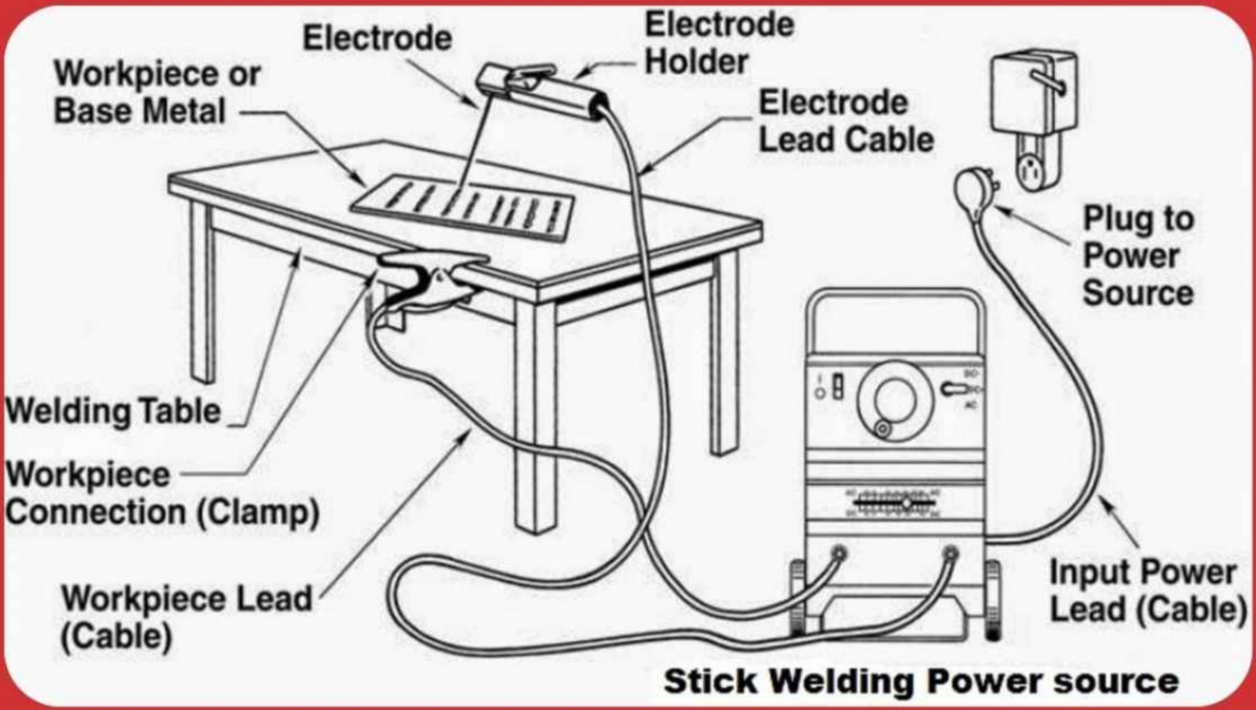
Stick Welding

Complete Guide for Beginners



Abdul Qadeer

Chapter 01

Stick Welding
Complete Guide for beginners

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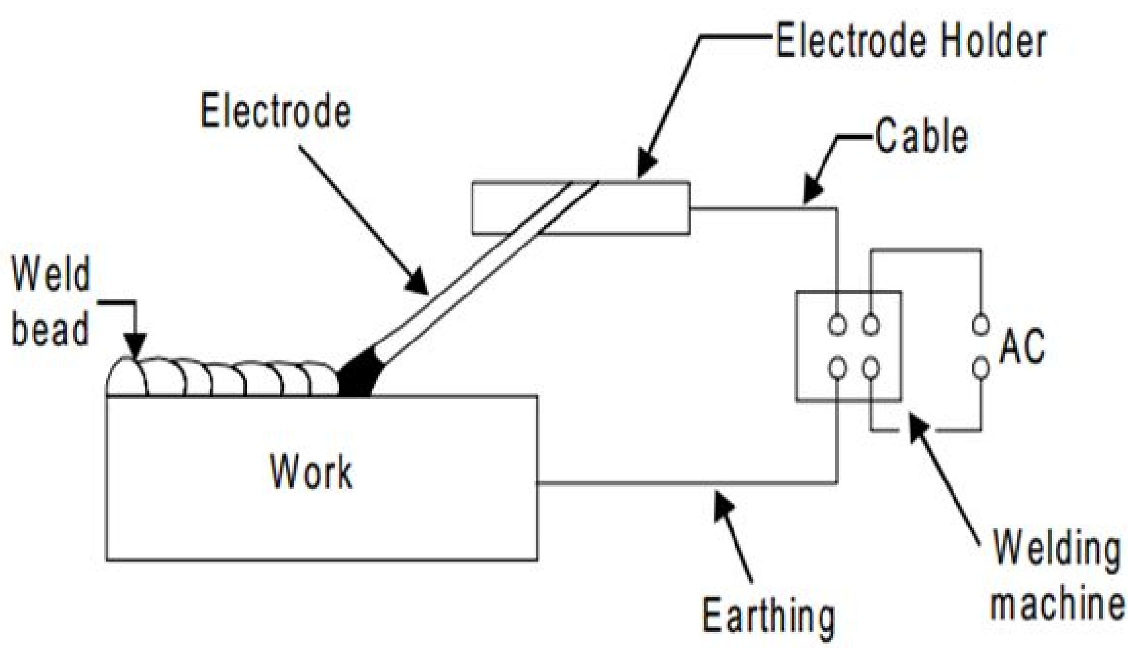
Chapter 01

INTRODUCTION TO STICK WELDING

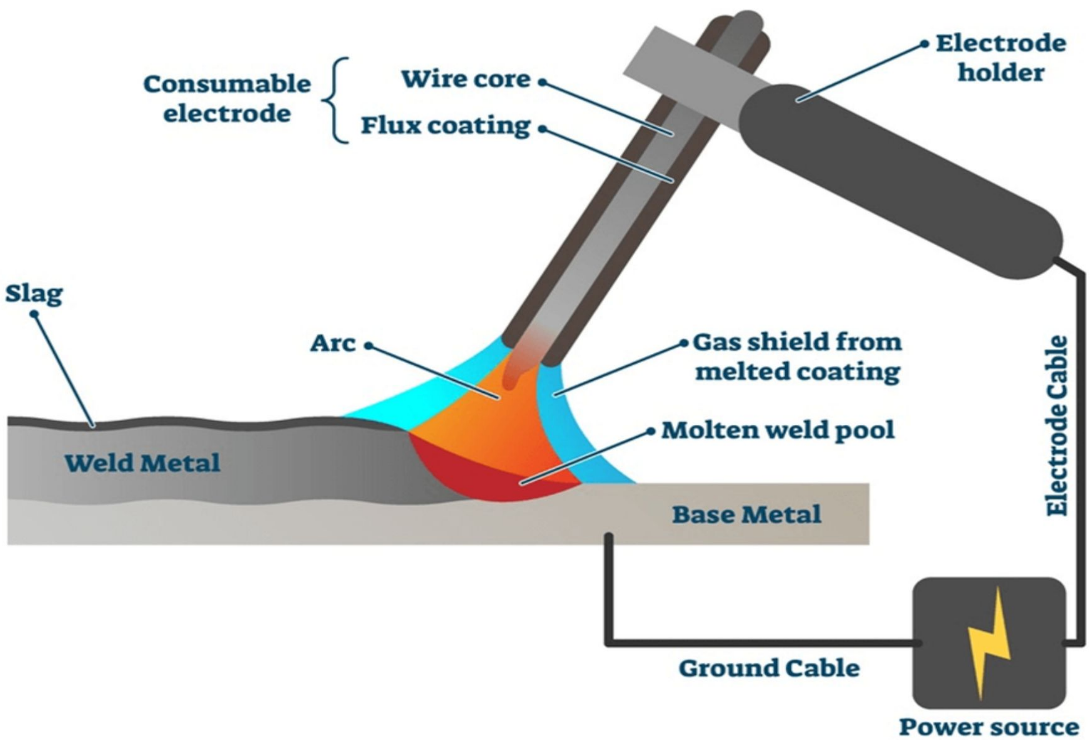
Stick welding is a slang word which is used for shielded metal arc welding (SMAW). It is the most widely used welding type. It is also known as manual metal arc welding (MMA). In his welding technique a flux coated electrode which is also known as stick is used with a combination of high voltage and current that melt and create a shielding environment for the weld pool and protect it from reacting with atmospheric gasses e.g. oxygen and nitrogen. so it is also known as flux shielding arc welding, due to this property this technique can be used in outdoor welding projects.

Stick welding processes join two metal pieces by using a high temperature electric arc due to which this process is also known as arc welding process. Electric arc is produced by striking the tip of the flux coated electrode (that is held in the electrode holder and connected to the arc welding power source) on the base metal placed on a welding table as shown in Fig below.

