TVET CERTIFICATE IV in WELDING

SMAW PLATE

WLDSP401

Perform SMAW Plate

Competence

Credits: 12

Learning hours:120

Sector: Mining and Manufacturing

Sub-sector: Welding

Module Note Issue date: August,2020

Purpose statement

This specific module describes the performance outcomes, skills and knowledge required to prepare the edge of thicker material and perform multi run welds on groove and fillet joints up to unlimited thickness in manufacturing with SMAW process.

Table of Contents

Total Number of Pages: 35 pages

Learning Unit 1 – Analyze the SMAW plate work

Shielded Metal Arc Welding of Plate (SMAW Plate) is an arc welding process in which the fusing of Plates is produced by heat from an electric arc that is maintained between the tip of a consumable covered electrode and the surface of the base metal in the joint being welded. SMAW Plate is most commonly used for a number of reasons, it can be used to make strong durable welds in a wide range of metal plate thickness and types.
The filler metal is deposited from the electrode, and the electrode covering provides the shielding. Some slang names for this process are ''stick welding'' or ''stick electrode welding.
The shielded metal arc welding of plate is basically a manually operated process.
The electrode is clamped in an electrode holder and the welder manipulates the tip of the electrode in relation to the metal being welded. The welder strikes, maintains, and stops the arc manually on a metal plate to be welded.

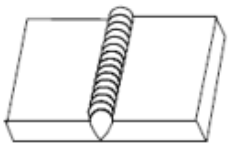
LO 1.1. Identify the work

Content/Topic 1. Plate welding positions

The welding position refers to the position of the welding operator towards the work piece to be welded. The following are four types of plate welding positions:

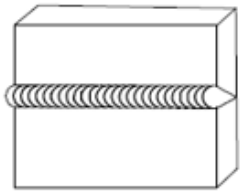
3.1. Flat or Down Hand Welding Position

The flat position or down hand position is one in which the welding is performed from the upper side of the joint and the face of the weld is approximately horizontal. This is the simplest and the most convenient position for welding. Using this technique, excellent welded joints at a fast speed with minimum risk of fatigue to the welders can be obtained.



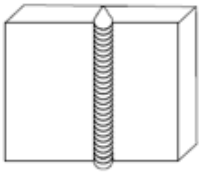
3.2. Horizontal Welding Position

In horizontal position, the plane of the work piece is vertical and the deposited weld head is horizontal. The metal deposition rate in horizontal welding is next to that achieved in flat or down hand welding position. This position of welding is most commonly used in welding vessels and reservoirs.



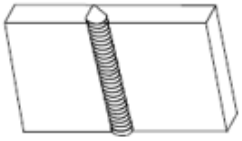
3.3. Vertical Welding Position

In vertical position, the plane of the workpiece is vertical and the weld is deposited upon a vertical surface. It is difficult to produce satisfactory welds in this position due to the effect of the force of gravity on the molten metal. The welder must constantly control the metal so that it does not run or drop from the weld. Vertical welding may be of two types viz., vertical-up and vertical-down. Vertical-up welding is preferred when strength is the major consideration. The vertical-down welding is used for a sealing operation and for welding sheet metal.



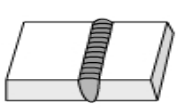
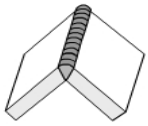
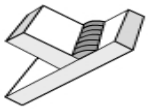
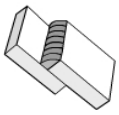
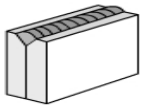
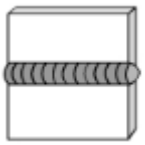
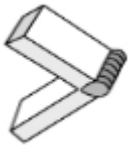
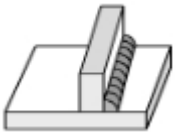
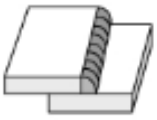
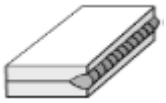
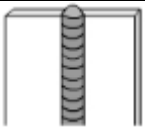
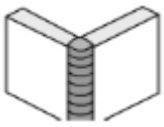
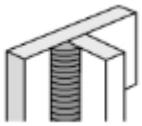
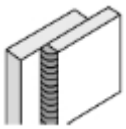
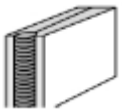
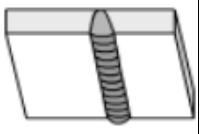
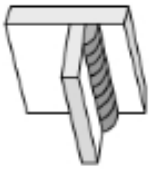
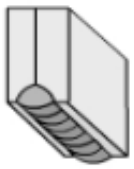
3.4. Overhead Welding Position

The overhead position is probably even more difficult to weld than the vertical position. Here the pull of gravity against the molten metal is much greater. The force of the flame against the weld serves to counteract the pull of gravity. In overhead position, the plane of the work piece is horizontal. But the welding is carried out from the underside. The electrode is held with its welding end upward. It is a good practice to use very short arc and basic coated electrodes for overhead- welding.



The types of welding positions are represented by letter symbols and number in welding symbols, here, **Groove** weld is indicated by letter **G,** while **Fillet** weld is indicated by letter **F.** therefore it may be either **1G** for flat position groove weld, **2G** for horizontal position groove weld, **3G** for vertical position groove weld and **4G** for overhead position and finally **5G** for welding pipes, or **1F** for flat position fillet welds, **2F** for horizontal, **3F** vertical and **4F** for overhead position Fillet weld respectively.

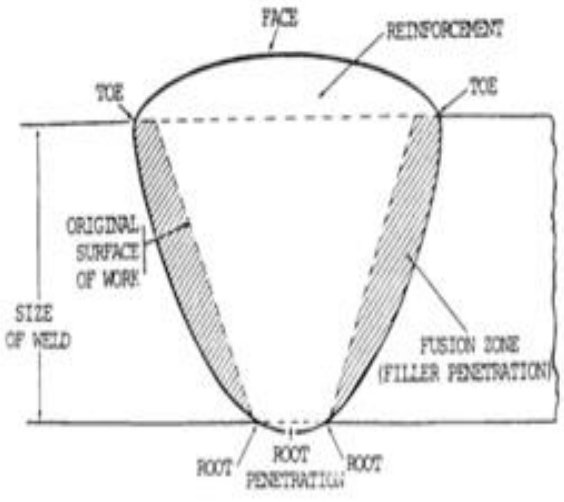
Table below shows the various positions and joints used in plate welding.

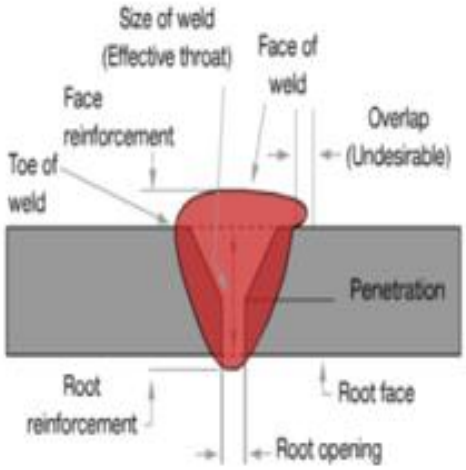
POSITION	JOINT				
	Butt Joint	Comer Joint	T – Joint	Lap Joint	Edge Joint
Flat					
Horizontal					
Vertical					
Overhead					

LO 1.2. Perform hand draft drawing

Content/Topic 1. Groove nomenclature

Grove weld: it is a type of weld which used when to parts come together in the same plane





i. **Fusion Zone (Filler Penetration):** The fusion zone is the area of base metal melted as determined in the cross section of a weld.

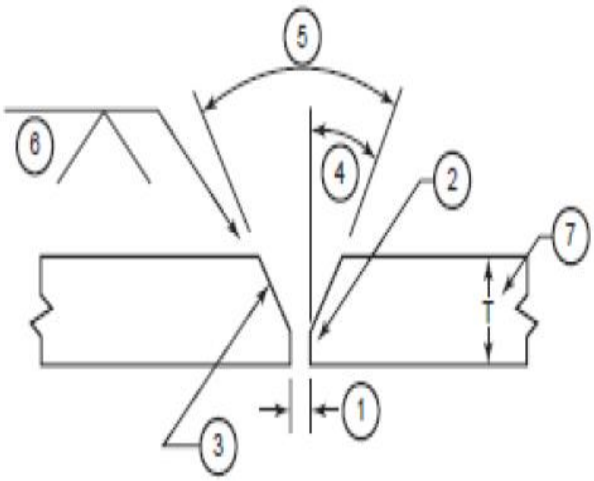
ii. **Root Penetration**: This is the point at which the bottom of the weld intersects the base metal surface, as shown in the cross section of weld.

iii. **Size of the Weld (Equal leg-length fillet welds):** The size of the weld is the depth of chamfering plus the root penetration when specified on grove weld.

iv. **Face of the Weld.** This is exposed surface of the weld, made by an arc or gas welding process on the side from which the welding was done.

v. **Toe of the Weld:** is the junction between the face of the weld and the base metal.

vi. **Reinforcement of the Weld**: This is the weld metal on the face of a groove weld in excess of the metal necessary for the specified weld size.

