
Product options in this category include hand wire brushes for small-diameter pipe or power wire wheels, such as a stringer bead wheels, and wire cup brushes for larger-diameter pipe and faster cleaning. Wire wheels can be used to clean the pipe surface prior to welding and for cleaning the welds between passes. Cup brushes tend to clean more surface area and often clean faster, but they also tend to create a kickback if the cup hits the wrong part of the pipe. Both products clean effectively. While the choice often comes down to operator preference, wire wheel brushes are most commonly used.
Note, wire products also work well to remove any burrs that may have formed while creating the land.
Because wire wheels and brushes are designed to let the wire tips do the work, it is important to orient the tool so only the wire tips hit the work surface. This promotes the most effective cleaning action, reducing the urge for the operator to push harder. It also helps extend product life and reduce the risk of wire breakage. With a wire brush, apply light pressure — just slightly more than the weight of the grinder to let the wire tips do the work.

Flap Discs: If the base material has more than light surface rust —perhaps even pits in the steel — it requires a more aggressive product to clean the metal. The bevel must always be completely cleaned and any rust or pits removed from the material.
Flap discs are a good option in this situation — especially a 60-grit flap disc to efficiently grind out any rust, pits, and imperfections on the pipe, while also minimizing the potential for gouging that can occur with a grinding wheel.
Flap discs are available in many different material types. A disc with an aluminum backing is more rigid, which is ideal for maintaining the edge of the bevel without rounding the material. Rounding the edges of the bevel during cleaning can be detrimental to properly filling the weld.

9.1Cleaning welds

Proper cleaning plays a key role in a successful welding operation. It affects quality since a material surface with dirt or impurities can lead to inclusions or issues such as porosity. Surface cleaning and preparation can also affect the appearance of the final weld and overall operation costs for rework and labor. Some jobs may require the use of an abrasive product, while other times cleaning can be done with a cloth or chemical solvent.

Interpass and post-weld cleaning are also important steps in the process, depending upon the application and the requirements for the finished weld.

How to Choose?

There are many options available for weld cleaning. Keep these factors in mind when making the choice.

Desired outcome. If there are surface finish requirements or aesthetic demands for the weld — if it needs to have a mirrored finish, for example — these can affect how to clean. There may be multiple products required during post-weld cleaning to achieve the desired finish. Start with an abrasive with the heaviest grit or grain allowed by the application, and then move to a finer grit as the job progresses. As an example, an operator could start with a 40-grit flap disc to clean a weld and end the job with an 80-grit flap disc for fine finishing — especially if the material will be painted or powder-coated. Typically, the smoother the completed weld, the better. When welding stainless steel, a wet cloth can be used for post-weld cleaning of the weld surface and to remove free iron. This also helps the passivation process, which is the treating or coating of a metal — usually with acids or pickling paste — to reduce the chemical reactivity of its surface.

When weld cleaning, save time and money by using as few steps as possible. Using a product with a finer grit will be slower, so it's a balancing act between productivity and surface finish requirements.

Material type. Different abrasives are suited to different types of material. When welding stainless steel or aluminum, for example, it's important to thoroughly clean it before starting, since these materials are not as forgiving to dirt and debris in the welding process. Take care when using heavier-grit abrasives on these materials. A 24-grit or 40-grit flap disc may be too aggressive for aluminum, bronze or other non-ferrous metals. A good rule of thumb is the finer the grit, the better. Often, 70 percent isopropyl alcohol can be used for cleaning both filler rods and base materials before welding.

Look for tools designed for use with stainless steel, such as stainless steel brushes or grinding wheels, to avoid introducing contamination into the weld during interpass cleaning. These wheels can also be used on other materials that are susceptible to contamination such as aluminum, brass or copper.

The bottom line: To avoid introducing dirt and debris into the weld, cleaning before and during welding is typically necessary regardless of material type, but some materials require extra attention.

- **Code requirements.** Some welding applications may have code requirements for weld inspection. Weld specifications may determine how many inclusions the finished weld can have, for example. These are important factors to consider when choosing the right products for cleaning welds.

9.2Common Tools for Cleaning

Common options for surface and weld cleaning include bonded abrasives/grinding wheels, coated abrasives/flap discs, and wire brushes and wheels. The choice depends on the requirements of the application and operator preference. Abrasive products and wire brushes differ in their performance and purpose. Abrasive products are designed to remove base material, whereas wire brushes are not.