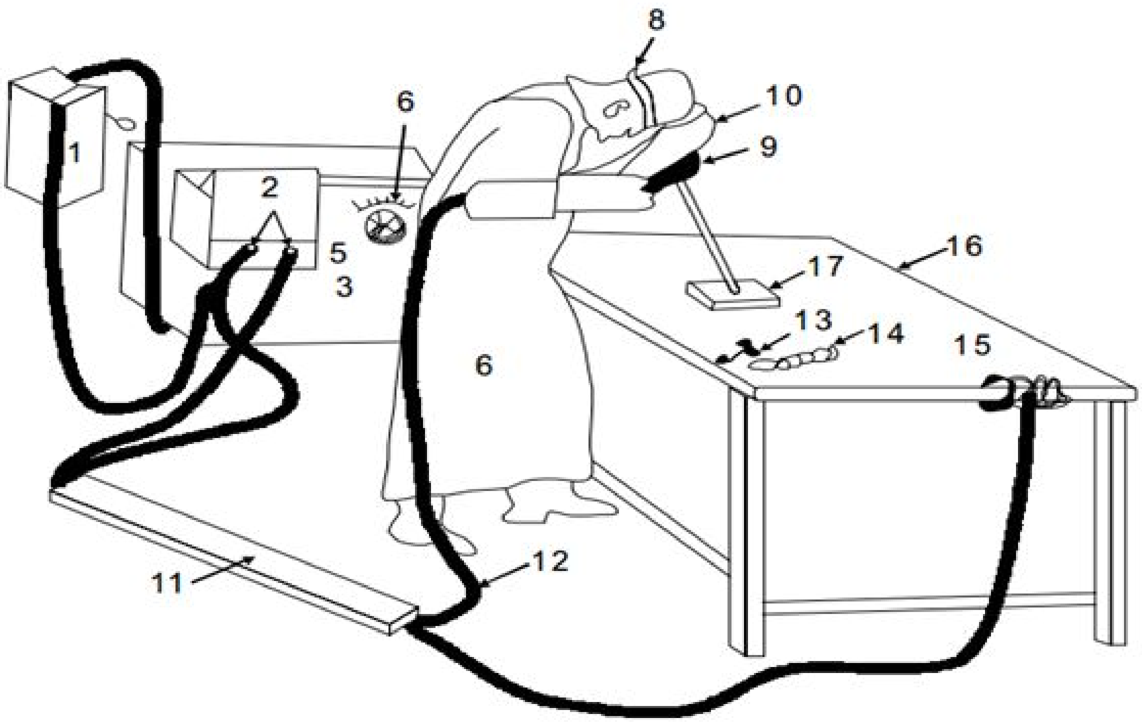


Line diagram of Stick welding setup

When tip of the consumable electrode is taped on the surface of the base metal it produce a high temperature spark due to which the electrode and base metal or melted and form a weld pool whereas flux produce a shielding gas and cover the weld pool and protect from it from contamination due to the atmospheric gasses e.g. oxygen and nitrogen. The metal from electrode is termed as filler metal whereas metal from the work piece to be welded is termed as base metal.



Tools and equipments required for Setting up stick welding



List of tools & equipment

1. Switch box
2. Secondary terminals
3. Welding machine/ power source
4. Current reading scale
5. Current regulating hand wheel
6. Leather apron
7. Hand gloves
8. Protective glasses
9. Electrode holder
10. Hand shield
11. Cable protection
12. Welding cables
13. Chipping hammers
14. Wire brush
15. Earth clamp

16. Welding table
17. Jobs

Explanation of tools and equipments

Stick welding Machine/ power source

Stick welding process can be performed by using either alternating or direct current (AC or DC). Direct current can be operated in different directions based on polarity. Power in the electrical circuit is measured in amperage and more power amperage is required for welding a thicker metal.
The A.C welding machine uses a step down transformer which receives current from main A.C Supply. This transformer lowers the high voltage Input from 220-440V to normal operating voltage less than 80-100 volt according to the requirement of material thickness. In this machine the current is available up to 400 amperes with steps of 50 amperes. Adjustment of current can be changed according to thickness of the material to be welded. Less current is required for thin materials and more current is required for thick materials. A.C. machine usually works with 50 hertz or 60 hertz power supply. The efficiency of A.C. welding transformers varies from 80% to 85%.
The D.C. welding machine consists of an A.C. motor-generator set or diesel/petrol engine-generator set or a transformer-rectifier welding set. D.C welding machines have a capacity of current upto 600 ampers and 50-90V are used to produce arc whereas 15-25 V are used to maintain arc.

Current (Amp.)	Voltage (volts)
50 to 100	15
100 to 250	20
200 to 250	25
250 to 350	30
350 to 500	35
Over 500	40

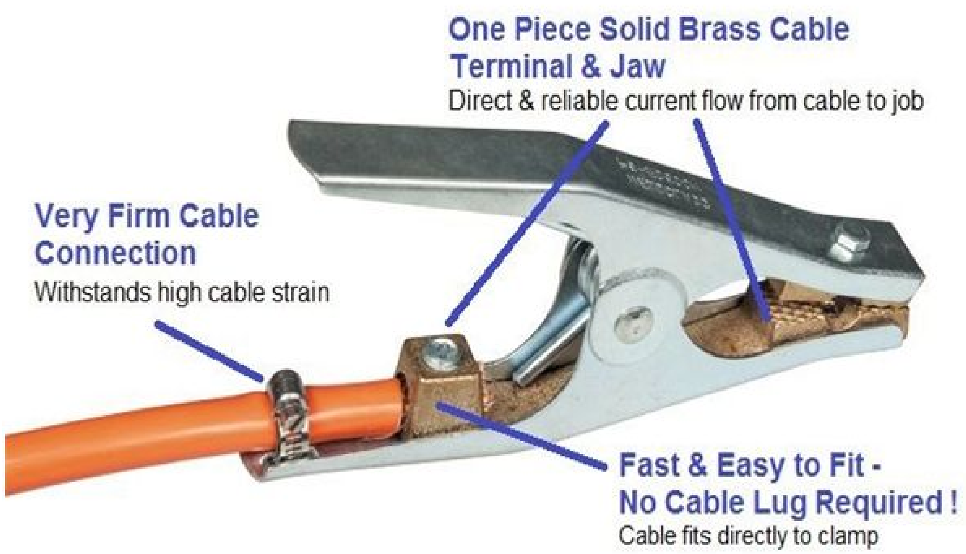
Table: Current & Voltage For Welding Machine

Welding table:

A welding table is a platform and works like a workbench for performing welding operations. It has a refractory brick top surface that supports the welding operation during high temperatures.

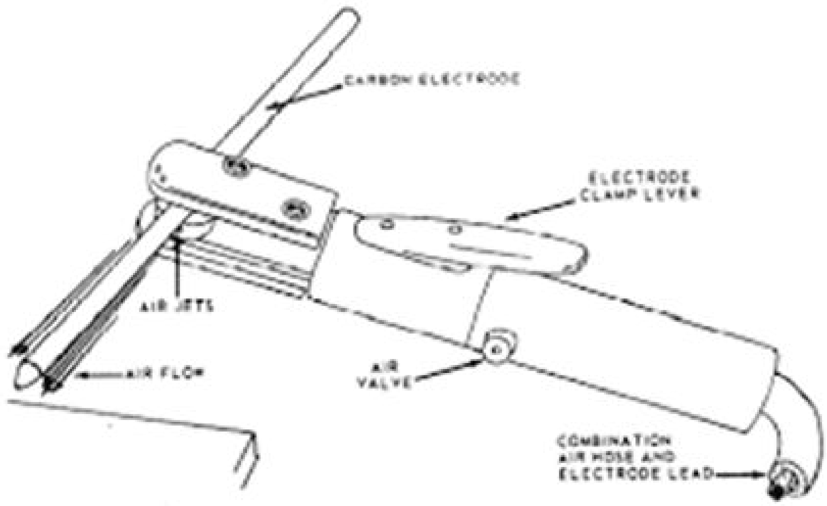
Welding ground clamps:

Welding ground clamps are used to make a connection between the workpiece and power source. As a result the job surface and power source remains at the same potential.



Electrode Holder:

Electrode holders are used to hold the weld electrode firmly and at the desired angle. The electrode holder connects to the welding cable and conducts the welding current to the electrode. Its insulated handle is used to guide the electrode over the weld joint and feed the electrode over the weld joint into the weld puddle.



Chipping hammers:

Chipping hammers are used to remove the slag from the weld bead after completion of the weld process. Chipping hammers are lightweight and hand-held that can be easily positioned to remove slag from vertical and overhead surfaces.

Wire brush

After removing the slag with a chipping hammer from the welded surface, a wire brush is used to clean the surface from slag particles.

A wire brush is also used to clean the rusty surface before the welding process.

Welding cables:

Welding cables are used to carry the current from the power source to the workpiece. Welding cables are flexible and thin, made of copper or aluminum and have a strong insulation that protects it from flames, heat oil and other impact loads.

Generally classified as a type of industrial power cable, welding cable is mainly used to power the secondary circuit of electric arc-welding generators.

Welding cables are required for conduction of current from the power source to various parts of Arc welding process equipment i.e. electrode, the arc, the work piece and back to the welding power source.

Welding Electrodes:

- An electrode is a stick or a rod of metal or alloy, with or without coatings.
- An Electrode can generate the arc at the desired welded location between electrode and work piece.

Hand Screen/Face shield

Arc welding process is highly hazardous and can be harmful if safety equipment is not used, so for this purpose to protect eyes and face from arc, heat and flash light, face shield or hand held screens are used.

Protective clothing:

- The operator wears protective clothing such as an apron to keep away from the exposure of direct heat to the body. Always wear gloves before touching any item in the workshop.
- Protective clothes should include a leather apron, cap, leather hand gloves, leather sleeves, etc. The high ankle leather safety shoes must be worn during welding work.

Welding Shop Safety: Hazards to Avoid

As mentioned, welders face a variety of potential hazards in the workplace. Some of the most common include:

Electric Shock

A sudden discharge of electricity to the human body can lead to serious injuries and in some cases, even death. Electrocution can occur when a welder touches two metal objects that have a voltage between them, which inserts them into the electrical circuit. Due to higher voltage, the current will be higher, which leads to a higher risk for the welder.

Exposure to Fumes and Gasses

Welding fumes contain a variety of potentially harmful metals, including aluminum, beryllium, arsenic, manganese and lead. Gasses that contain nitrogen, carbon dioxide, argon, carbon monoxide and hydrogen fluoride are also often produced during welding.

When a welder is overexposed to these fumes and gasses, this can lead to serious health problems such as impaired speech and movement, respiratory illness and even cancer.

Physical Injuries

Without wearing the proper PPE (personal protective equipment), welders can experience a variety of physical hazards, including eye damage, cuts, burns or even crushed fingers and toes. These injuries should be taken seriously, as they can put a welder out of work in some cases.

Fire and Explosions

A welding arc produces extreme temperatures and can spark fire and explosion hazards if safety procedures are not followed. While the arc itself can reach temperatures up to 10,000 degrees Fahrenheit, the most common cause Welding Safety Rules to Follow

So how does one avoid these hazards? Here are some important safety tips for practicing safe welding:

Arc welding safety tips:

1. Protect Yourself from Fumes and Gasses

Exposure to fumes and gasses can be controlled by providing adequate ventilation in the work area. Some employers will provide a fan, an exhaust system or exhaust hoods to remove fumes and gasses from the area welders are working in.