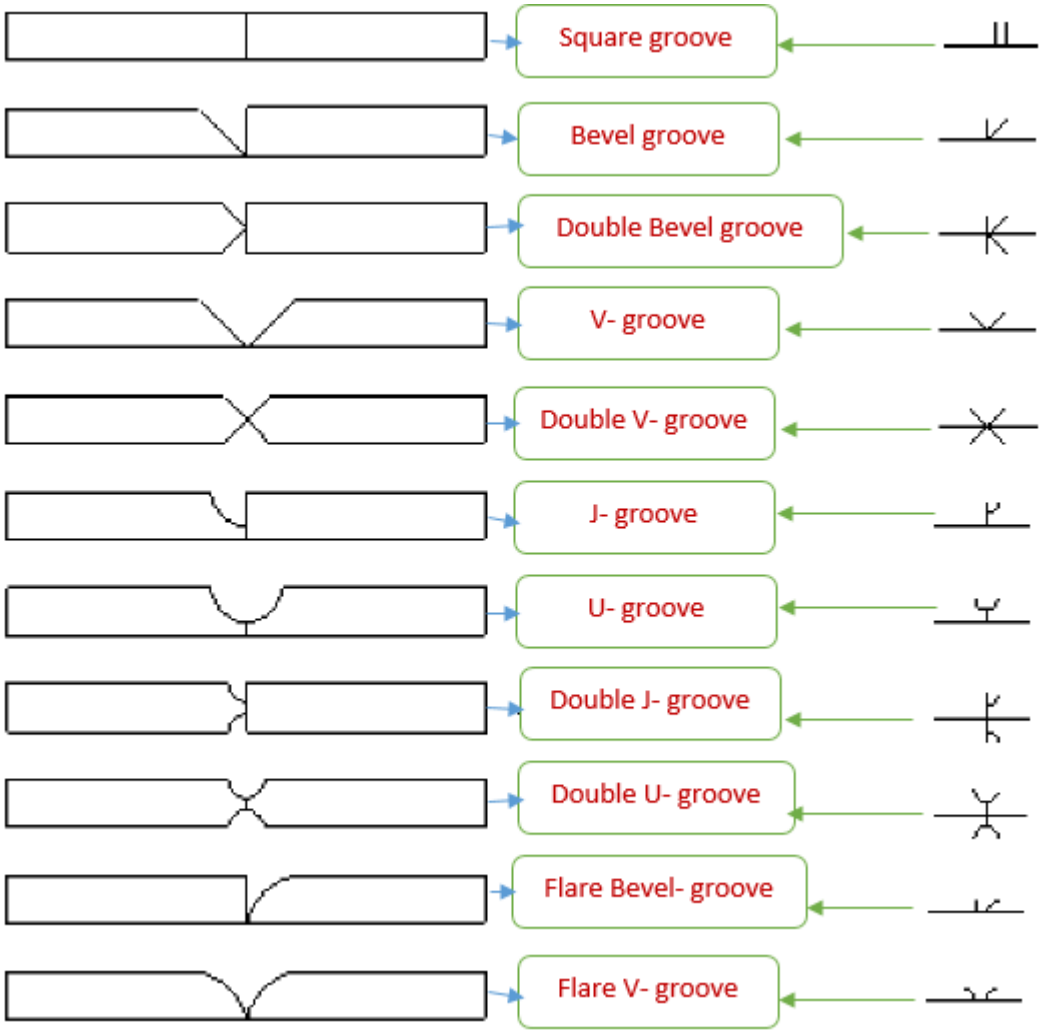


Groove Weld

1. Root Opening: A separation at the joint root between the workpieces.
2. Root Face: That portion of the groove face adjacent to the joint root.
3. Groove Face: The surface of a joint member included in the groove.
4. Bevel Angle: The angle formed between the prepared edge of a member and a plane perpendicular to the surface of the member.
5. Groove Angle: The total included angle of the groove between workpieces.
6. Groove Weld Size: The joint penetration of a groove weld.
7. Plate Thickness (T): Thickness of the base metals to be welded.

Content/Topic 2. Groove weld symbols

A groove weld may be applied in a butt joint and may have a preparation or not before welding. This is the reason there are several types of groove welding symbols.



The symbols for these grooves are nearly identical to the symbols that represent them.

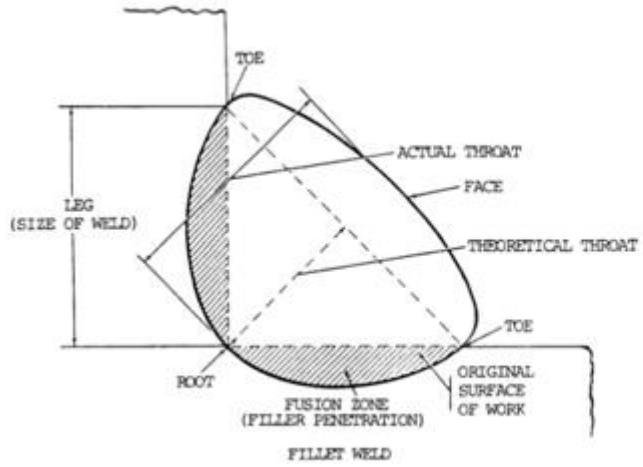
Below is a welding symbol of a single V-Groove weld on the other side. All single groove welds should be considered complete joint penetration (CJP) unless otherwise specified.

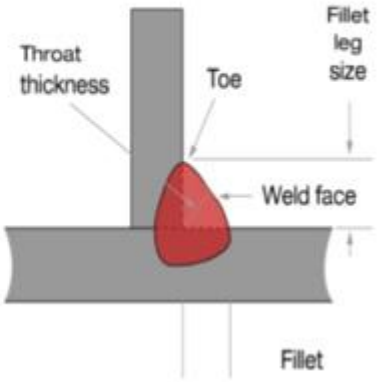
If a weld is to be applied to both sides of the joint this is called a double groove weld.

For example, below is a welding symbol of a double bevel groove weld.

Content /Topic 3. Fillet weld configuration

Fillet weld: This weld is used when the joint has two members coming together to form an intersection of commonly 90 degrees.

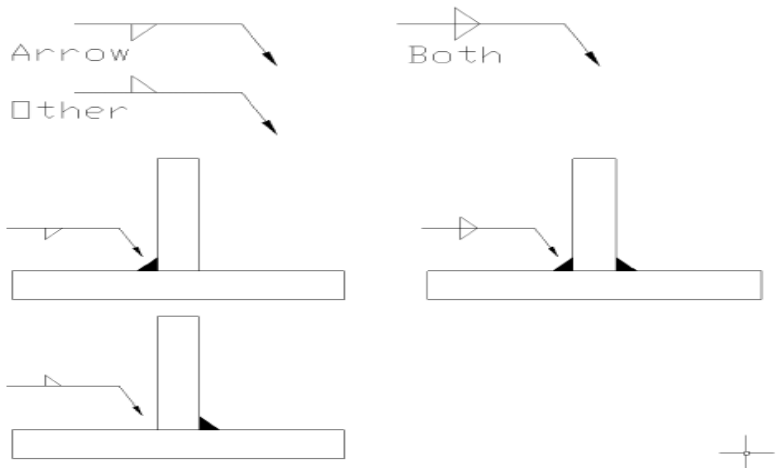




i. **Fusion Zone (Filler Penetration):** The fusion zone is the area of base metal melted as determined in the cross section of a weld.
ii. **Leg of a Fillet Weld:** The leg of a fillet weld is the distance from the root of the joint to the toe of the fillet weld. There are two legs in a fillet weld.
iii. **Root of the Weld**: This is the point at which the bottom of the weld intersects the base metal surface, as shown in the cross section of weld.
iv. **Size of the Weld (Equal leg-length fillet welds):** The size of the weld is designated by leg-length of the largest isosceles right triangle that can be scribed within the fillet weld cross section. The size of the weld is designated by the leg-length of the largest right triangle that can be inscribed within the fillet weld cross section.
v. **Throat of a Fillet Weld (Theoretical throat**): This is the perpendicular distance of the weld and the hypotenuse of the largest right triangle that can be inscribed within the fillet weld cross section.
vi. **Actual throat**: This is distance from the root of a fillet weld to the center of its face.
vii. **Face of the Weld.** This is exposed surface of the weld, made by an arc or gas welding process on the side from which the welding was done.
viii. **Toe of the Weld:** This is the junction between the face of the weld and the base metal.

Content /Topic 4. Fillet weld symbols

Fillet welds are one of the most common weld types in the industry. This weld is used when the joint has two members coming together to form an intersection of commonly 90 degrees. These welds can be applied on varying angles but this would be the most prominent. sides of the reference line it is called a double Fillet weld. The vertical leg of the symbol will always be placed to the left regardless of which way the arrow is pointing.



LO 1.3. Estimate cost

Content /Topic 1. Elements of Bill of quantity

A bill of quantity (BOQ) is a document which is especially used in tendering in the construction industry, supplies or other works in which materials, parts, and food too (and their costs) are itemized or described in details

Elements of Bill of quantity(BOQ):

Parts of BOQ can be varied according to the project size as well the practices.