Bonded abrasives/grinding wheels. If there are slag inclusions or porosity in the weld, for example, a grinding wheel can be used for interpass cleaning to remove some of the weld material in addition to removing the inclusion. These products are often used to clean mild steel and for sloppier welds that may have a lot of slag or spatter, since the wheels will remove more material faster. Grinding wheels rely on a combination of the grain type, grain size and bonding agents (resins and additive fillers) to determine their performance. Because bonded abrasives are generally more aggressive and remove material faster, they require a higher level of operator skill to prevent damage, gouging or undercutting. Application needs determine the thickness of the wheel to be used — the heavier the material to be removed, the thicker the wheel necessary.

Coated abrasives/flap discs use the same grain types as those found in bonded abrasives, but the grains are bonded to a backing cloth rather than molded and pressed into a hard grinding wheel. This cloth is layered to form a flap disc, a design that gives flap discs a softer, more forgiving feel. Flap discs can be used on stainless steel (though be sure to use a finer grit) or on mild or carbon steel for slight material removal in pre-weld cleaning, as well as for blending and finishing the surface post-weld. This makes them a good choice when the finished material needs to be painted, primed or powder coated. Be mindful of the direction of spin when using a flap disc. Make sure it is spinning and throwing the sparks and debris away from the base material and weld — and not back across them — to avoid contamination.

Wire brushes and wheels are a good option for interpass or post-weld cleaning, when it is necessary to remove spatter and other contaminants. If the material has a lot of mill scale, rust or heat discoloration to remove (without removing a lot of material), wire brushes also work well for pre-cleaning. When choosing a power brush, there are several knot styles, wire gauges and trim length options. By changing one or more of these characteristics, the operator can fine-tune brush performance for a specific application. For example, stringer bead brushes have narrower knots twisted from base to tip, making them better suited to penetrate tighter spaces like corners, fillets, and root pass welds during cleaning. Remember, the tips of wire brushes do the work, so using appropriate pressure is key to performance and efficiency. Using excessive pressure causes the wires to flex and bend, which can hinder cleaning and cause wire breakage that reduces brush life.

Best Practices for Success

In addition to proper abrasive selection and cleaning techniques, there are some best practices to consider.

Looking at only the initial purchase cost may be tempting, but lower quality, less-expensive abrasives, brushes or wheels may not provide enough aggressiveness for the job, or they may have a much shorter product life. It may be best to invest more for a product that cleans better or lasts longer since it can significantly affect overall operation costs and productivity.

Another best practice is to avoid over speeding. Choose an appropriately sized product for the operating tool, and always use the manufacturer's recommended tool guard. Be sure the maximum safe rpm marked on the wire brush or abrasive wheel is greater than or equal to the maximum operating rpm on the tool.

A 4 1/2-inch grinder and a 4 1/2-wheel may both be rated for 13,000 rpm, which means they are safe to use together. However, removing the guard on that tool to use a larger wheel can cause safety and performance issues, since the larger product is rated at a much lower rpm. The product is not designed to run that fast, making it more susceptible to breakage, which increases the potential for injury and shortens product life.

Proper Cleaning Yields Success

Clean materials and welds are critical in any welding operation. Remember, however, there is no one-size-fits-all solution for choosing an abrasive, brush or wheel for pre-weld, interpass, and post-weld cleaning. Always assess the priorities and requirements for the job. The right choice can help generate efficiency, quality and cost savings in the long term

Self-Check -9	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

Explain the following terms

1. What is the benefit of cleaning weld?
2. List the commons tools used to clean weld

Answer Sheet-1

Score = ___________ Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

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10.1 Introduction

Interruptions or flaws in the physical, mechanical or metallurgical properties of a weld are called discontinuities.

The number or extent of the discontinuities that is acceptable for a given product depends on its standards. More discontinuities would be permissible for a welded gate than for an airplane, for instance, because the latter is subject to much more critical usage. Lives could be lost if the welds in a plane failed.

10.2 The Difference Between Defect and Discontinuity

When a product has more discontinuities than its code of standards allows, the product is deemed, defective and unfit for use.

How does an organization know when a product has crossed the line from having discontinuities to being defective? A measurement called tolerance is used.

Tolerance is the difference between the ideal, or perfect, version of the product and a version of the product that is still fit for use despite its discontinuities. Other factors that determine if a product's discontinuities are great enough to be categorized as defects are the size, location and type of the discontinuity.