2. Take Precautions against Electrocution

To avoid electrocution, welders must always inspect the electrode holder for damage before starting their weld. They also must ensure their gloves are dry and in good condition, never touch the metal parts of the electrode holder with skin or wet clothing, and keep dry insulation between their body and the ground or metal being welded.

3. Check Your Equipment

A good welder always checks to ensure their equipment is functioning properly and is fully grounded before using it. Even the most experienced welders should regularly check their equipment for common wear and tear, such as frayed wires or leaking hoses, as this can increase the chances of an accident occurring.

If a piece of equipment was running perfectly the day before, don't assume that it's still in the same condition. Always do a full inspection before using it again—you can never be too sure!

4. Avoid Clutter

A cluttered workspace is one of the most common causes of welding fires and explosions. Sparks from the welding arc can fly up to 35 feet in distance, so it's important to keep your workspace clear, especially of any flammable materials.

As a general rule, always stay organized and keep everything in its place**.**

5. Dress for the Job

Wearing the proper attire is critical for welders. Any exposed skin is vulnerable to the harmful effects of infrared and ultraviolet rays, so welders must always ensure they are fully covered.

So what should you wear? Welders must wear flame-resistant clothing with the proper PPE, which brings us to our next point.

6. Wear the Right PPE

Selecting the proper PPE for the job is one of the most important decisions you can make to protect yourself as a welder. Here's a quick look at the types of PPE welders should wear:

- Ear protection: If readings of noise average above 85 dB for eight continuous hours, you are required to use hearing protection at all times.
- Eye and face protection: This includes safety glasses, face shields and depending on the project, helmets.
- Heat and radiation protection: In order to protect themselves from heat and radiation, welders must wear flame-resistant outerwear, gloves to protect hands and lower parts of the arms, and welding hoods and goggles.
- Fume protection: Fume extraction systems and respirators can help to protect welders from exposure to harmful fumes.
- Electrical shock protection: In addition to taking the safety precautions outlined in tip #3, welders must wear insulated clothing to protect themselves from electrocution.
- Foot protection: Leather shoes that are spark and heat resistant with coverage above the ankle are best for foot protection. Pant legs should go over the shoes.

7. Enforce Safety Procedures

As a welder, it's important to hold yourself and those around you accountable when it comes to following safety guidelines. If you see a safety violation, report it—it's in the best interest for you and those you share a workspace with! Additionally, if you ever feel unsafe in your work area, don't be afraid to speak up.

Application of Stick welding

Stick welding is one of the oldest and most widely used processes commonly used in construction, farm machinery, shipbuilding, underwater welding projects, and pipelines. It Can weld from ⅛ inch thin or thicker metallic objects.

It is also used in industrial heavy projects of iron and steel like carbon steel cast iron, low and high alloy steels etc. Because its tools and equipment are portable it can also be used in a variety of indoor and outdoor welding projects.

Materials that can be welded by using stick welding

- Iron
- Aluminum
- Bronze
- Carbon steel
- Cast iron
- Low-alloy steels
- Malleable iron
- Nickel
- Stainless steel

Advantages of stick welding

- Stick welding is a most versatile method that can be used to weld a variety of materials.
- It can be easily used in outdoor welding projects
- Its tools and equipment are portable and can be easily replaced from different project locations.
- This technique has different types of electrodes that can be easily used according to the type of material to be welded.
- It can be used in all welding positions easily e.g.1F, 2F, 3F, 4F, 1G, 2G, 3G, 4G etc.

Disadvantages of stick welding

- High skilled welder is required
- Its operating cycle is slow
- Low deposition rate
- Corrosion at the weld joint can be occurred if proper safety precautions are not observed during operation
- Electrode replacement is required after completion of short length of weld bead
- If current and voltage is not adjusted properly according to the thickness of material it can be damaged by high flow of current.

Understanding the Stick Welding bead making Process

Stick welding bead making operation

- Set equipment as shown in the fig below

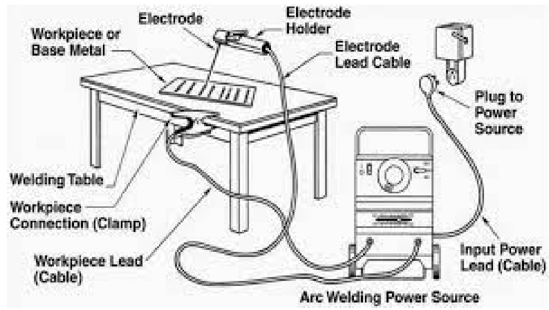


Fig: Typical Layout for Stick Welding apparatus

- Clean the work piece from dust and rust and file its edges from burrs.
- By using scriber draw 3 to 4 parallel lines on the face of the work piece
- Clamp the work piece on the welding table.
- Insert the electrode in to the electrode holder at proper angle
- Set amperage according to thickness of the material and electrode requirement initially at 100am.
- Attach the welding ground clamp with welding table
- Make a safety check and remove all unnecessary tools and equipment and cotton waste from the surrounding of the work station.
- To produce an electric arc, scratch the electrode on the rough work piece, upon giving spark slightly to pick up the electrode in such a distance that spark cannot finish now scratch the electrode again two to three times.
- Now practice the electrode movement by bead making exercise.
- For this purpose hold the electrode holder at proper angle and strike on the work piece at beginning of the 1st line and slowly move the electrode holder in such a way that the base metal and consumable electrode both melt and form a weld pool. Keep moving the electrode with slow speed on the straight line drawn on the work piece. Keep in mind that the vertical distance of the electrode from base metal so that the continuity of the weld bead will maintain. In the meantime molten flux releases a shielding gas that covers the weld pool and saves it from contamination. After solidification of molten metal molten flux solidifies on the joint or bead in the form of slag and can be easily removed by a chipping hammer.

- Practice three to four beads on the work piece and observe the accuracy of the bead.

Main Features of a welded component

1. Parent metal / base metal

Parent metal or base metal is a metal to be joined by using any type of welding.

2. Filler metal

Filler metal is a metal or alloy rod or powder that is added into the weld pool during welding.

3. Weld metal

Portion of the parent metal that is melted due to high temperature arc or flame during welding and helps in joint formation is welding metal.

All metal melted during the making of a weld and retained in the weld.

4. Heat-affected zone

The part of the parent metal near the weld metal affected by the heat of welding or thermal cutting but not melted.

5. Fusion line

Line between weld metal and the Heat affected zone in a fusion weld. is called Fusion line.

6. Root

Root is a specific area on the side of the first run furthest from the welder.

Chapter 02

WELDING ELECTRODES

Types of Electrodes with respect to consumption

Stick welding electrodes can be classified into two categories:

1. Non-Consumable electrodes.
2. Consumable electrodes.

1. Non-Consumable Electrodes:

These electrodes are not consumed during the welding operation, hence they are named, non-consumable electrodes. They are generally made of carbon, graphite or tungsten. Carbon electrodes are softer while tungsten and graphite electrodes are hard and brittle.

Carbon and graphite electrodes can be used only for D.C. welding, while tungsten electrodes can be used for both D.C. and A.C. welding. The filler material is added separately when these types of electrodes are used. Since the electrodes are not consumed, the arc obtained is stable.

2. Consumable Electrodes:

These electrodes get melted during welding operation, and supply the filler material. They are generally made with similar composition as the metal to be welded.
The arc length can be maintained by moving the electrode towards or away from the work.

The consumable electrodes may be of following two types:

(I) Bare Electrodes:

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

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

(ii) Coated Electrodes:

These are sometimes also called conventional electrodes.
A coating (thin layer) of flux material is applied all-round the welding rod, and hence termed as coated electrode. The flux, during welding, provides a shielding to the molten metal zone from the atmospheric oxygen and nitrogen. This flux also prevents formation of oxides and nitrides. Flux chemically reacts with the oxides present in the metal and forms a low melting temperature fusible slag.
The slag floats on the top of the weld and can easily be brushed off after solidification of weld. The quality of weld produced by coated electrodes is much better as compared to that of bare electrodes.

Flux its uses and advantage

A flux is a substance used to prevent the formation of oxides and the other unwanted contaminants, or to dissolve them and facilitate removal. During welding the flux melts and becomes a liquid slag, covering the operation and protecting the molten weld metal, the slag hardens upon cooling and must be removed later by Chipping or brushing.

Uses of flux

Flux dissolves the metal surface oxides that facilitate the molten metal wetting and acts as a barrier to oxygen and minimizes oxidation. Fluxes are used to generate a surface for wetting the solder.

Why flux is so important in welding?

During a welding process, the base metal and the filler undergo significant temperature changes in a very short amount of time. The heated metal may interact with the surrounding air and cause oxidation, which creates an oxide layer on the weld, reducing the weld strength.

And, it is not just oxygen that can create infective welds, the formation of sulfides and nitrides can also hurt the weld's strength.

Types of electrode flux

For welding, flux is not used as a separate application. They are almost always present with the electrode. Flux is coated on the electrode with a thickness of **1mm** to **3mm**.

1. Retile electrode

Retile electrode coating is made from titanium oxide. They offer excellent arc control and slag control to the welder. Due to these properties, Retile electrode coating is often known as the most welder-friendly flux type.

2. Basic flux

Basic flux is made from calcium carbonate, calcium fluoride, magnesium carbonate, and a few other shielding compounds. The benefit of using basic flux is that it results in better mechanical properties and low hydrogen diffusion levels.

3. Cellulose electrode coating

Cellulose electrode coating uses a mixture of cellulose and other organic compounds. When cellulose undergoes high temperatures in welding, it decomposes to produce carbon monoxide and hydrogen.

The production of these two gasses gives the weld shielding from the atmosphere. They also provide much better penetration in welds.

4. Iron oxide coating

The iron oxide coating is a mixture of metallic oxides of iron, manganese, and silica. Once they are under heat, they produce a molten acidic slag.

Due to the high oxygen generation, iron oxide coating is not suitable for welding metals that easily undergo oxygen inclusion. One way to prevent oxidation of the weld is by adding deoxidizing agents with the welding core.