Generally, it has:

1. **Serial number**: is a unique, identifying number or group of numbers and letters assigned an item
2. **Item Description and/or specifications:** Define exactly how each standard will be measured or give information about items
3. **Unity price**: is the price per one items required
4. **Total price:** is the price per total similar item required
5. **Labor cost**:30% of material total price: is the cost of labor is the sum of all wages paid to employees, as well as the cost of employee benefits and payroll taxes paid by an employer
   Labor cost=summation of all material total cost multiply with 30%

6. **Taxes:** is a mandatory financial charge or some other type of charge imposed upon a taxpayer (an individual or other legal entity) by a governmental organization in order to fund various public expenditures(outgoings). A failure to pay, along with resistance to taxation, is punishable by law
7. **Transport:** a particular movement of an items or things from a point A to the Point B
8. **Grand total:** is the sum of the sums of several groups of numbers
9. **Contingencies:** a future event or circumstance which is possible but cannot be predicted with certainty

Below is a sample of Bill of Quantity (cost estimation):

COSTING LIST (bill of quantity) FOR 1 DOOR

No	Designation	Spécification	Quantity	UNIT PRICE	TOTAL PRICE
1	HS P	6000mm	1p	15000F	15,000frws
2	Sheet metal	1,5mm	1/2p	20000f	10,000frws
3	**Omega**	**6000mm**	**0p**	**15000f**	**0frws**
4	**PB**	**6000mm**	**1p**	**15000f**	**15000frws**
5	Tubes	20x20mm	1p	4000f	4000frws
6	Tee bar	2x20mm	1/4	4000f	1000frws
7	Flat bar	2x20mm	1/4	4000f	1000frws
8	hingle	12mm	3	500f	1500frws
9	Rock	Kale	1p	13000f	13000frws
10	Cutting disc	230x3x22 ,23mm	1p	2000f	2000frws
11	Grinding disc		1/2p	2000f	1000frws
12	Anti rust		1/2kg	5000f	2500frws
13	**Mastic for metals**	**P38**	**4kg**	**150000f**	**4000frws**
14	Electrode	2.5mm	200p	20	4000frws
	Sub-Total				55,000frws
	Labour Cost		(107000fx35) :100=37450f		
	Grand TOTAL		**144,450F**		

Prepared by :..... **Approved by:** .....

The Importance of BOQ

BOQ shall be used in every phase (pre-contract & post-contract) of the project but need of BOQ differs based on different contract agreements & project. The major usages are listed below.

- It provides basic idea of the project by giving the quantities to tenderers.
- It defines the extent of the work.
- It gives estimated or anticipated contract sum. (very important to client)
- It provides a basis for valuation of variation. (Variation is to be discussed in detail).

Learning Unit 2 – Organize the workplace

LO 2.1. Arrange the workplace

Content/Topic 1. Workplace layout.

Workplace Arrangement is such a systematic and efficient functional arrangement of various departments, machines, tools, equipment and other supports services of an industrial or workshop organization that will facilitate the smooth processing of the proposed or undertaken product in the most effective, most efficient and most economical manner in the minimum possible time"

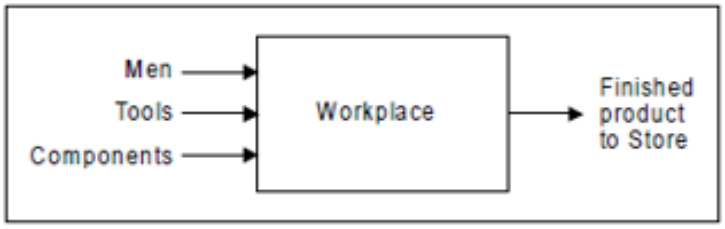
A good workplace layout should meet the following basic requirement:

i. Integration of manufacturing centre facilities in terms of man, machine and material.
ii. Movements of production personnel and material handling should be minimized.
iii. Smooth and continuous flow of production or manufacturing work with least possible bottlenecks and congestion points.
iv. Floor space utilization should be optimum as for as possible.
v. Working place should be free from pollution and safe working conditions should prevail in each shop of the plant.
vi. The handling of raw material, semi-finished and finished product should be should be tackled optimally and effectively
vii. Plant layout and shop layouts must be flexible to facilitate changes in production Requirements
viii. There should be better working environment in term of proper light, ventilation and other amenities such as drinking water and toilets for welfare for the manufacturing personnel

TYPES OF LAYOUTS

1. Fixed or Position Layout

Fixed or position layout is also known as project layout. In this type of layout, the major part of an assembly or material remains at a fixed position. All its accessories, auxiliary material, machinery, equipment needed, tools required and the labor are brought to the fixed site to work. Thus, the product by virtue of its bulk or weight remains at one location.



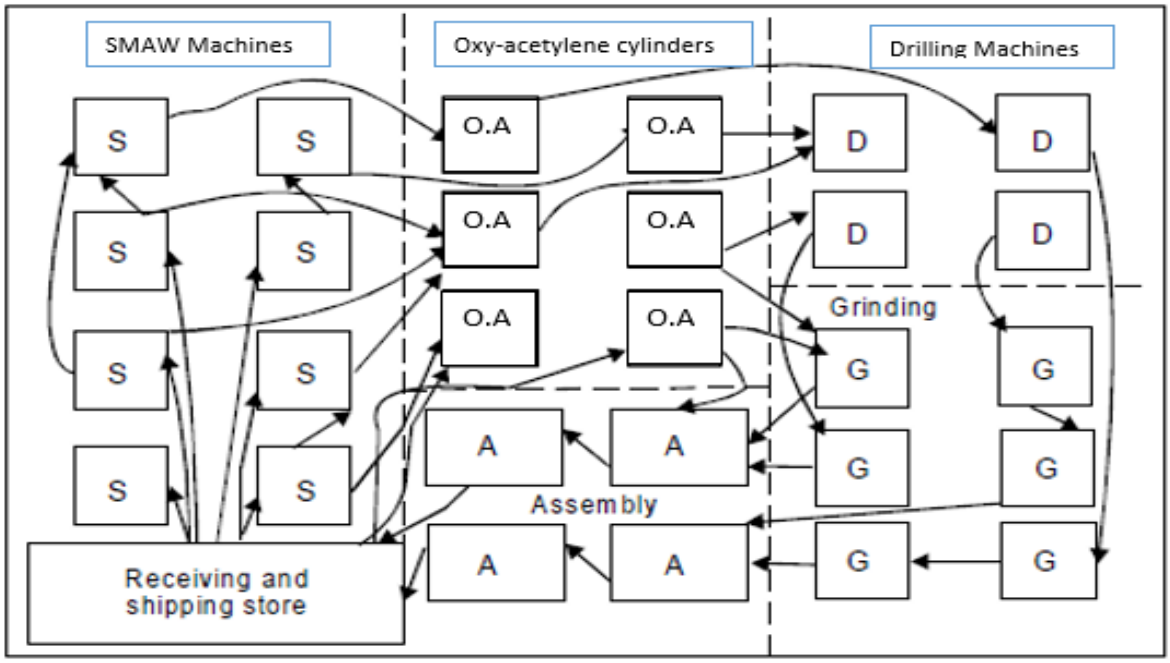
Typical fixed workplace layout

This layout is suitable when one or a few pieces of an item are to be manufactured and material forming or treating operation requires only tools or simple machines. This layout is highly preferable when the cost of moving the major piece of material is high and the

responsibility of product quality by one skilled workman or group of skilled workers is expected.

2. Process or Functional Layout

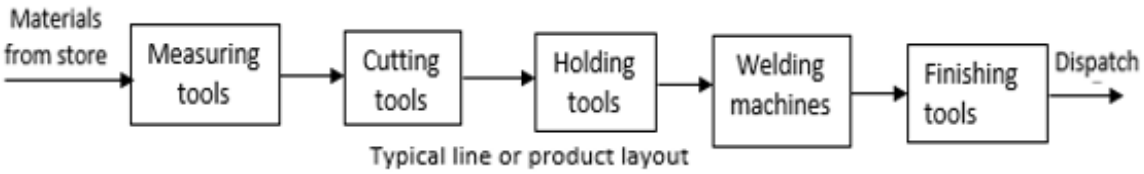
In this type of layout arrangements of similar machines, production facilities and manufacturing operations are grouped together according to their functions. Machine tools of one kind are positioned together so that all the similar operations are performed always at the same place; for example, all the SMAW welding machines may be grouped together, all drilling machines in one area for carrying out drilling work, all oxy-acetylene welding setup in one area for carrying out oxy-acetylene welding work, all grinding machines in one area for carrying out grinding work and/or all other buffing and polishing machines at one place for carrying out surface finishing work, and so on.



This type of layout is normally preferred for the industries involved in job order type of production and manufacturing and/or maintenance activities of non- repetitive type. This layout needs not to have to be changed every time of the product or component changes. Also the breakdown of any machine does not affect the production. This type of layout is highly suitable for batch production.

3. Line or Product Layout

This layout implies that various operations on raw material are performed in a sequence and the machines are placed along the product flow line, i.e., machines are arranged in the sequence in which the raw material will be operated upon. In this type of layout all the machines are placed in a line according to the sequence of operations, i.e., each following machine or section is arranged to perform the next operation to that performed by its preceding machine or section. In this layout raw material starts from one end of production lines and moves from one machine to next along a sequential path. Line layout is advantages in the continuous- production system where the number of end products is small and the parts are highly standardized and interchangeable.



Typical line or product layout

This layout is used for mass production and ensures smooth flow of materials and reduced material handling. Breakdown of any machine in the line in this layout may result in even stoppage of production.

LO 2.2. Select the tools, materials and equipment

Content/Topic 1. Materials and equipment for plate welding

Electrodes: the arc welding electrodes used for plates welds are grouped into two majors classes (series) according to their major welding characteristics. Those are E60 series and E70 series.

The American welding society (AWS) numbering system can tell a welder quite a bit about a specific stick electrode including what application it works best in and how it should be used to maximize performance.

The prefix **"E"** designates an arc welding electrode; the first **2 digits** of a 4-digits indicate minimum tensile strength of electrode; for example, **E6010** is an electrode having tensile strength of **60kpi** (kilo-pound per square inch) or **60,000psi** tensile strength electrode.