10.3 Common Welding Discontinuities

Below are six common welding discontinuities, along with their possible causes. If these discontinuities surpass a given product's standards, they are defects.

1. Porosity

Porosity occurs when gas becomes trapped in the weld pool, forming permanent bubbles as the metal cools from a liquid state back to a solid. Extensive porosity can result in a loss of weld strength.

Causes

- Failing to properly shield the weld from atmospheric contamination
- Neglecting to remove impurities like dirt from the base metal
- Striking too long of an arc

2. Inclusions

Inclusions occur when slag, oxides or other nonmetallic materials become trapped between the bases metal and the weld, between the beads of the weld or in the weld metal. The structural integrity of the weld can be compromised by the presence of inclusions.

Causes

- Leaving heavy mill scale, rust, or preexisting deposits of slag in the material
- Improperly cleaning prior welds
- Manipulating the arc incorrectly

3. Inadequate Joint Penetration

When a weld does not penetrate the joint enough to achieve a sound fusion of the metals, the problem can be described as an inadequate joint penetration. This discontinuity becomes a defect when it serves as a source of stress in the weld that can result in fatigue failure.

Causes

- Misdirecting the arc or other improper welding techniques
- Not preheating thick metals or using enough welding current to penetrate the joint
- Poor design, fit, or detail of the joint

4. Incomplete Fusion

Two types of incomplete fusion can happen: interpass cold lap and lack of sidewall fusion.

- Interpass cold lap is when the filler metal and previously deposited weld metal do not fuse sufficiently.
- Lack of sidewall fusion is when the joint face and weld metal fail to fuse properly.

Causes

- Leaving slag or oxides on joint surfaces or neglecting to break up oxide layers on the base or filler metals
- Traveling at an improper speed or using the wrong electrode angle
- Selecting the wrong welding process for the metal

5. Arc Strikes

When the arc strikes areas other than the joint, it melts the metal and causes small, localized discontinuities in its surface. They can serve as the starting point for cracking and dangerous fatigue failure.[2]

Causes

- Improper or careless technique that causes the arc to strike the wrong location
- Defective ground connections.

6. Overlap

Weld deposits that flow over the surface of the base metal because they are larger than the specified joint design are referred to as overlap. They can prevent the metals from fusing.

Causes

- Traveling too slowly
- Misdirecting the arc
- Improperly sizing the weld

Self-Check -10	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

1. **__________ is a groove melted into the base metal next to the weld toe or weld root and has not been filled in.**
   a) Cracks
   b) Craters
   c) Under fill
   d) Undercut

2. **If the weld does not combine with another weld or the base metal it is referred to as:**
   a) incomplete penetration
   b) incomplete fusion
   c) incomplete bonding
   d) incomplete inclusion

3. **To determine if a welder is qualified, the welder must pass a _______________ test.**
   a) WPQR
   b) WPS
   c) PQR
   d) Code

4. **Which of the following defects will have the more severe effect on the load-bearing capacity of a weld?**
   a) Undercut
   b) Incompletely filled groove
   c) Irregular width
   d) Excess penetration

5. **Slag inclusions would occur with:**

   a. Manual metal arc

   b. Metal inert gas

   c. Submerged arc welding

   d. Both A and C (answer)

Answer Sheet-1

Score = ___________
Rating: ____________

Name: __________________________ Date: _______________

Answer

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3. .
4. .
5. .

LAP Test	Practical Demonstration

Name: _______________________________ Date: _________________

Time started: __________________________ Time finished: _________________

Instructions: Given necessary equipment, tools and materials you are required to perform the following tasks within3hr hour

Task1. Prepare material according to work order

Task2. Bevel the pipe ends

Task3. Fix the work piece

Task4. Set up welding machine

Task5. Make tack weld

Task6. Weld root pass

Task7. Weld hot pass, fill pass and cap

Task8. Clean the weld

Equipment: -

- SMAW welding machine

Tools: - chip hammer, steel rule, hacksaw, wire brush, scriber, fixing jig
Materials: -3 inch pipe

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

- Removing defects
- Inspecting weld joints visually
- Completing and maintaining weld records and completion details
- Observing Occupational Health and Safety (OHS) procedures

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

- Remove defects
- Inspect weld joints visually
- Complete and maintaining weld records and completion details
- Observe Occupational Health and Safety (OHS) procedures