Some of the most commonly used electrodes with flux are:

1. E6010 = High cellulose sodium flux. DCEP for flat, vertical, overhead, and horizontal positions
2. E6011 = High cellulose potassium flux. AC or DCEP for flat, vertical, overhead, and horizontal positions
3. E6012 = High titania sodium flux. AC or DCEN for flat, vertical, overhead, and horizontal positions.
4. E6013 = High titania potassium flux. AC, DCEP, or DCEN for flat, vertical, overhead, and horizontal positions.
5. E7018 = low-hydrogen potassium, iron powder flux. AC or DCEP for flat, vertical, overhead, and horizontal positions.

Abbreviations: AC – Alternating Current, DC, direct current

DCEP – Direct current electrode positive (Reverse Polarity)

DCEN – Direct current electrode Negative (Straight Polarity)

Types Of Filler Rod

The term filler rod refers to a filler metal used in gas welding, brazing, and certain electric welding processes in which the filler metal is not a part of the electrical circuit. The only function of the filler rod is to supply filler metal to the joint. Filler rod comes in wire or rod form that is often referred to as a "welding rod."

As a rule, filler rods are uncoated except for a thin film resulting from the manufacturing process. Filler rods for welding 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. You determine the rod diameter for a given job by the thickness of the metal you are joining.

Following are the commonly used types of welding rods

E 6010

The 6010 electrodes are quite popular. They're **used to deliver deep penetration in case of thick metals and where base metal is difficult to clean.** Taking this into account, E6010 electrodes are mainly used in pipe welding and applications such as shipyards, water towers, steel castings, field construction and steel storage tanks.

Important to note though is that they can only run on welding equipment that use direct current and reverse polarity (DCEP).

E 6011

A distinguishing characteristic of the 6011 electrode is that it can be used on either alternating or direct current.
This offers massive convenience as you can easily shift from one type of current to another to determine what works best. Like the 6010 electrode, the 6011 also delivers a deep penetration.
A drawback of this electrode is that since it generates flat weld beads, it leaves ripples and somewhat rough finishes.

E 6012

The 6012 is a general purpose welding rod that boasts superb bridging characteristics, particularly in application with sub-par fit-up.
This electrode is also known to provide a good stable arc and it runs at high currents with minimal spatter. Better yet, it's compatible with both AC and DC power sources..
Typical applications of this type of welding rod include connecting open joints, welding repair works, non-critical welding and the welding of rusted carbon steel sheets.

E 6013

This is another popular electrode that generates a soft arc with little splatter. The 6013 is often used for medium penetration welding. It ***creates a pretty stable and smooth arc,*** it's perfect for those applications that require a change in position e.g. in ship repairing, welding overworked or worn out mild steel surfaces and general sheet metal fabrication work..Also important to note is that it's compatible with both AC & DC.

E 7018

The 7018 is one of the most versatile welding rods, and it's primarily used for low to moderate carbon steel welding. This electrode is designed to produce a much stronger weld that can withstand up to 70,000 psi. This welding electrode can be used with both AC and DC power sources and in all four positions. Due to these characteristics, the 7018 has proven useful in structural welding

What are Stainless Steel Rods?

A stainless steel rod is a thin, long and hard metal alloy that comes in cylindrical or quadrilateral shapes. They are a key component of the construction world and have diverse applications across many fields.

For instance, you'll find a stainless steel pole in use during the erection of elaborate buildings. They also feature in household fixtures and food-grade utensils.

Stainless Steel Rod Grades

A stainless steel round bar can come in different grades that dictate the overall resistance and intended application. Mostly, this is a function of the chemical makeup and finishing treatment of the steel round bar.

Steel rod grading comes in a set of figures and numbers. The characters indicate the type of alloy present and its preferred application. You can contact us at any time to ask questions about the grade of our steel bars for sale.

Characteristics of Electrodes				
Electrode	**Coating**	**Position**	**Current**	**Penetration**
E-6010	High Cellulose Sodium	All Positions	DCEP	Deep
E-6011	High Cellulose Potassium	All Positions	DCEP AC	Deep
E-6012	HIgh Titania Sodium	All Positions	DCEN AC	Medium
E-6013	High Titania Potassium	All Positions	DCEP DCEN AC	Shallow
E-7018	Iron Powder Low Hydrogen	All Positions	DCEP AC	Shallow to Medium

Electrode/ Stick identification with coding

Electrodes are similar in shape but they have different applications. AWS uses a standard electrode classification system which is described above. Here we have to know what are the meaning of numbers and letters of code e.g code

E7018 represents the following.

For the mild steel electrodes mentioned above, here is how the AWS system works:

- The letter "E" indicates an electrode.
- The first two digits represent the resulting weld's minimum tensile strength, measured in pounds per square inch (psi). For example, the number 70 in a E7018 electrode indicates that the electrode will produce a weld bead with a minimum tensile strength of 70,000 psi.
- The third digit represents the welding position(s) for which the electrode can be used. For example, 1 means the electrode can be used in all positions and 2 means it can be used on flat and horizontal filet welds only.
- The fourth digit represents the coating type and the type of welding current (AC, DC or both) that can be used with the electrode.

Storage of electrodes:

If electrodes are not stored properly they can absorb moisture contents present in atmospheric air and become useless due to wet flux. Electrodes containing low hydrogen in their flux composition cannot be used after they have been exposed to the air for more than 15 minutes.

As a rule electrodes are obtained in sealed (airtight) packets that protect them from the atmosphere. As soon as the packet has been opened the electrodes will be at risk of becoming damp. The correct way to store electrodes, after the packet has been opened, is in a "warming box" or "drying oven". Such a device may be as simple as a sealed cupboard with a small electric lamp burning inside to keep the air warm and dry. More elaborate "thermostatically controlled" ovens are used in some establishments.

Using a "damp rod" will result in poor quality of your weld, including weakness. Damp rods may be "re-dried" by baking in an oven at the "specified temperature and for a specified time". (See manufacturers' instructions on packaging)

Chapter 03

WELDING POSITIONS

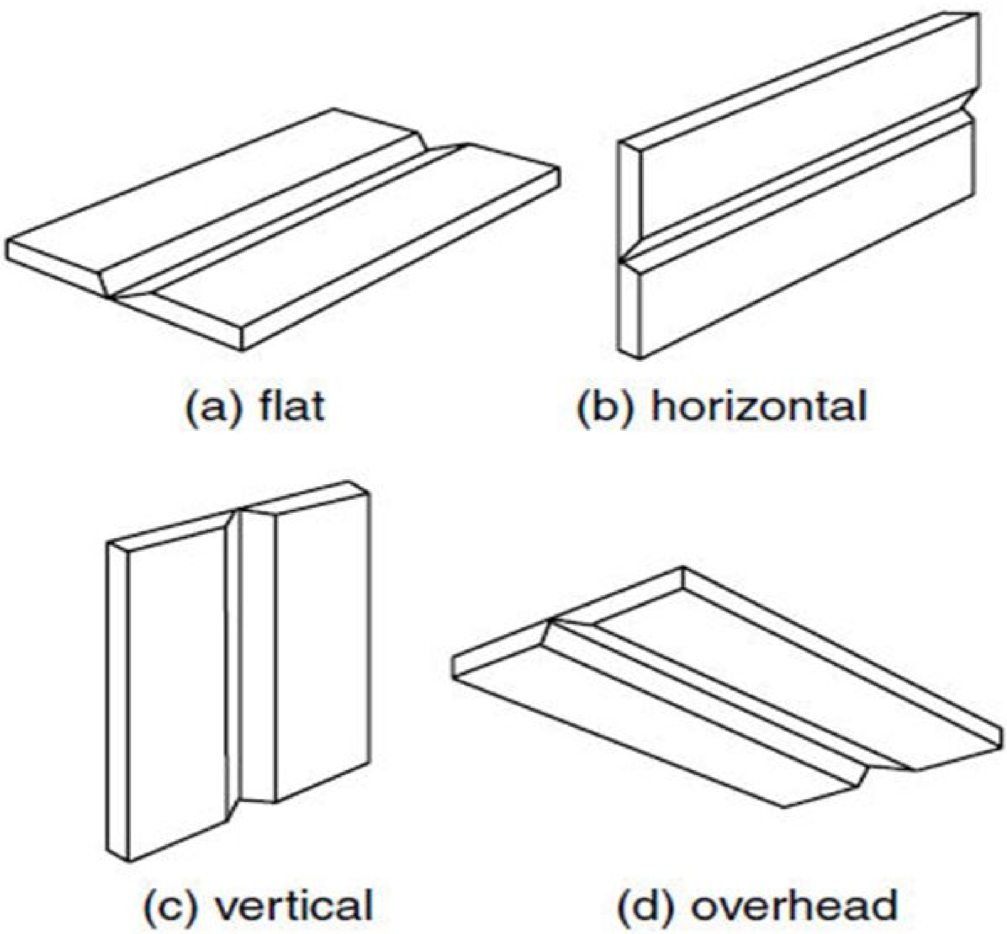
Introduction

A welding position is a posture of welded work piece in which the work piece we have to join. It is according to the requirement of the joint and application of the welded piece.
A welding position allows a welder to join metals in the position in which they are found or the position in which a specific component will be used.
There are four main welding positions in welding; each welding position requires different techniques for work piece preparation and welding**.**

Before starting a stick welding it is necessary to understand the difference between welding positions so that you can choose the proper filler metal electrode and other necessary parameters such as welding current, voltage, polarity etc. Fillet and groove welds are performed in four basic positions

There are four basic welding positions: These positions are represented by Numbers; 1,2,3 & 4 on drawing.

Flat (Represented by 1)
Horizontal (Represented by 2)
Vertical (Represented by 3)
Overhead (Represented by 4)



To understand and identify the type of weld and welding position, standard numbers and letters are given in the drawing so that the welder can easily understand it. e.g. 1 "F" 2F, 3F, 4F and 1G, 2G, 3G & 4G. Letter F represents fillet and letter "G" represents groove weld whereas numbers 1, 2, 3 & 4 represent welding positions Flat, horizontal, vertical & overhead respectively.

Understand the two basic weld types: (Fillet and Groove)

Weld joints in stick welding are usually obtained by placing two pieces of metal either in the fillet position (perpendicular to each other) or in case of thicker material, butt joint face to face position. V- Groove is designed on the faces of the pieces to be welded single, double or square groove.