The 3rd character indicates the different positions in which welding can be done using this electrode. In this case "1" in **E6010** means that the welding can be done in flat, overhead, horizontal and vertical (upwards).

1 Flat, Horizontal, Vertical (up), Overhead
2 Flat, Horizontal
4 Flat, Horizontal, Overhead, Vertical (down)

Flat Position - usually groove welds, fillet welds only if welded like a "V"
Horizontal - Fillet welds, welds on walls (travel is from side to side).
Vertical - welds on walls (travel is either up or down).
Overhead - weld that needs to be done upside down.

This fifth character indicates the type of flux coating used, penetration of the electrode and the type of current suitable for the electrode. In this case the "3" in **E6013** tells that it has a rutile potassium-based flux coating. The penetration of the electrode is light and it can be used with AC and DC currents.

Class	Electrode Coating	Penetration	Current Type
Exxx0	Cellulose, Sodium	Deep	DCEP
Exxx1	Cellulose, Potassium	Deep	AC, DCEP
Exxx2	Rutile, Sodium	Medium	AC, DCEN
Exxx3	Rutile, Potassium	Light	AC, DCEP, DCEN
Exxx4	Rutile, Iron Powder	Medium	AC, DCEP, DCEN
Exxx5	Low Hydrogen, Sodium	Medium	DCEP
Exxx6	Low Hydrogen, Potassium	Medium	AC, DCEP
Exxx7	Iron Powder, Iron Oxide	Medium	AC, DCEN
Exxx8	Low Hydrogen, Iron Powder	Medium	AC, DCEP
Exxx9	Iron Oxide, Rutile, Potassium	Medium	AC, DCEP, DCEN

Sometimes there is an extra character which are used for additional requirements.
For example, in the electrode **E7018- A1**, the suffix "A1" in the last refers to added chemical composition of 0.5 % Mo. These suffixes generally differ from manufacturer to manufacturer and even though the electrodes may be belonging to the same standard they may still be slightly different as each manufacturer likes to add a personal touch.

a. E60 series

The E60 series are obtained into four types which are E6010, E6011, E6012 and E6013 electrodes respectively.
Both **E6010 and E6011 are Cellulose-based fluxes**. As a result, these electrodes have a forceful arc with little slag left on a weld bead. They can be used on metals that has a little rust, oil or dust without seriously affecting the weld's strength.
E6010 - This electrode is used when welding with DCEP (Reverse Polarity). This type provides for deep penetration into thick metal, and can be used where the parent metal is difficult to clean. (Dirty, rusty or painted). The characters **60** for this type of electrode means that electrode have tensile strength of 60kpsi (kilo pounds per square inch), **1** means that the welding can be done all position (in flat, overhead, horizontal and vertical-upwards), then **0** is a type of coating which is cellulose, sodium
E6011 - This is used for both AC and DC operations on thick metal. Because E6011 electrodes can be used with alternating current (AC), Smaller transformer type welders that put out only AC welding current can be used.
The characters **60** for this type of electrode means that electrode have tensile strength of 60kpsi (kilo pounds per square inch), **1** means that the welding can be done all position (in flat, overhead, horizontal and vertical-upwards), then **1** is a type of coating which is cellulose, potassium.

E6012- are electrodes giving a smooth, easy arc with a thick slag left on the weld bead.
The characters **60** for this type of electrode means that electrode have tensile strength of 60kpsi (kilo pounds per square inch), **1** means that the welding can be done all position (in flat, overhead, horizontal and vertical-upwards), then **2** is a type of coating which is rutile, sodium

E6013 - This is a "general-purpose electrode". Is used where the weld appearance is important and where "medium penetration" is required. Suitable for both AC and DC.
Both E6012 and E6013 are easy electrodes to use, hey do not have forceful arcs, so they can be used on thinner metals such as some thicker sheet metal gauges that are used as guards on equipment.
The characters **60** for this type of electrode means that electrode have tensile strength of 60kpsi (kilo pounds per square inch), **1** means that the welding can be done all position (in flat, overhead, horizontal and vertical-upwards), then **3** is a type of coating which is rutile, potassium.

b. E70 series

The E70 series are classified into E7016 and E7018 electrodes. Both of these electrodes have a mineral-based flux. The resulting is a smooth and easy, with a very heavy slag left on the weld bead. Of these two electrodes, E7018 is the one used most often to make high strength welds on a plate.
Electrodes with rutile-based fluxes (giving an easy arc with low spatter) are easier to control and are used for fillet, stringer beads and butt joints.

1. Equipment

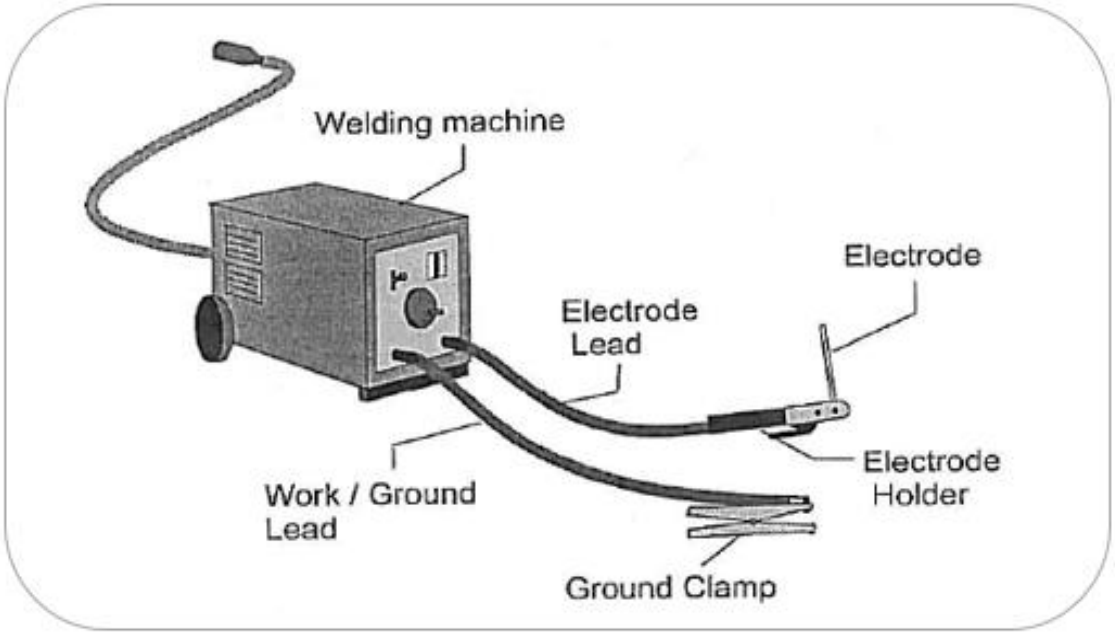
a. Electrode dry oven

Electrode dry oven is a high quality welding rod heater made of stainless steel enabling it to be used in tough environments for drying electrodes for the purpose of removing and/or preventing moistures or wetness in electrodes coatings.
Below is the example type of electrode dry oven. This is HP6 type dry oven, it has a variable thermostat (30–110°C) and an indicator lamp that indicates that the quiver is plugged in. The heater inside the HP6 is located in the middle to obtain excellent heating result on all welding rods. It is insulated all around to keep the heat inside the welding rod heater which also makes it safe and energy efficient.

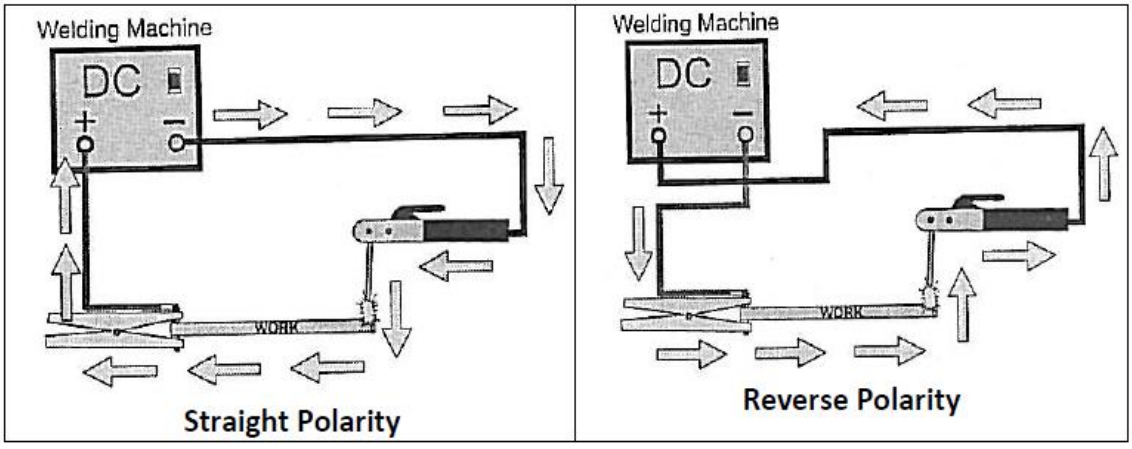
This type of electrode dry oven is available with input voltage 24V, 110V or 230V.
It is a Portable electrode dry oven because it is simple and light in weight as it has 4kg weight and can carry 6kgs of electrodes.

b. DC welding machine

A DC welding machine produces "**direct** current" to the welding-electrode. DC is a more "stable" current than AC and is particularly suitable for welding thin steel plate and certain "non-ferrous" metals. One of the major advantages of DC machines is that the welder (Operator) has the choice of changing the output "**polarity**" from "straight" to "reverse".