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 20.
3. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the “Self-check 1” in page __.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1
7. Submit your accomplished Self-check. This will form part of your training portfolio.
8. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
9. Accomplish the “Self-check 2” in page __.
10. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).
11. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
12. Accomplish the “Self-check 3” in page __.
13. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).
14. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to for each Learning Act

Remove defects using *appropriate methods* for the given task

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

GENERAL PROCEDUR

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

For Repairs Requiring Welding

- Remove the defect by grinding with CARBIDE BURR CUTTERS only or by chipping and grinding with CARBIDE BURR CENTERS to an acceptable level. Abrasive-type wheels and stones are not allowed on vacuum welds.
- Visually inspect the area prepared for welding.
- Re-Weld in accordance with a Buyer approved welding procedure.
- Welded repairs shall be visually inspected after welding

REPAIRS TO EDGE PREPARATION

- Defects shall be removed by grinding with CARBIDE BURR CUTTERS only. Abrasive-type wheels and stones are not allowed on vacuum materials, weld preps. The cavity shall be blended uniformly into the surrounding surfaces.
- Ground surface repairs shall be visually inspected to verify that the nonconformity has been removed or the indication reduced to an acceptable limit.

REPAIRS TO WELDS

For Repairs Not Requiring Welding

- Weld defects shall be removed by grinding with CARBIDE BURR CUTTERS only. Abrasive-type wheels and stones are not allowed on the interior or the exterior of vacuum welds.
- Visually inspect the area prepared for welding to ensure that the defect has been removed or the indication reduced to an acceptable limit.
- A depth micrometer or an ultrasonic thickness gauge shall check the reduced material thickness.

For Repair Requiring Welding

- Remove the defect by grinding (as specified in A. above) or by chipping and grinding (as specified in A. above) to an acceptable level.
- Visually inspect the area prepared for welding.
- Re-Weld in accordance with a Buyer approved welding procedure
- The repaired area can be left in the as-welded condition or can be blended by grinding. Grinding is restricted to the use of CARBIDE BURR CUTTERS only. The repaired area shall blend uniformly into the surrounding surface and shall be visually inspected after welding.

For Fillet Weld Repairs Requiring Welding

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

Self-Check -1	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1.
2.
3.
4.
5.

***Note:* Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

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Inspection and Repair

In order to determine the suitability of the weldment for its intended purpose, some degree of nondestructive examination/testing (NDE/NDT) should be conducted as part of sound fabrication practice and quality assurance. For non-code fabrication, NDE may be as simple as visual or liquid/dye penetrant inspection. For code fabrication, certain mandatory inspections may be required. These NDE methods should be considered for both intermediate inspections during multi-pass welding, as well as for final acceptance of the weldment.NDE methods are similar to those used for carbon and stainless steels.

Liquid/dye penetrant inspection is commonly used to reveal surface defects, such as hot cracking. Radiographic and ultrasonic testing can be used to detect for subsurface defects and thoroughly check the soundness of the weldment; however, the results can be difficult to interpret and these methods are generally not well suited for inspection of fillet welds.

Magnetic particle inspection is not an effective NDE method for Ni-/Co-base alloys since they are non-magnetic. If further information is required, it is suggested that the fabricator consult with an outside laboratory that is experienced with NDE of Ni-/Co-base alloy welds. Welding defects that are believed to affect quality or mechanical integrity should be re-moved and repaired. Removal techniques include grinding, plasma arc gouging, and air carbon-arc gouging. As explained previously in the weld joint preparation section, extreme care must be exercised during air carbon-arc gouging to insure that carbon contamination of the weld joint area does not occur. It is suggested that the prepared cavity is liquid/dye penetrant inspected to insure that all objectionable defects have been removed. The repair cavity should then be thoroughly cleaned prior to any welding repair. Since Ni-/Co-base alloys have low weld penetration characteristics, the ground cavity must be broad enough and have sufficient sidewall clearance in the weld groove to allow for weld electrode/bead manipulation. The technique of "healing" or "washing out" cracks and defects by autogenously re-melting weld beads, or by depositing additional filler metal over the defect, is not recommended

Welding Quality Control

In the fabrication or repair of equipment, tests are used to determine the quality and soundness of the welds. Many different tests have been designed for specific faults. The type of test used depends upon the requirements of the welds and the availability of testing equipment.