Fillet weld description

Fillet weld is a most common type of weld in which two pieces of metal are joined by placing perpendicular to each other e.g. in the form of t - joint or lap joint as shown in the fig. In this weld, the joint or weld bead looks like a right angle triangle.

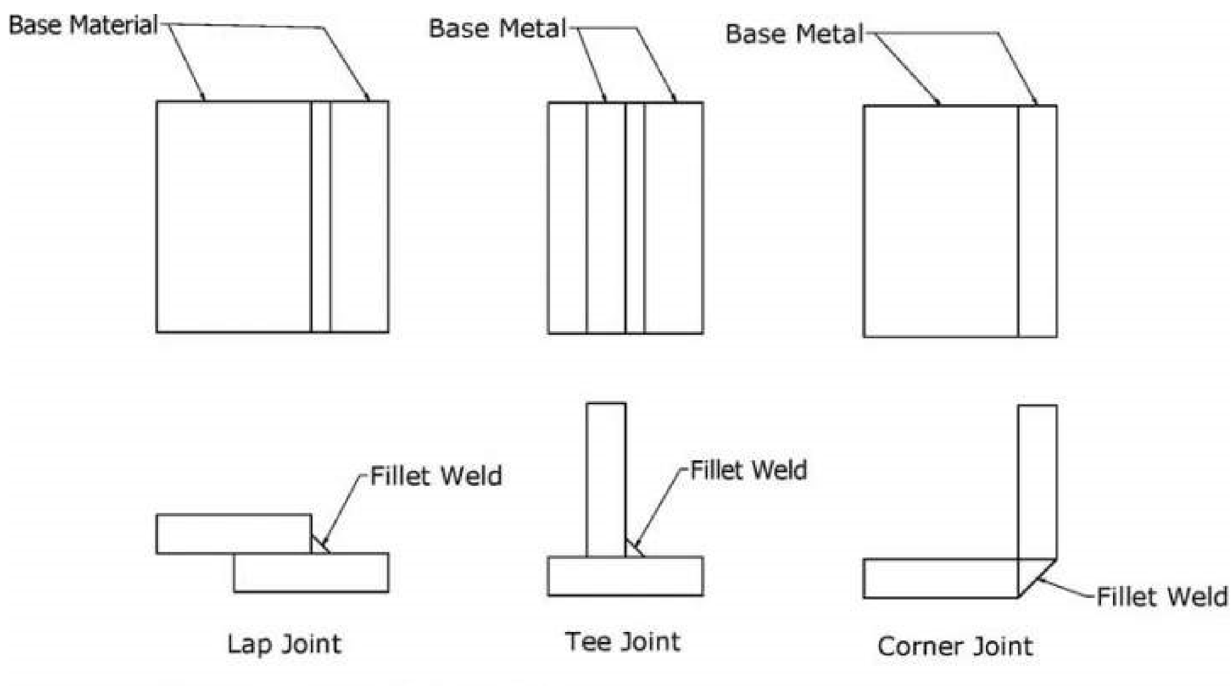
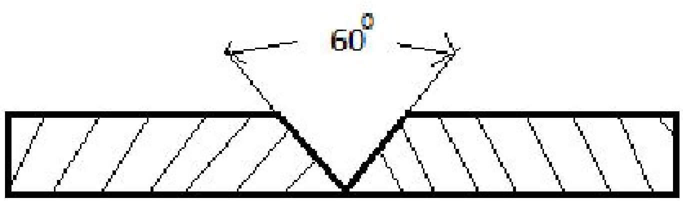


Fig: Fillet Weld Joints

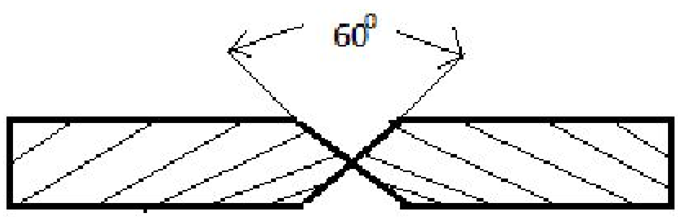
Groove weld description

For joining the metal pieces that have to be welded only from one side and having thickness between 3/16” to ¾ “(5-19mm) v groove is recommended and it can be obtained by beveling the edges of the pieces at 30 degree by using a file, or grinder. Groove welds are the most used welds after the fillet weld. There are seven basic types of groove weld:

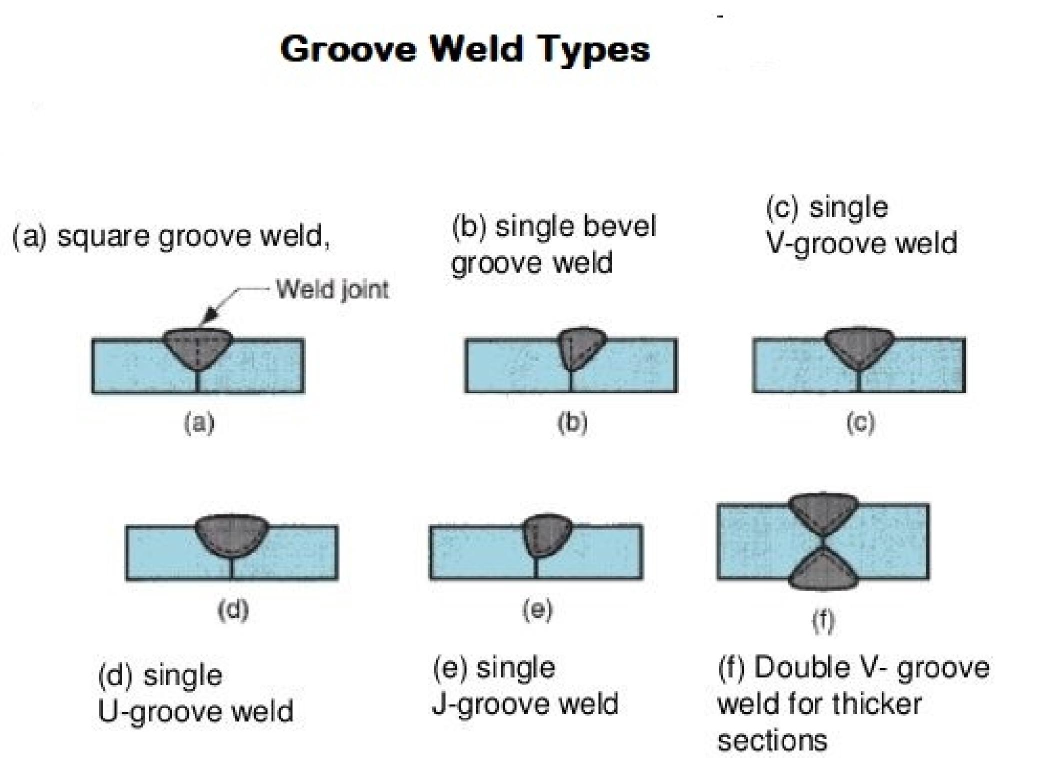
1. Single-V groove weld
2. Single-bevel groove weld
3. Single-U groove weld
4. Single-J groove weld
5. Square groove weld
6. Flare-V weld
7. Flare-bevel weld



(a) Single V-weld groove



(b) Double V-weld groove



Important parameters to be considered before welding operation

Before welding, it is recommended that one check the condition of the welding power source, the cables, electrode holder, and the grounding clamp. If the power source has a control panel and remote control, their functionality should also be reviewed. The quality and strength of the welding electrodes must be checked and they must match the work piece. The coating on the electrode must be intact.

Adjustment of current for stick welding

Current adjustment is the most important task while operating a stick welding machine because excess of current can damage the material and low current cannot completely allow the metal to melt and make a weld pool.

The following table -I indicates the amount of current for Stick welding amperage setting with respect to diameter of electrode whereas table - II indicates the amperage value with respect to material thickness.

Electrode	Diameter (Inches)	Diameter (mm)	Amperage Range
6010/6011	3/32"	2.4	40-85
6010/6011	1/8"	3.2	75-125
6010/6011	5/32"	4.0	110-165
6010/6011	3/16"	4.8	140-210
6010/6011	7/32"	5.6	160-250
6010/6011	1/4"	6.4	210-315
6013	1/16"	1.6	20-45
6013	5/64"	2.0	35-60
6013	332"	2.4	40-90
6013	1/8"	3.2	80-130
6013	5/32"	4.0	105-180
6013	3/16"	4.8	150-230
6013	7/32"	5.6	210-300
6013	1/4"	6.4	250-350
7014	3/32"	2.7	80-125
7014	1/8"	3.2	110-165
7014	5/32"	4.0	150-210
7014	3/16"	4.8	200-275

Table -I

Plate Thickness (mm)	Electrode Diameter (mm)	Amperage Range (I)
3	2.4	60 – 90
3	2.4	60 – 90
3	2.4	60 – 90
6	2.4	60 – 90
6	3.2	150 – 190
6	3.2	90 – 130
10	2.4	60 – 90
10	3.2	90 – 130
10	4.0	150 -190

Table-II

Arc length

Arc length is the distance between the electrode and the weld puddle. Maintaining the arc length in stick welding is the most important factor.

To maintain a steady arc is the hallmark of the stick welding and a rule of thumb is to keep the arc length the same as the diameter of the electrode.

Generally, this is equal to the electrode diameter and more often 1/16 to 3/32 in. long. Remember that voltage is proportional to distance. Push the electrode closer to cool the puddle and hold a longer arc to increase heat.

During welding if you observe that the electrode got stuck in the weld pool means arc length is short. In the case of a long arc, you may get excessive spatter, low deposition, undercut, and porosity.

The length of the arc increases easily as the electrode decreases in size during the welding so always monitor the length of the arc while stick welding. The movement may be somewhat difficult to control at first but it is easy to get accustomed to.

Replacing the electrode

After consumption of one electrode there is a need to replace the electrode with a new one. So for this purpose remove the remaining part of the electrode and insert new.