In DC welding machines, Direct Current (DC) flows from a "negative" connection and completes its "circuit" at the "positive" connection. When the electrode is connected to the "negative" (-) output connection of the machine then the system is considered as being "straight polarity".



DCEN **DCEP**

In such a connection the current flows from the work to the electrode. The electrode in this case is "negative" and we call this circuit "DCEN" (direct current- electrode **negative**).

If the welding leads are switched around, that is if we connect the **electrode lead** to a **Positive** (+) output connection, then the electrode becomes "positive" and the flow will be from the electrode to the work. Such a circuit is called "DCEP" (Direct current -electrode **positive**).

On some DC machines simply operating a switch (polarity switch) from "straight to reverse" can change the current "polarity". On other types of machine, it is necessary to (physically) swap the welding-leads at the machines' "output-terminals" in order to switch polarity.

DCSP (Direct current Straight Polarity) also known as Direct current electrode negative (DCEN) results in fast melting of the electrode but less heat into the base metal, whereas DCRP (DC Reversed Polarity) also known as DC Electrode positive (DCEP) results in deep weld penetration and is suitable for thick metal joints.

i. Welding cables

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

ii. **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 500amps.

iii. 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 workpiece.

iv. Ground clamp

A good ground clamp is essential to produce quality welds. Without proper grounding, the circuit voltage fails to produce enough heat for proper welding, and there is the possibility of damage to the welding machine and cables. Three basic methods are used to ground a welding machine. You can fasten the ground cable to the workbench with a C-clamp, attach a spring-loaded clamp directly onto the workpiece, or bolt or tack-weld the end of the ground cable to the welding bench. The third way creates a permanent common ground.

Learning Unit 3 – Perform Plate Welds

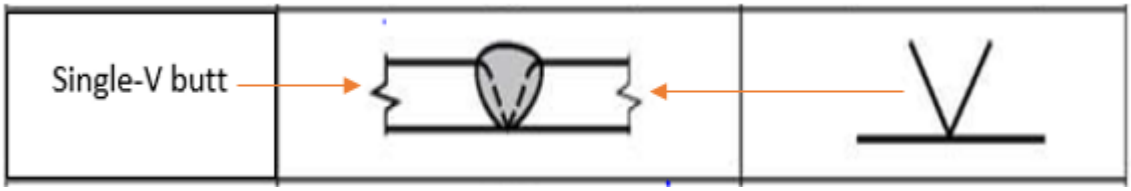
LO 3.1. Prepare work pieces.

Content/Topic 1. Edge preparation:

a. **Types of edge shapes**:

i. **V-shape** (single V butt)

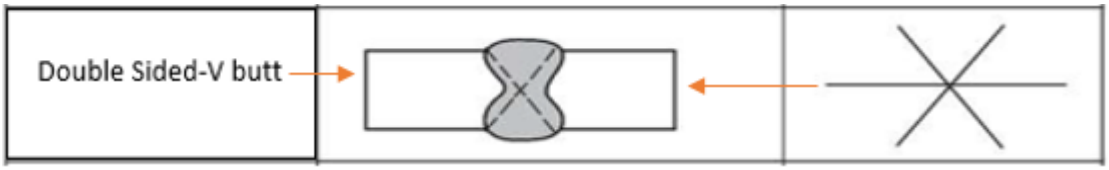
The single V butt joint has a 45° weld prepared on one side of each plate the full depth of the material.



The joined plates will form a V shapes as the symbol indicates.

ii. **X-shape** (Double-V)

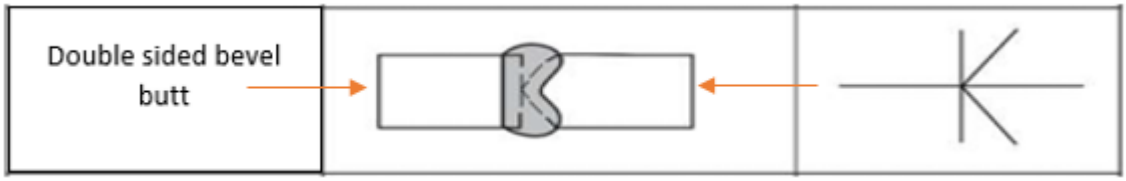
Both ends of each plate have a 45° bevel cut out meeting halfway through the plate to form a point. When joined together, the points meet.



This creates an X as seen in the symbol, the full depth of the point

iii. **K-shapes** (Double sided bevel)

One plate has no weld prep, keeping its corners square. The other side has two 45° bevels finishing along the middle to make a point.



As the symbols displays, the joined plates will form a K.

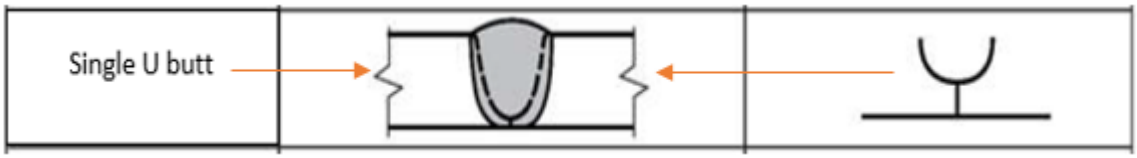
iv. **Y-shape** (Square V butt broad root face)

Similar to the single V butt, this weld preparation has a 45° angle on one side of each plate from the top of metal to no more than ¾ of the way down the plate depth, leaving a section of material below.

Here, the joint imitates its symbol as a Y

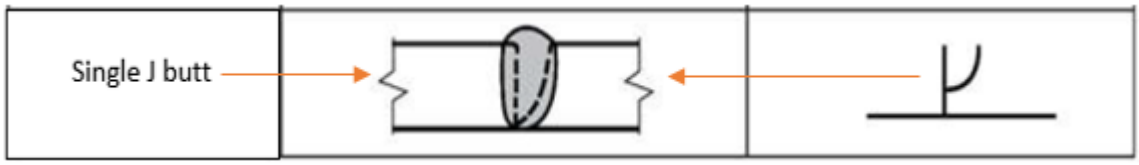
v. **U-shape** (Single U butt)

Both plates have a corner cut out in a ¼ moon shape about ¾ of the plate gauge deep to form a U partway through the joined sections, as the symbol shows.



vi. **J-shape** (single J butt)

One plate has a square end, while the other has a corner cut out in a ¼ moon shape partway through the plate thickness, forming a mild J when joined, as you can see in the symbol.



b. Advantages of edge preparation

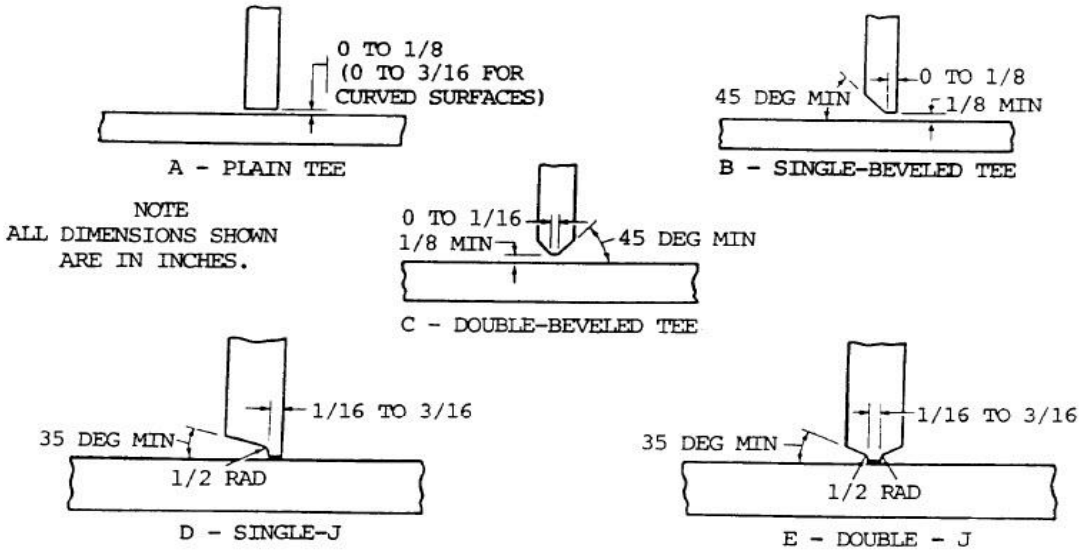
Edge preparation is generally done for products where it is intended to be put under some considerable load.

- Edge preparation makes it easier to get a stronger bond via Welding and adding filler metal.
- Edge preparation provides access for the Welding operation.
- It provides an area where some filler metal can be added.
- This makes the weld/joint very strong and can be subjected to greater amount of load

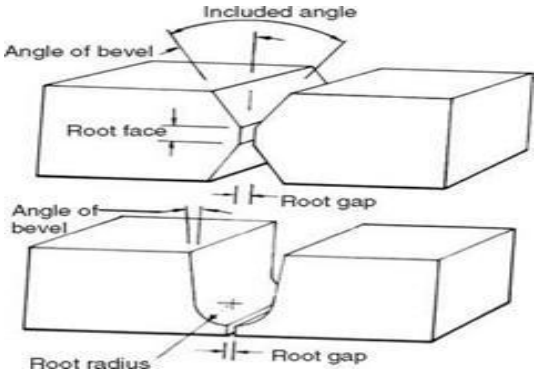
c. Disadvantages of edge preparation

- Sharped workpieces can cause accident like injuries, even death.
- During edge preparation it requires experiences for doing it.
- Poor edge preparation may cause welding defects and/or poor weldment on edges

d. Industrial application of edge preparation: Edge preparation consists of removing material along edges of metal surfaces. You must prepare edges for welding when parts and assemblies require certain strength. To achieve full welding penetration, you must cut the edges of the metal. The weld replaces the removed material and makes a complete bridge between the joining parts



Edge preparation is only possible for certain weld types. For example, root opening preparation is available for square groove or butt, V groove or butt, bevel groove or butt, U groove or butt, J groove or butt, flare V groove or butt, and flare bevel groove or butt welds. Angle cut preparation is available for V groove or butt and bevel groove or butt welds.