Nondestructive Testing

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

Visual Inspection

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

- 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 errors at early stages
- 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, incomplete root penetration, undercut, and under fill), warp age, base metal defects etc.

Self-Check -1	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1.
2.
3.
4.
5.

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

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Information Sheet-3	Completing and maintaining weld records

Completing and maintaining Weld records

- Weld inspection, weld logging, and weld recordkeeping always have been a part of quality assurance (QA) procedures for certain industries

Qualification records will be maintained for each welder, documenting:

- Processes for which the welder is qualified
- Current qualification status
- Dates and results of each qualification test

QUALIFIED WELDING PROCEDURE SPECIFICATION

- The individual responsible for welding activities will maintain qualified Welding Procedure Specifications (QWPS). .
- The QWPS shall be retained until the procedure is no longer being used or has been replaced by a subsequent re-qualification.
- A blank sample of the Qualified Welding Procedure Specification is shown in Exhibit “A1” (front page) and “A2” (back page)

PROCEDURE QUALIFICATION RECORD

- Procedure Qualification Records (PQR) will be maintained by the individual responsible for welding activities.
- The PQR shall be retained until the procedure is no longer being used or has been replaced by a subsequent re-qualification. A blank sample of the Qualified Welding Procedure Specification is shown in Exhibit “B1” (front page) and “B2” (back page).

WELDER PERFORMANCE QUALIFICATION RECORD

- The “Welder Performance Qualification Record” (see Exhibit “C”) tracks specific test results of the initial qualification and requalification test(s), and continuation weld test(s) for each welder, and will be maintained by the individual responsible for welding activities.
- To remain qualified on a particular process for process piping welding, a welder must weld each process within a six month period; see *Section 1.00 (“Compliance – Continuation Weld Test”).*
- The “Welder Performance Qualification Record” shall be maintained for a period of 5 years following the welder no longer performing the welding process/covered task.
- Radiographic test reports establishing a welder’s qualifications must be maintained for at least five years.

EXHIBIT “A1”

QW – 482 WELDING PROCEDURE SPECIFICATIONS (WPS)

Company Name ______________________ By ______________________
Welding Procedure Specification No. ____________ Date ____________ Supporting PQR No.(s) ____________
Revision No. ____________ Date ____________

Welding Process(es) ______________________ Type(s) ______________________
(Automatic, Manual, Machine, or Semi-Automatic)

JOINTS (QW-402)

Joint Design ______________________
Root Spacing ______________________
Backing: Yes ____________ No ____________
Backing Material (Type) ______________________
(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 details of weld groove may be specified.

Details

*BASE METALS (QW-403)

P-No. ____________ Group No. ____________ to P-No. ____________ Group No. ____________
OR
Specification and type/grade or UNS Number ______________________
to Specification and type/grade or UNS Number ______________________
OR
Chem. Analysis and Mech. Prop. ______________________
to Chem. Analysis and Mech. Prop. ______________________
Thickness Range:
Base Metal: Groove ______________________ Fillet ______________________
Maximum Pass Thickness ≤ $^{1}/_{2}$ in. (13 mm) ☐ (Yes) ☐ (No)
Other ______________________

*FILLER METALS (QW-404)

	1	2
Spec. No. (SFA)		
AWS No. (Class)		
F-No.		
A-No.		
Size of Filler Metals		
Filler Metal Product Form		
Supplemental Filler Metal		
Weld Metal		
Thickness Range:		
Groove		
Fillet		
Electrode-Flux (Class)		
Flux Type		
Flux Trade Name		
Consumable Insert		
Other		

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

EXHIBIT "A2"

QW-482 (Back)

WPS No. ______________ Rev. ______________

POSITIONS (QW-405)
Position(s) of Groove ______________
Welding Progression: Up ______________ Down ______________
Position(s) of Fillet ______________
Other ______________

PREHEAT (QW-406)
Preheat Temperature, Minimum ______________
Inter-pass Temperature, Maximum ______________
Preheat Maintenance ______________
Other ______________
(Continuous or special heating, where applicable, should be recorded)

POSTWELD HEAT TREATMENT (QW-407)
Temperature Range ______________
Time Range ______________
Other ______________

GAS (QW-408)

Percent Composition

	Gas(es)	(Mixture)	Flow Rate
Shielding			
Trailing			
Backing			
Other			

ELECTRICAL CHARACTERISTICS (QW-409)

Weld Pass(es)	Process	Filler Metal		Current Type and Polarity	Amps (Range)	Wire Feed Speed (Range)	Energy or Power (Range)	Volts (Range)	Travel Speed (Range)	Other (e.g. Remarks, Comments, hot Wire Addition, Technique, Torch Angle, etc.)
		Classifi cation	Diameter							

Amps and volts or power, or energy range should be recorded for each electrode size, position, and thickness, etc.