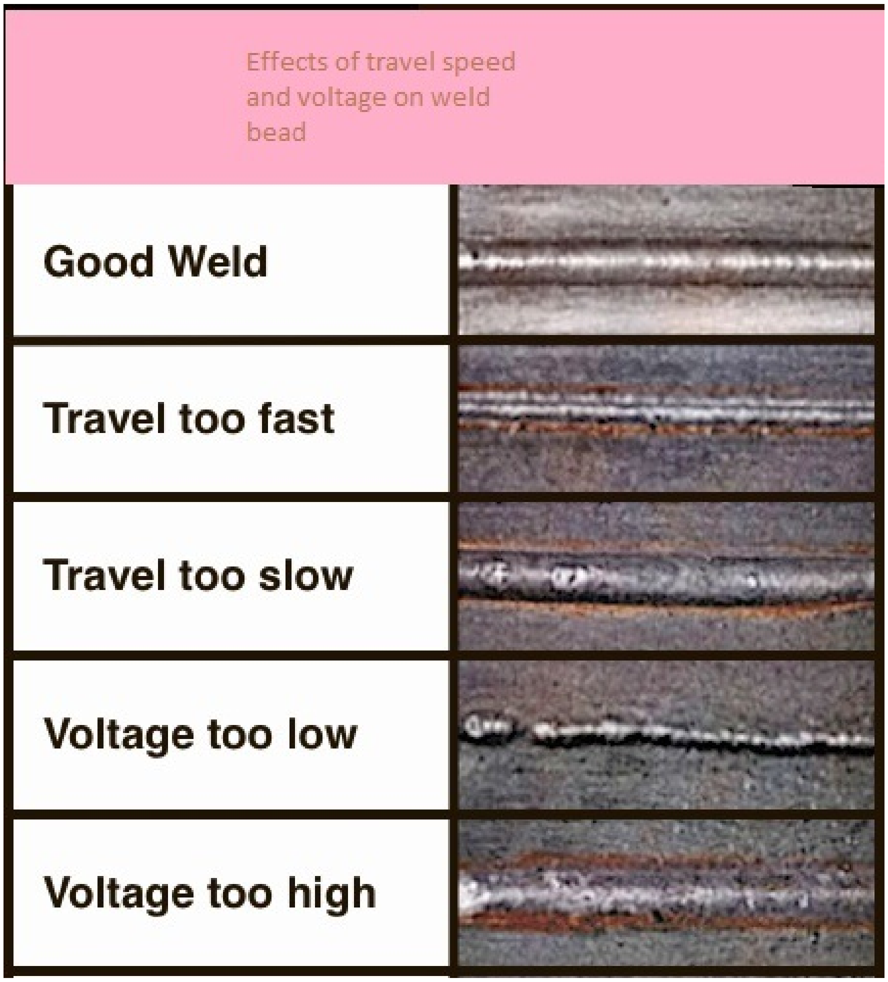
Now to start the weld bead again, strike the electrode tip slightly ahead to the end of the first bead and then move the electrode back to attach with the previous bead so that continuity of the bead remains good.

Angle of travel

Angle of travel is the angle at which the movement of the electrode is done on the parts to be welded. When welding on a flat surface, the SMAW techniques that you need to use are the backhand or drag (for flat and horizontal positions). Hold the welding stick perpendicular to the part where the materials are to be welded and then tilt at approximately 5 degrees to 15 degrees. It may vary from 5 to 30 degrees, depending on the welder's choice and welding positions.

Travel Speed

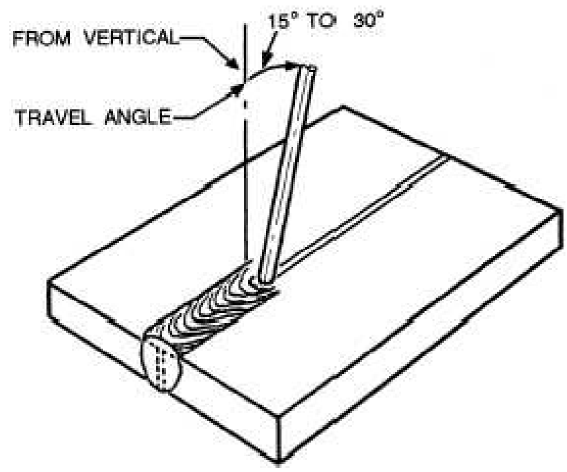
A speed at which the electrode travels on the parts to be welded to make a solid joint.
The speed of travel depends on the skill of the operator, the position of the weld, the type of electrode, and the required joint penetration. Travel speed greatly affect the quality of weld because if the travel speed is too fast, then the molten pool cools to quickly as a result weld bead becomes too narrow and if the travel speed is too slow, then there's deep penetration due to which due to which the metal deposit piles up too much and the weld bead becomes wide and thick.



Effects of travel speed and voltage on weld bead

Electrode Angle

The angle at which you hold the electrode in the electrode holder is termed as electrode angle. It affects the shape of the weld bead. Electrode angle consists of two positions; work angle and travel angle. Work angle is the angle from the horizontal measured surface at right angle to the direction of weld and travel angle is described above



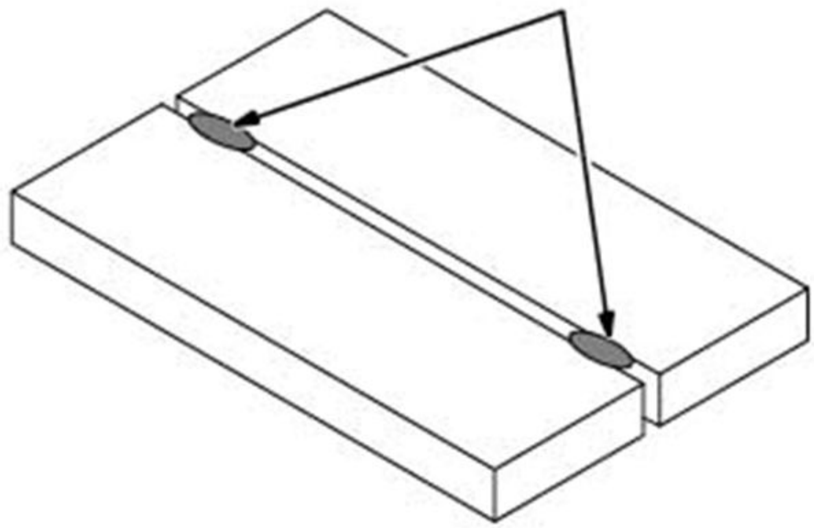
Electrode Manipulation

The art of moving the electrode on the work piece to form a welding joint by using the manual method (movement of hand of the operator to guide the electrode for bead making) is termed as electrode manipulation.

Electrode manipulation is directly affected by the operator's experience because electrode manipulation is difficult for beginners. However it can be improved by observing the experienced operators and practicing more.

Tack Welds

Tack weld is the initial two point weld that temporarily joins the pieces of metal to hold them in place. This will reduce joint distortion, which is caused by the expansion and contraction of metal as it is heated and cooled as shown in fig below.

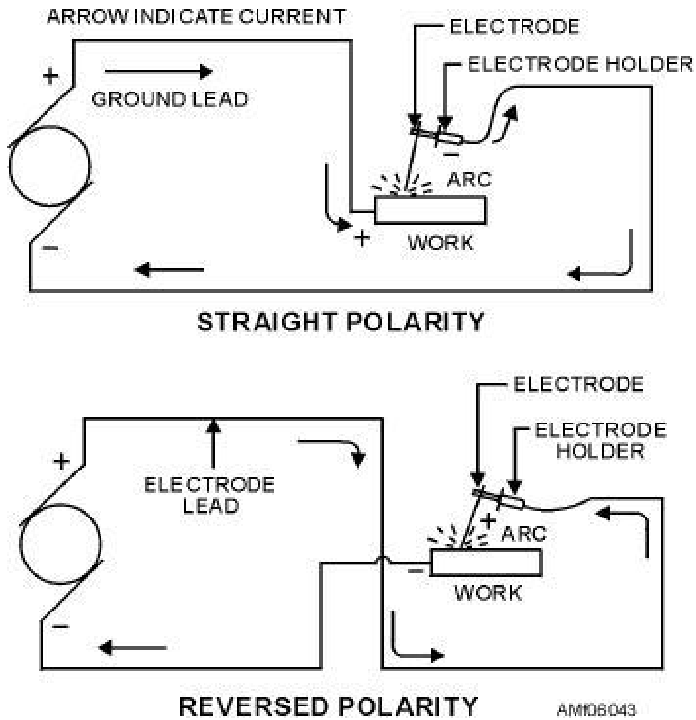


Polarity in welding

The electrical circuit that is created when you turn on the welding machine has a negative and a positive pole – this property is called polarity. Polarity matters greatly in welding because choosing the right polarity affects the strength and quality of the weld. Using the wrong polarity will lead to lots of spatter, bad penetration, and a lack of control of your welding arc.

What is straight and reverse polarity in welding?

“Straight” and “reverse” polarity is common terms for “electrode-negative” and “electrode-positive” polarity. Welding currents with electrode-positive (reverse) polarity result in deeper penetration, while electrode-negative (straight) polarity has the benefit of faster melt-off and faster deposition rate. Different shielding gasses may further affect the weld as well.

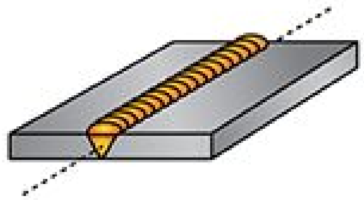


Welding procedure for Flat Position (1F & 1G)

Flat position

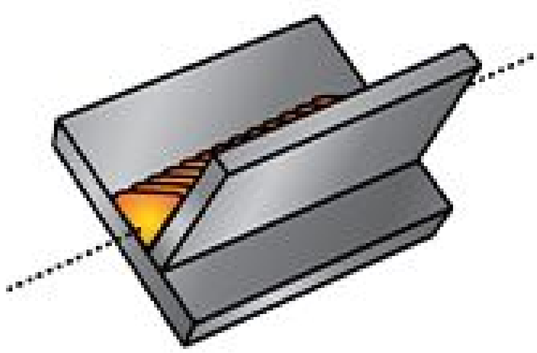
Flat position is the best and easiest position because during this position the work piece is placed flat parallel to the worktable and there is no risk of weld pool molten metal to flow from the joint. This Type of welding is also termed as down hand welding position. In this process the joint is prepared on the upper side of the work piece due to which it is quite easy to maintain the weld pool. This position can be used with any type of welding. Angle of travel for flat position will change depending upon type of weld e.g. either fillet or groove weld if proper angle of travel is not maintained during welding there may be poor quality of weld bead.