Edge preparation are applied in industries for several applications such as:

i. Edge preparation is used in welding heavy equipment manufacturing industry
ii. It may be used to some extent in welding industrial piping.
iii. The edge preparation is used in welding of thick plates in industries.

iv. It is also used in maintenance and bridges fabrication.

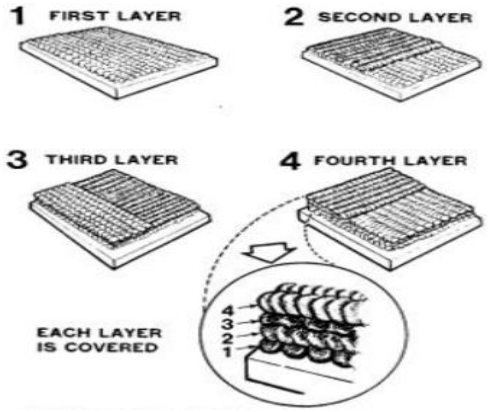
LO 3.2. Perform steel plate welds

Content/Topic 1. Padding

A padding weld consists of successive layers of overlapping weld beads. It is used in building up broken or worn parts, in repairing machining defects, for making local bosses on a part,

and for filling in large cavities when heavy sections are welded. Depending upon the space to be filled up a padding weld may be of either single layer or multi-layer type.

To lay a padding weld, the surface is thoroughly cleaned with a wire brush before depositing the first run at the edge of the surface using a narrow or slightly spreading bead.

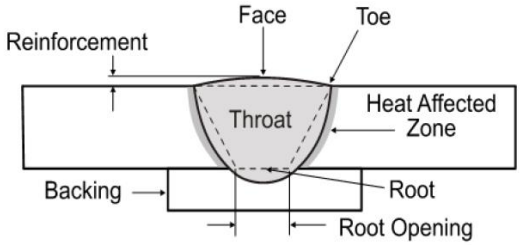


When the weld is not accessible from the backside it is imperative to seal it thoroughly while laying the root run.

If the two adjacent padding beads are separated by a depression, then the padding will not be continuous and hence may be un-satisfactory. Before laying the next bead the beads already laid should be thoroughly de-slagged with the help of chipping hammer and a steel wire brush.

Content/Topic 2. Groove weld

A groove weld is a type of weld used when two parts come together in the same plane. These welds will be applied in a butt joint and may have a preparation or not before welding.



On open groove welds, a stick welder typically performs a whipping motion with his or her wrist on the root pass, which is the first weld operation performed. The objective here is to fuse the work plates together at the bottom with a flat bead of weld metal. The most common stick electrodes for root passes on low-carbon steel are E6010 and 6011 "fast-freeze" rods.

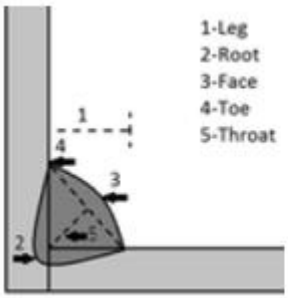
Content /Topic 3. Fillet weld

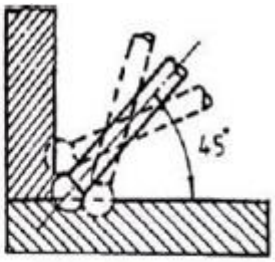
Fillet welds: A weld of approximately triangular cross section joining two surfaces at approximately right angles to each other.

Fillet welding refers to the process of joining two pieces of metal together whether they be perpendicular or at an angle. These welds are commonly referred to as Tee joints which are two pieces of metal perpendicular to each other or Lap joints which are two pieces of metal that overlap and are welded at the edges.

Fillet welds often suffer from poor penetration at the root of the weld and poor fusion at one surface. In welding fillet welds, the electrode is equally inclined to horizontal and vertical surfaces.

This angle, however, may be varied to get more heat on either of the two surfaces as shown in Figure below:





Electrode angles in fillet welds.

Like butt welds, fillet welds can be made either in a single pass or in multi-pass.

Fillet welds with a leg length of up to 8 mm are usually made in a single pass. When making a multi-run fillet weld the first run is made with an electrode 3.15 or 4 mm in diameter without weaving and that ensures good penetration at the root of the weld.

Content/Topic 4. Aligning and presetting of plates

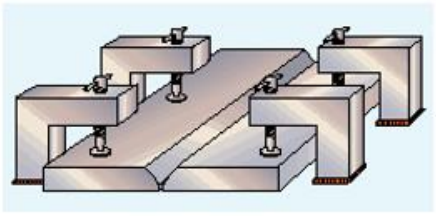
The metal plates are pre-set and left free to move during welding. In practice, the workpieces are pre-set by a pre-determined amount so that distortion occurring during welding is used to achieve overall alignment and dimensional control.
As it is difficult to predict the amount of pre-setting needed to accommodate shrinkage, a number of trial welds will be required. Pre-setting is a technique more suitable for simple components or assemblies.

Because of the difficulty in applying pre-setting, 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. This can be cured by either applying a small amount of pre-set or stress relieving before removing the restraint.

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

Jigs and fixtures

Jigs and fixtures are used to locate the parts and to ensure that dimensional accuracy is maintained whilst welding.

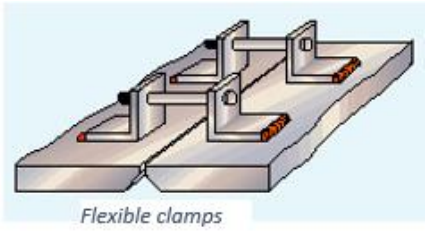


Jigs and fixtures

The welding engineer will need to ensure that the finished fabrication can be removed easily after welding.

Flexible clamps

A flexible clamp 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).



Flexible clamps

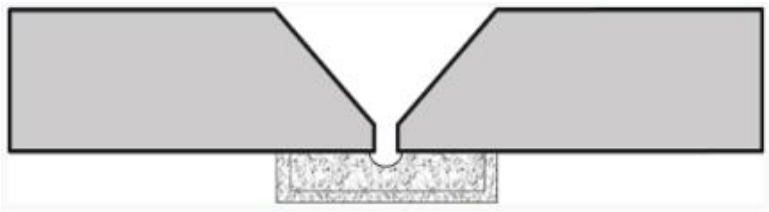
A disadvantage is that, as the restraining forces in the clamps are transferred into the joint when the clamps are removed, the level of residual stress across the joint can be quite high.

Content/Topic 5. Plate backing methods:

Backing plate is defined as material placed at the root of a weld joint for the purpose of supporting molten weld metal. Its function is to facilitate complete joint penetration.

a. Ceramic backing plate:

Ceramic backing plate is a temporary backing that may be made from copper or a ceramic substance that do not become fused to the root and are easily removed when welding is finished. This type of backing is also referred to as removable backing.



Ceramic backing plate

Ceramic Backing Material are used to prevent the molten metal from running out during the SMAW Plate process, it supports the weld root and can be broken free when the metal cools.

The use of ceramic backing strips enables welding to be carried out from a single side, with full penetration and reduces (and often removes) the need to grind out and re-weld a root from the reverse side.

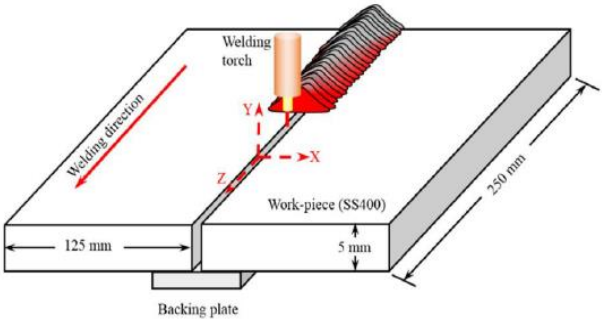
Ceramic backing plate are commonly used in heavy-SMAW plates applications, including structural steel fabrication, bridge-building, etc.

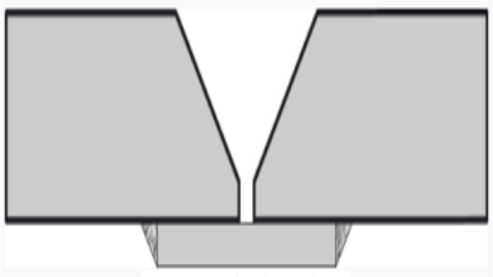
Ceramic backing strips can be used with every weldable material to reduce oxidation and prevent hydrogen inclusion, by providing a heat-reflecting, weld-supporting surface against which to deposit the welding consumable.

Gas release gaps reduce porosity by preventing gas-entrapment. By removing the need to grind out and re-weld from the reverse side and facilitating deposition of root and fill in a single pass, the use of ceramic backing strips can reduce re-work, improve efficiency and provide operational economies.

b. Permanent backing plate

Permanent backing is usually made from a base metal similar to that being welded and, as the name implies, becomes a permanent part of the joint because it is fused to the root of the weld and is not easy to remove.