Pulsing Current ______________ Heat Input (max.) ______________

Tungsten Electrode Size and Type ______________
(Pure Tungsten, 2% Thoriated, etc.)

Mode of Metal Transfer for GMAW (FCAW) ______________
(Spray Arc, Short Circuiting Arc, etc.)

Other ______________

TECHNIQUE (QW-410)
String or Weave Bead ______________
Orifice, Nozzle, or Gas Cup Size ______________
Initial and Interpass Cleaning (Brushing, Grinding, etc.) ______________

Method of Back Gouging ______________
Oscillation ______________
Contact Tube to Work Distance ______________
Multiple or Single Pass (Per Side) ______________
Multiple or Single Electrodes ______________
Electrode Spacing ______________
Peening ______________
Other ______________

EXHIBIT "B1"

QW-483 PROCEDURE QUALIFICATION RECORDS (PQR)

Company Name ______________________________

Procedure Qualification Record No. ______________________ Date ______________

WPS No. ______________________________

Welding Process(es) ______________________________

Types (Manual, Automatic, Semi-Automatic) ______________________________

JOINTS (QW-402)

Groove Design of Test Coupon

(For combination qualifications, the deposited weld metal thickness shall be recorded for each filler metal and process

BASE METALS (QW-403)

Material Spec. ______________

Type/Grade, or UNS Number ______________

P-No. ______ Group No. ______ to P-No. ______ Group No. ______

Thickness of Test Coupon ______________

Diameter of Test Coupon ______________

Maximum Pass Thickness ______________

Other ______________

POSTWELD HEAT TREATMENT (QW-407)

Temperature ______________

Time ______________

Other ______________

GAS (QW-408)

Percent Composition

	Gas(es)	(Mixture)	Flow Rate
Shielding			
Trailing			
Backing			
Other			

FILLER METALS (QW-404)

	1	2
SFA Specification		
AWS Classification		
Filler Metal F-No.		
Weld Metal Analysis A-No.		
Size of Filler Metal		
Filler Metal Product Form		
Supplemental Filler Metal		
Electrode Flux Classification		
Flux Type		
Flux Trade Name		
Weld Metal Thickness		

Other ______________

ELECTRICAL CHARACTERISTICS (QW-409)

Current ______________

Polarity ______________

Amps. ______________

Volts ______________

Tungsten Electrode Size ______________

Mode of Metal Transfer for GMAW (FCAW) ______________

Heat Input ______________

Other ______________

TECHNIQUE (QW-410)

Travel Speed ______________

String or Weave Bead ______________

Oscillation ______________

Multipass or Single Pass (Per Side) ______________

Single or Multiple Electrodes ______________

Other ______________

POSITION (QW-405)

Position of Groove ______________

Weld Progression (Uphill, Downhill) ______________

Other ______________

PREHEAT (QW-406)

Preheat Temperature ______________

Interpass Temperature ______________

Other ______________

EXHIBIT "B2"

QW-483 (Back)

PQR No. ______________

Tensile Test (QW-150)

Specimen No.	Width	Thickness	Area	Ultimate Total Load	Ultimate Unit Stress, (psi or MPa)	Type of Failure and Location

Guided-Bend Tests (QW-160)

Type and Figure No.	Result

Toughness Tests (QW-170)

Specimen No.	Notch Location	Specimen Size	Test Temperature	Impact Values			Drop Weight Break (Y/N)
				ft-lb or J	% Shear	Mils (in.) or mm	

Comments ______________

Fillet-Weld Test (QW-180)

Result — Satisfactory: Yes ______ No ______ Penetration into Parent Metal: Yes ______ No ______

Macro — Results ______________

Other Tests

Type of Test ______________

Deposit Analysis ______________

Other ______________

- -

Welder's Name ______________ Clock No. ______ Stamp No. ______

Tests Conducted by ______________ Laboratory Test No. ______

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.

Manufacturer or Contractor ______________

Date ______________ Certified by ______________

(Detail of record of tests are illustrative only and may be modified to conform to the type and number of tests required by the Code.)