Flat Position



1G

Flat Position



1F

To prepare a lap joint (1F)

LAP JOINT

Aim: To make a Lap joint, using the given two M.S pieces by stick welding.

Material Required:

Mild steel plate of size 100X50X5mm – 2 No’s

Welding Electrodes: M.S electrodes 3.1 mm X350 mm

Welding Equipment: Air cooled transformer

Voltage-80 to 600 V,3-ф supply, Current up to 350 Amps

Tools and equipment:

Hacksaw, steel rule, scriber, rough file, try square Arc welding apparatus, welding table, Mild steel electrodes, chipping hammer, wire brush, Tongs, safety goggles, face shield.

Sequence of operations:

1. Marking 2. Cutting 3.Edge preparation (Removal of rust, scale etc.) by filling

4. Try square leveling 5.Tacking 6.Welding 7.Cooling 8.Chipping 9. Cleaning

Procedure:

1. Arrange all mentioned tools and equipment at your workstation.

2. Cut the material according to the given size and square it by using a rough file.

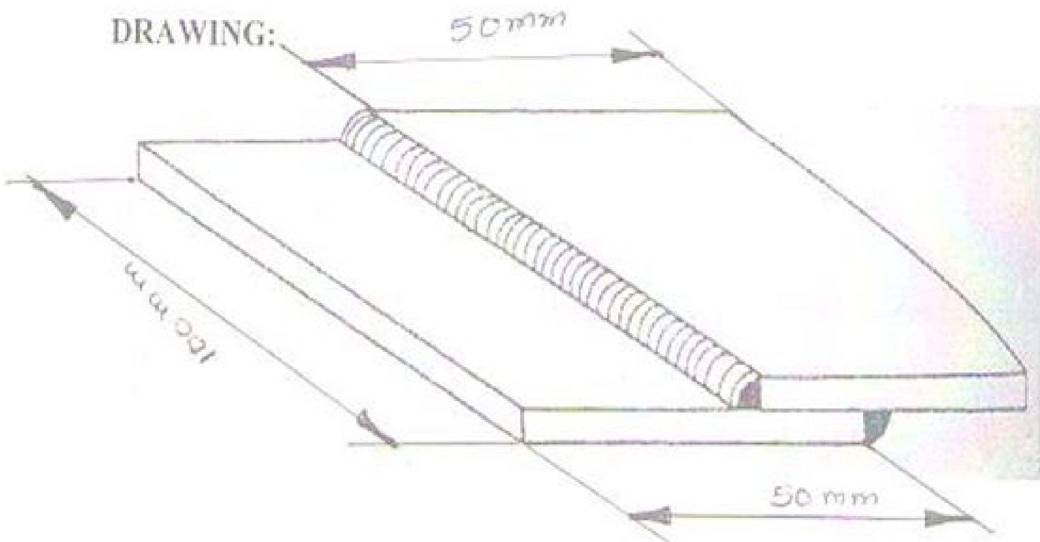
2. Position the two pieces on the welding table such that the two pieces overlapped one over the other as shown in the drawing.

3. Hold the electrode in the electrode holder and set the current to proper value.

4. Fasten the ground clamp to the welding table.

5. By using an electric arc make tack weld on two joining surfaces so that the position cannot miss align.
6. Now complete the joint by applying a bead on the joining surface and check the accuracy.
7. To get a strong and accurate joint also weld the lower surface of the joint.
8. By using a chipping hammer remove slag and finish the surfaces.
Safety precautions:

1. Exhaust fans should be installed in welding shops for removal of smoke and other gasses.
2. Welded work pieces and scrap of electrodes should be kept away from the working area.
3. All the raw material should be stored in the store room.
4. Fire extinguisher should be installed in the welding shop.



To prepare "V" Groove but joint (1G)

Material required:

Mild steel plate of size 100X50X5mm – 2 No's

Welding Equipment: Air cooled transformer

Voltage-80 to 600 V 3 phase supply, amps up to 350

Tools and equipment:

Hacksaw, steel rule, scriber, rough file, try square Arc welding apparatus, welding table, Mild steel electrodes, chipping hammer, wire brush, Tongs, bevel protector, safety goggles, face shield.

- **Sequence of operations:**

1. Marking 2. Cutting 3. Edge preparation (Removal of rust, scale etc.) by filling

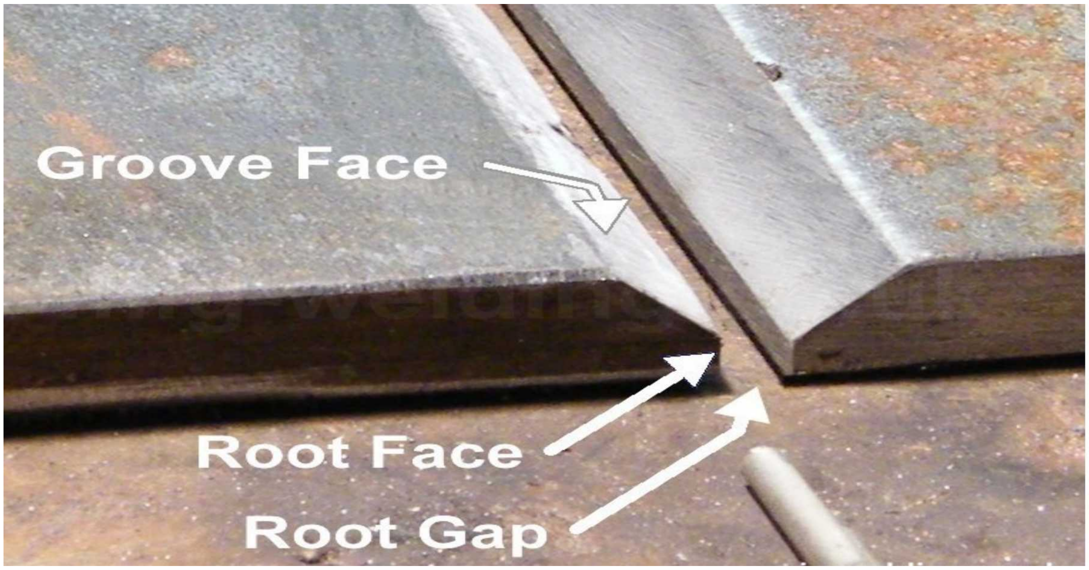
4. Try square level 5.Tacking 6.Welding.Cooling.Chipping9. Cleaning

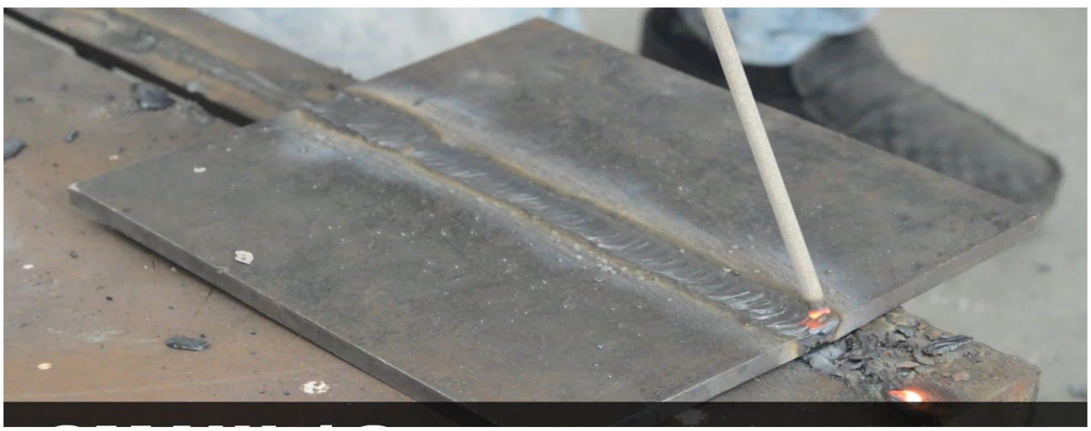
- **Procedure:**

1. The given M.S pieces are thoroughly cleaned off from rust and scale.
2. One edge of each piece is beveled, to an angle of 450, so that by joining two pieces it becomes a capital letter “V” shape joint.
3. The two pieces are positioned on the welding table such that their beveled edges touch each other to form a “V “shape.
4. The electrode is fitted in the electrode holder and the welding current is set to be a proper value.
5. The ground clamp is fastened to the welding table.
6. By using an electric arc make tack weld on two joining surfaces so that the position cannot miss align.
7. Start welding by sharply striking the bottom of the groove with the welding electrode.
7. During the process of welding, the electrode is kept at 150 to 250 from vertical and in the direction of welding.
8. After this, move the welding electrode back to the beginning without stretching the arc, and move the electrode easily while monitoring the width of the molten weld pool.
9. Move the welding electrode with the handle pointing forward. The boundary of the slag formed is visible after the molten weld.
10. Now complete the bead first to fill the “V” groove.
11. Now to complete the joint make the final bead.
12. Remove the slag by using a chipping hammer.
13. Joint is ready to inspect its quality.

Safety precautions:

1. Do not work without a face shield or goggles.
2. Do not dip the welded work piece in water for cooling purposes.
3. Before working ensure that all electrical wires are insulted.
4. Earthling of all electrical systems is necessary.
5. Do not grip the hot work piece in hands, use tongs to grip.





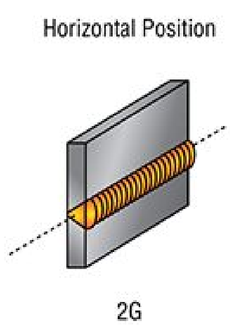
Horizontal welding position (2F &2G)

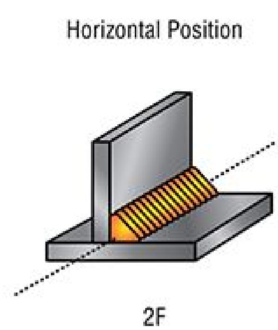
The welding position in which the weld face lies in an approximately vertical plane and the weld axis at the point of welding is in horizontal position. Welds in the horizontal position share many similarities with flat position welds.