Permanent backing plate

It is inexpensive, easily applied, and requires little special skill.

The backing bar becomes a permanent feature of the joint, which may be undesirable from an aesthetic point of view, depending on the part. It also presents a fatigue notch to the weld root. Once fabricated, the backing bar is tack welded into position. A permanent backing bar is unlikely to be used where a product or gases flow through pipework because of possible entrapment and flow disruption

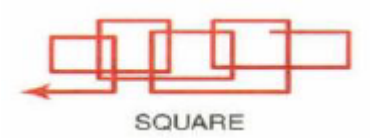
Content/Topic 6. Weaving techniques

Weaving: is a welding technique in which the energy source is oscillated transversely as it progresses along the weld path.

1. **Zigzag**: the zigzag pattern is used as cover passes in the flat and vertical positions. Do not weave more than two-and-a-half times the width of the electrode. These patterns deposit a large width of the electrode.

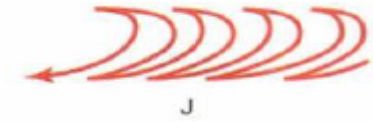
These patterns deposit a large quantity of metal at one time.

2. **Box weave**: this is also good for most 1G (flat) welds but can also be used for vertical 3G positions.



These patterns can also be used if there is a large gap to be filled when both pieces of metal are nearly the same size and thickness.

3. **Double J**: the "J" Pattern works well on flat (1F) lap joints, all vertical (3G) joints, and horizontal (2G) butt and lap (2F) welds.

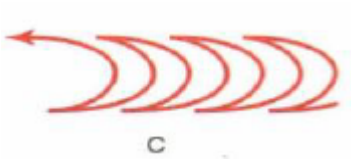


This pattern allows the heat to be concentrated on the thicker plate. It also allows the reinforcement to be built up on the metal deposited during the first part of the pattern. As the result, a uniform bead contour is maintained during out-of-position welds.

4. **Circles**: the circular weave pattern is often used for flat position welds on butt, tee and outside corner joints, and for buildup or surfacing applications.

The circle weave pattern can be made wider or longer to change the bead width or penetration.

5. **Crescent**: the crescent patten (C) is good for most 1G (flat) welds but can also be used for vertical 3G positions.



These patterns can also be used if there is a large gap to be filled when both pieces of metal are nearly the same size and thickness.

Content/Topic 7. Positioning of the work pieces

Welding is easier if the welder can find the most comfortable angle. The welder should be in either a seated or a standing position in front of the welding table. The welding machine should be turned off.

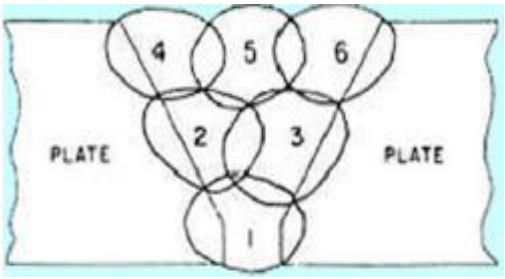
Different workpiece angles

With an electrode in place in the electrode holder, the welder can draw a straight line along the plate to be welded; then, by turning the plate to several different angles, the welder should be able to determine which angle is most comfortable for welding as shown in figure above.

Content/Topic 8. Multi runs for groove weld

All welds start with an arc strike. Arc strike is the process of establishing a stable arc between the end of electrode and the work. Always start with striking the arc in the weld joint just ahead of where you are going to be welding, then multi runs can be followed.

1. Root pass
2. Hot pass (within 5min)
3. Filler runs (filler pass)
4. 5. & 6. Cover passes

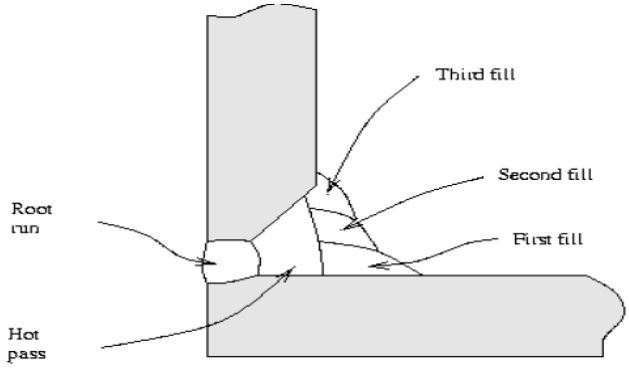


- **Root pass**: the root pass is the first pass on an open joint, usually when welding pipe and mild steel. It is usually used as a first pass that will provide the base for subsequent filler passes

- **Hot pass**: hot pass is a term used in plate welding, when the bead is complete it is given a quick clean up with a grinder then the hot pass follows, it burns out the slag that is trapped at the junction between the bead and the pipe wall, the slag is often called wagon tracks
- **Filler runs**: Weld made after root pass by filling the gap between two plates of a work piece to be welded with filler metal.
- **Cover passes**: The weld pass that finishes the welded joint. The cover bead is higher than the adjacent surface and overlaps the groove.

Content/Topic 9. Multi runs for fillet weld:

- **First run**: is the run on an open joint, usually when welding plate and/or other mild steel. It is usually used as a first pass that will provide the base for subsequent filler passes
- **Filler runs**: it is the weld made after first run by filling the gap between two plates of a work piece to be welded with filler metal.
- **Cover passes:** The weld pass that finishes the welded joint. The cover bead is higher than the adjacent surface and overlaps the groove.

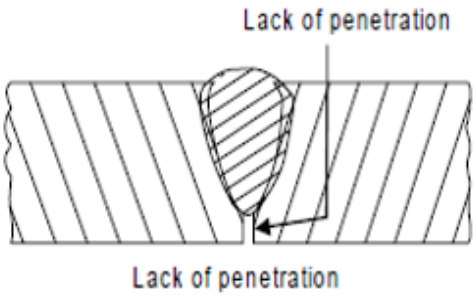


LO 3.3. Check defects

- Content/Topic 1. Types of defects, causes and remedies:

1. Lack of Penetration

It is the failure of the filler metal to penetrate into the joint.



Lack of penetration

Causes of lack of penetration:

- ✓ Improper joint preparation.
- ✓ Improper weld technique.
- ✓ Insufficient heat input.
- ✓ Wrong current setting
- ✓ Wrong electrode angle
- ✓ Wrong selection of electrode
- ✓ Fast travel speed

Remedies for lack of penetration

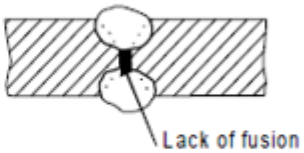
- ✓ Material too thick. Joint preparation and design must provide access to bottom of groove.
- ✓ Keep arc on leading edge of weld puddle.
- ✓ Reduce travel speed.
- ✓ Increase amperage. Select larger electrode and increase amperage.

2. Lack of Fusion

Lack of fusion is the failure of the filler metal to fuse with the parent metal.

Causes:

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



Lack of Fusion

Remedies:

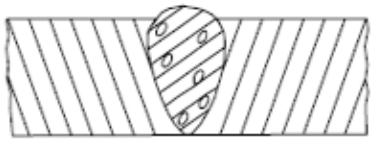
- ✓ Reduce your travel speed
- ✓ Use correct welding technique
- ✓ Use sufficient heat

3. Porosity

It is a group of small holes throughout the weld metal. It is caused by the trapping of gas during the welding process.

Causes:

- ➢ Chemicals in the metal
- ➢ Dampness
- ➢ Too rapid cooling of the weld.


Porosity

Remedies:

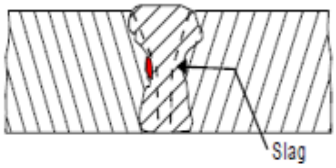
- ✓ Remove chemical in metal
- ✓ Prevent dampness of the metal
- ✓ Slow the cooling of the metal

4. Slag Inclusion

It is the entrapment of slag or other impurities in the weld.

It is caused by:

- Slag from previous runs not being cleaned away,
- Insufficient cleaning and preparation of the base metal before welding commences.



Slag Inclusion

Remedies:

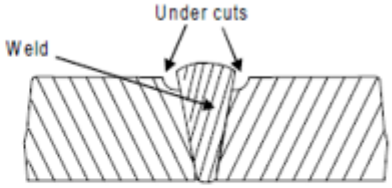
- ✓ Clean away the Slag from previous runs
- ✓ Sufficient clean and prepare the base metal before welding commences.

5. Undercuts

These are grooves or slots along the edges of the weld.

Causes:

- Too fast a travel
- Bad welding technique
- Too excessive a heat build-up.

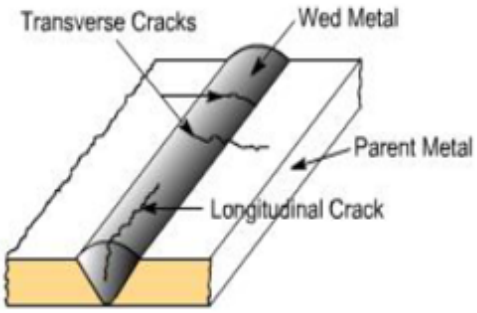


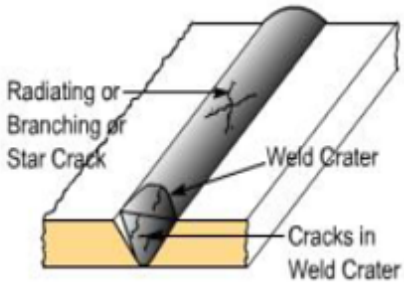
Remedies:

- ✓ Reduce travel speed
- ✓ Use proper welding technique
- ✓ Use moderate heat input

6. Cracking (Craters)

These are generally the result of longitudinal shrinkage stresses acting on weld metal of low ductility.