EXHIBIT "C"

QW-484A WELDER PERFORMANCE QUALIFICATIONS (WPQ)

Welder's name ______________________ Identification no. ______________________

Test Description

Identification of WPS followed ______________________ ☐ Test Coupon ☐ Production Weld

Specification and type/grade or UNS Number of base metal(s) ______________ Thickness ______________

Testing Conditions and Qualification Limits

Welding Variables (QW-350)	**Actual Values**	**Range Qualified**
Welding process(es)		
Type (i.e.; manual, semi-automatic) used		
Backing (with/without)		
Plate ☐ Pipe ☐ (enter diameter if pipe or tube)		
Base metal P-Number to P-Number		
Filler metal or electrode specification(s) (SFA) (info. only)		
Filler metal or electrode classification(s) (info. only)		
Filler metal F-Number(s)		
Consumable insert (GTAW or PAW)		
Filler Metal Product Form (solid/metal or flux cored/powder) (GTAW or PAW)		
Deposit thickness for each process		
Process 1 3 layers minimum ☐Yes ☐No		
Process 2 3 layers minimum ☐Yes ☐No		
Position qualified (2G, 6G, 3F, etc.)		
Vertical progression (uphill or downhill)		
Type of fuel gas (OFW)		
Inert gas backing (GTAW, PAW, GMAW)		
Transfer mode (spray/globular or pulse to short circuit-GMAW)		
GTAW current type/polarity (AC, DCEP, DCEN)		

RESULTS

Visual examination of completed weld (QW-302.4) ______________

☐Transverse face and root bends [QW-462.3(a)] ☐ Longitudinal bends [QW-462.3(b)] ☐Side bends (QW-462.2)

☐ Pipe bend specimen, corrosion-resistant weld metal overlay [QW-462.5(c)]

☐ Plate bend specimen, corrosion-resistant weld metal overlay [QW-462.5(d)]

☐ Pipe specimen, macro test for fusion [QW-462.5(b)] ☐ Plate specimen, macro test for fusion (QW-462.5(e)]

Type	Result	Type	Result	Type	Result

Alternative Volumetric Examination Results (QW-191) ______________ RT ☐ or UT ☐ (check one)

Fillet weld — fracture test (QW-181.2) ______________ Length and percent of defects ______________

☐ Fillet welds in plate [QW-462.4(b)] ☐ Fillet welds in pipe [QW-462.4(c)]

Macro examination (QW-184) ______________ Fillet size (in.) ______ x ______ Concavity/convexity (in.) ______________

Other tests ______________

Film or specimens evaluated by ______________ Company ______________

Mechanical tests conducted by ______________ Laboratory test no. ______________

Welding supervised by ______________

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME BOILER AND PRESSURE VESSEL CODE.

Manufacturer or Contractor ______________

Date ______________ Certified by ______________

Self-Check -1	**Written Test**

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1.
2.
3.
4.
5.

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

1.

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Key Safety Practices

Following proper safety procedures can help maximize product performance and efficiency, while also contributing to a safer environment for operators and nearby workers.

No matter which product is in use, operators should always use a tool guard to improve safety and wear proper safety gear such as face and eye protection and gloves. Most manufacturers' tool and accessory instructions include specifications about the recommended safety gear.

Also, be sure the rpm rating of the wheel or disc meets or exceeds the recommended rpm rating of the grinder for safest use. Just because a product fits, a specific tool does not mean it was designed to be safely used with it.

Grinding wheels with a harder bond tend to load, which refers to base material accumulating on the wheel due to the heat of the grinding process. Some operators form chips or notches around the edge of a grinding wheel to clean a wheel that loads, but this is a dangerous practice that can result in flying debris. Instead, look for a wheel with the appropriate bond strength for pipeline welding.

At the end of the day, quality and productivity are important — but safety is critical. Choosing the right product to prepare and clean the base material for welding — and following some key best practices — helps prolong product life, improve operator efficiency and benefit safety on the pipeline jobsite.

Self-Check -1	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

3.
4.
5.
6.
7.

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

1.

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2...

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References

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- *Henderson, J.G. (1953). Metallurgical Dictionary. New York: Reinhold Publishing Corporation.*
- *Smith, Dave (1984). Welding Skills and Technology. New York: McGraw-Hill Book Company. ISBN 0-07-000757-8.*
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Funk,

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