Possible Causes:

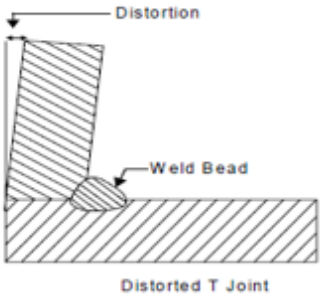
- Unsuitable parent metals used in the weld
- Bad welding technique.

Remedies:

- ✓ Use suitable parent metals
- ✓ Use proper welding technique

7. Distortion

Distortion is a contraction of weld metal during welding that forces base metal to move. It is also defined as any permanent change in shape and size of joining pieces from the original caused during welding.



Possible causes

- ✓ Excessive heat input.
- ✓ Improper tack weld
- ✓ Excessive current setting
- ✓ Travel speed too slow
- ✓ Many passes on the same arc without allowing them to be cooled.

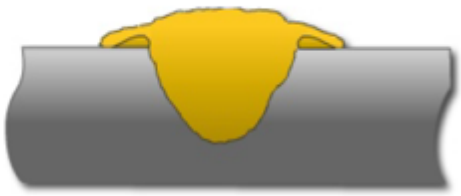
Remedies

- ✓ Use jigs, fixtures and clamp to hold base metal in position.
- ✓ Make tack welds properly along joint before starting welding operation.
- ✓ Select lower amperage for electrode.
- ✓ Increase travel speed.
- ✓ Weld in small segments and allow cooling between welds.
- ✓ Avoiding over welding
- ✓ Pre-bending or pre-setting

8. Overlap

These consist of metal that has flowed on to the parent metal without fusing with it. This defect is caused by:

- ➢ Contamination of the surface of the parent metal
- ➢ Insufficient heat



Remedies:

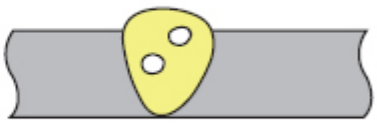
- ✓ Prevent or remove the contamination of the parent metal
- ✓ Use sufficient heat

9. Blowholes

These are large holes in the weld caused by

- Gas being trapped, due to moisture.
- Contamination of either the filler or parent metals.

Blowholes :



Remedies:

- ✓ Prevent the moisture in parent metal or prevent the gas to be trapped in weld
- ✓ Reduce the contamination of either the filler metal or parent metal

10. Burn Through

It occurs when the arc burns through the bottom of the weld. is the collapse of the weld pool; it is caused by:

- ✓ Too great a heat concentration
- ✓ Poor edge preparation.

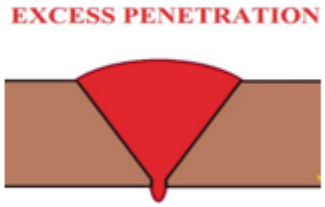
Remedies:

- ✓ Reduce the heat concentration
- ✓ Proper edge preparation

11. Excessive Penetration

It is where the weld metal protrudes through the root of the weld. It is caused by:

- Incorrect edge preparation
- Too big a heat concentration
- Too slow a travel.



Remedies:

- ✓ Proper edge preparation
- ✓ Try reduce the heat concentration
- ✓ Increase the travel speed.

L.O.3.4. Finish the welded pieces

Content/Topic 1. Methods of preventing corrosion:

a. Red oxide painting

Red oxide paint is a specially formulated coating used as a base coat for ferrous metals. It gives iron and steel surfaces a layer of protection.

Red oxide paint is intended for use on interior and exterior ferrous metal and is not usually suitable for galvanized or nonferrous metals like aluminum, copper or brass.

Red oxide paint is an anti-corrosion coating designed to stop rust formation. It can be applied directly over a rusty surface and is most ideal for exterior use.

Before painting with red oxide primer, make sure all substrates are clean and free from grease or oil. Use a degreasing solution to remove these materials and allow the surface to dry. A clean surface ensures that the paint applied after the primer adheres properly. After cleaning, remove all loose and flaking material by scraping with a paint scraper, wire brush or by sanding.

When applying red oxide paint, use a brush or a short pile roller or Spray red oxide paint onto the surface with a minimum working pressure of 2000 psi. Use at least two coats of red oxide primer to provide an adequate base coat to your metal. Each coat will be dry to the touch in about 2 hours, but not fully cured for about 6 hours. Red oxide primer will not be ready for an overcoat until it dries for between 16 and 24 hours. Always check the manufacturer's label for specific instructions on drying times.

Red oxide paint, like other paints and coatings, should be used with standards and safe working practices in mind to avoid injury or hazards while handling. Red oxide paint is flammable, so keep it away from sources of ignition such as open flames and cigarettes. Before you begin working, ensure you have adequate ventilation. Either work outdoors, or open all windows in your work space and make use of exhaust fans. Wear a respirator or a painter's mask to avoid breathing in vapors and spray. Safety goggles, gloves and protective clothing should also be worn.

When you're through painting, do not discard unused paint down drains or other water courses. Dispose of red oxide paint at your local hazardous waste depot.

b. Keeping away from humidity:

Absolute humidity is the measure of water vapor (moisture) in the air, regardless of temperature. It is expressed as grams of moisture per cubic meter of air (g/m3).

For instance, it is more important to keep certain types of rods away from moisture more than others**.** But, it is important to keep all rods dry and away from humidity as much as possible.

Learning Unit 4. Perform Housekeeping

LO 4.1. Clean tools, equipment and workplace

Content/Topic 1. Cleaning tools and equipment

Following are some of the equipment which you will come across during the process of cleaning.

a. Brush: It is used for cleaning the working surface prior to welding and general cleaning of the weldment. Most of the brushes used for cleaning tools and equipment in workshops are wire brushes.

b. **Cloth rugs -** these are made of soft absorbent cloth such as flannel. Dry polishing cloth helps to clean and shine the polished surfaces by rubbing them vigorously.

c. **Mops:** a tool for cleaning floors made of a bundle of cloth or yarn or a sponge fastened to a long handle, something that looks like a cloth or yarn mop. this process is known as mopping and is generally coarser than a duster. Mopping is mostly done on floors.

d. **Soapy water:** is a mixture of powder detergent in water used for cleaning equipment and/or workplace.
e. **Compressed air**: air which is compressed by air compressor then perform cleaning process, an air compressor is a pneumatic machine used for cleaning tools and even heavy machinery in the workshop.

Content/Topic 2. Methods of cleaning

a. **<u>Dusting:</u>** the term “dust” is already familiar, but how dust should be removed? If any surface is wiped with a piece of dry cloth (duster), it carries the loose dust with it and the process is known as dusting. This should be done with a clean soft cloth.
b. **<u>Removal of dirt:</u>** this is the process of removing dirt on tools and equipment. sometimes mopping alone is not sufficient to remove dirt. Such surfaces are then scrubbed with the help of a yard (bamboo) broom along with plenty of water. Eventually the dirt loosens and is carried off by water. In case of tougher stains or dirt, detergent may be added to the water.

c. **Chemical spraying**: Chemicals was mostly sprayed on farms, around the home, in gardens, parks and reserves to control pests and diseases, now it can also be used in workshops for the purpose of cleaning most equipment and/or tools used there.

During chemicals spraying, care must be taken to avoid hazards because droplets are produced that can remain suspended in air and may be carried by wind away from the target area.

LO 4.2. Store tools, equipment and materials

Content/Topic 1. Care and storage procedures of tools, equipment and materials

Regardless of the location in which you store your tools, you may want to consider storing them in a sand/oil mixture, which can be used for years. This can be done by using a five-gallon bucket filled with sand and a half gallon of mineral (or motor) oil. Shovels, hoes, pitchforks, etc., can all be stored in this mixture. These buckets may be used year after year as long as they are kept away from rain. Simply add oil each year as needed.

In addition to buckets containing a sand/oil mixture, other methods can be used to preserve your tools. Below are some more tips for storing your gardening equipment:

Put clean tools in an empty plastic container, such as a trashcan. Also, consider hanging tools up on a rack or installing brackets to hold and organize your equipment. Hardware stores offer strong adhesives to hold tools that will not leave residue when you decide to remove the bonding agents. Both of these methods will keep your tools off of the ground, away from dirt and bugs, and out from underfoot.

Gloves should always be kept in a closed container so your hand will not get eaten by visitors when you put them on. Consider using an empty coffee can, ice cream tub or a popcorn tin that can also hold random excess nuts and bolts that may be lying around. Space bags that use vacuum suction to remove air can also be a nice place to protect gloves when storing them for a longer period of time.

Special care should be taken to store larger machines such as lawn mowers and big power tools in accordance with manufacturer directions.

Hoses should be drained before storage. Also, roll up hoses to prevent them from getting cracked or being damaged during moves.

Put chemicals and fertilizers in a locked case away from children and pets.

Gardening tools should be kept in a cool, dry place, such as a garage or storage unit. This will help keep your valuables away from humidity.

Overall, be sure to take care of your tools to ensure their longevity and efficiency. Inspect your tools each season and take the proper steps, some of which are mentioned above, to keep them in good condition.

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