2F is a filet weld position, in which the welding is done on the upper side of the surfaces that is approximately horizontal that lies against a surface that is approximately vertical

Groove welding at horizontal position (2G) is slightly more difficult than a filllet weld at horizontal position (2F). This difficulty is due to gravity that tries to flow out the slag from groove weld due to which it is difficult to maintain the slag. Whereas in 2F position: the bottom shelf provides the support to weld puddles due to which gravity has no effect on it. To combat the effect of gravity on the weld puddle in a horizontal groove weld, favor the top edge of the joint slightly with the work angle, knowing the puddle may sag a bit. In a horizontal fillet weld, keep a 45-degree angle to the joint to make sure the heat is focused where the two pieces come together.

In horizontal weld be careful to run too hot in a horizontal position because if the weld poodle is too fluid it can become more victim of gravity. Tweak your weld parameters to make sure the puddle doesn't get too hot or too fluid.





Vertical Position (3F & 3G)

In vertical position welding, the axis of the weld is approximately vertical. In this position, both the plate and the weld lie almost vertically. The 3F and 3G refer to vertical fillet and vertical groove positions.

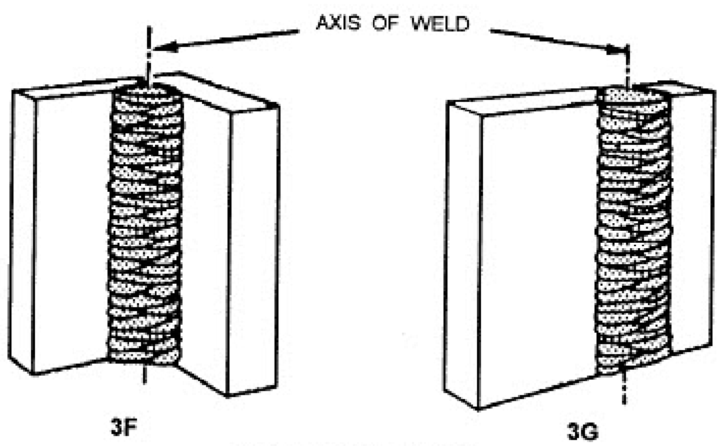
When welding vertically, the force of gravity pushes the molten metal downward and so it has the tendency to pile up. To counteract this, you can use either an upward or downhill vertical position. You can also use fast-freeze or fill-freeze electrodes to counteract this force.

To control this in the upward vertical position, point the flame upward, holding it at a 45-degree angle to the plate. This way, the welder will use the metal from the lower parts of the work piece to weld against the force of gravity.

Vertical down welding is suited for welding light gauge metal because the penetration is shallow and diminishes the possibility of burning through the metal. Furthermore, vertical down welding is faster which is very important in production work.

To produce good welds, you must maintain the proper angle between the electrode and the base metal. In welding upward, you should hold the electrode at 90 degrees to the vertical. Keep the arc short to obtain good fusion and penetration.

Note: In vertical upward position the movement of electrode is upward and in vertical downward position the movement of electrode is downward.

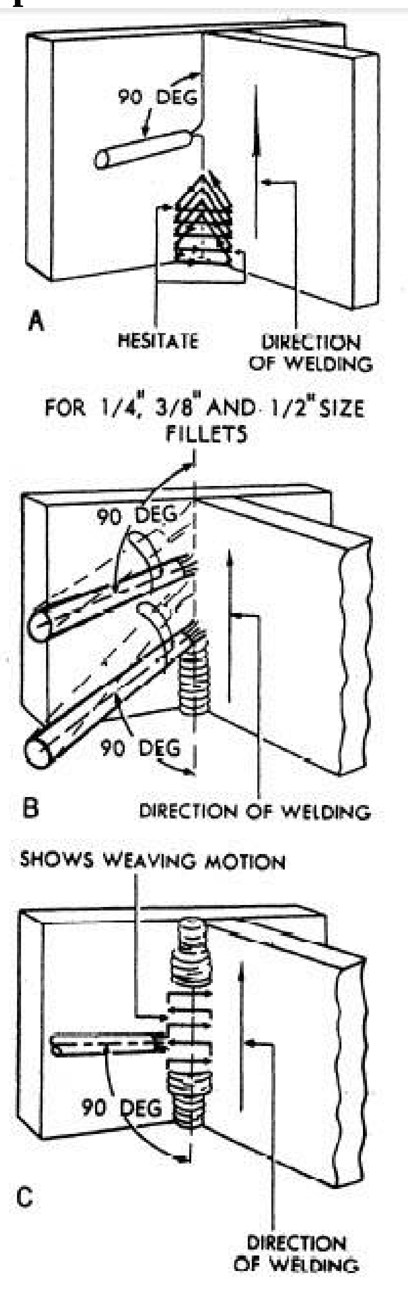


VERTICAL POSITION

Current Settings and Electrode Movement

As compared to flat position, vertical position requires less current. And there is also a difference of usage of current in vertical upward and downward technique. In upward technique the current is slightly higher than downward.

TEE JOINTS. To weld tee joints in the vertical position, start the joint at the bottom and weld upward.



Be Careful while welding at a vertical position and avoid overheating of metal. If metal overheats, quickly shift the electrodes away from the crater without breaking the arc. This permits the molten metal to solidify without running downward due to gravity.

Important parameters to be followed for stick welding in vertical position

Choosing the right electrode

Choosing the right electrode is the most important step before starting a stick welding in a vertical position because you have to work against the gravitational force. So, to ensure the best quality of resultant joint choosing the right electrode is necessary.
It is recommended to use low iron powder content because iron powder takes more time to cool down. An electrode with less iron powder will set quicker and also produce less slag. AWS 6010 or AWS 7018 electrodes are perfect for vertically up position. When moving vertically down, the AWS 7024 electrode is perfect. It does not set quickly, due to which it allows the weld pool to travel down the surface.

Create weld shelves

When you have to weld thin metal structures, use the vertically up movement. No matter what, it is difficult and time-consuming. By creating weld shelves it becomes easier and produces the best results.
Weld shelf is created when you join one section of the work piece and then move on the next. The pool of the former weld acts as the weld shelf for the next section. To ensure best penetration, try to resist the pool two times the diameter of the electrode you are using.

Current and voltage setting

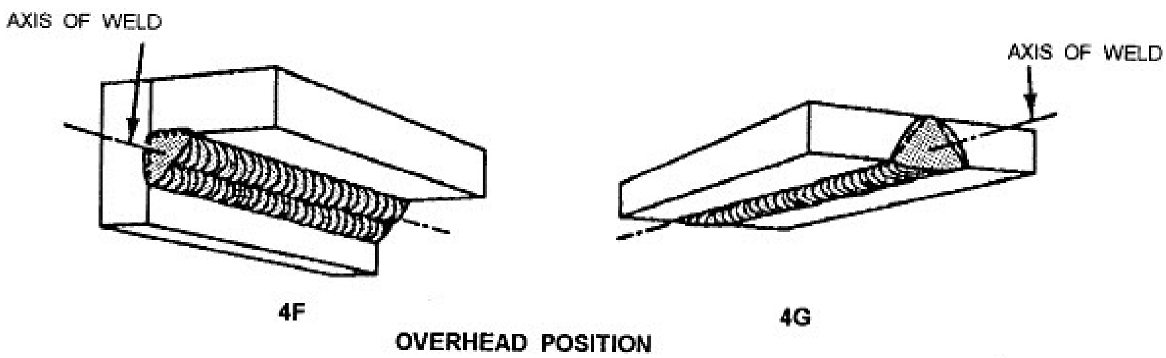
In vertical position use low current as compared to flat and horizontal position. Because high current can cause different welding defects e.g. undercut and blow holes. so to maintain a better control set the amperage at a lower value.

Overhead Position (4F and 4G)

Overhead welding position is a position in which you have to weld a joint above your head in such a way that you position yourself underneath the

weld surface. And for making a joint you have to look upward by giving tension to your neck muscles due to which this position is complicated among all the other positions. This position requires a lot of physical and mental attention to complete a welding joint.
In overhead welding, the metal deposited tends to drop or sag on the plate, causing the bead to have a high crown.

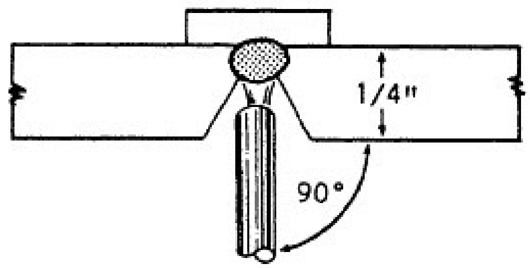
The molten puddle should be kept small to overcome this difficulty, and enough filler metal should be added to obtain good fusion with some reinforcement at the bead. If the puddle becomes too large it can flow out due to the force of gravity, so when you notice the poodle is trying to flow out, stop the welding process for a moment until the molten metal becomes solid.



This position is mostly used in construction of big structures where these parts can not be prepared in a workshop and needs on-site welding e.g in shipbuilding, pipeline, steel bridges, etc.

Butt Joint Welding

But joint is a most common type of joint in which pieces to be welded are joined from face to face usually by using groove weld technique as shown in fig below.



Overhead Groove weld

The preparation of material overhead groove weld is just like a preparation of material in flat weld position that is by beveling the edges of the two pieces individually to form a V shape groove using a rough file or grinder.

After preparation of material to be welded, hold the work pieces in an overhead position where you have to assemble them by using appropriate holding and sporting equipment.

This technique of welding is difficult among others because it is crucial to maintain the weld metal pool. It is recommended to use the backing strip of copper. The benefit of this is to support the molten metal weld pool to solidify rapidly as a result you can continue your welding without delay.

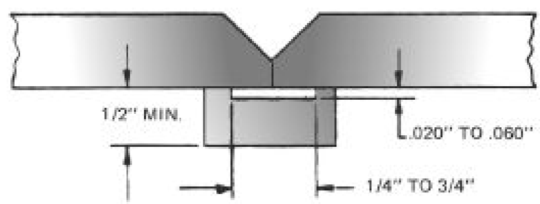
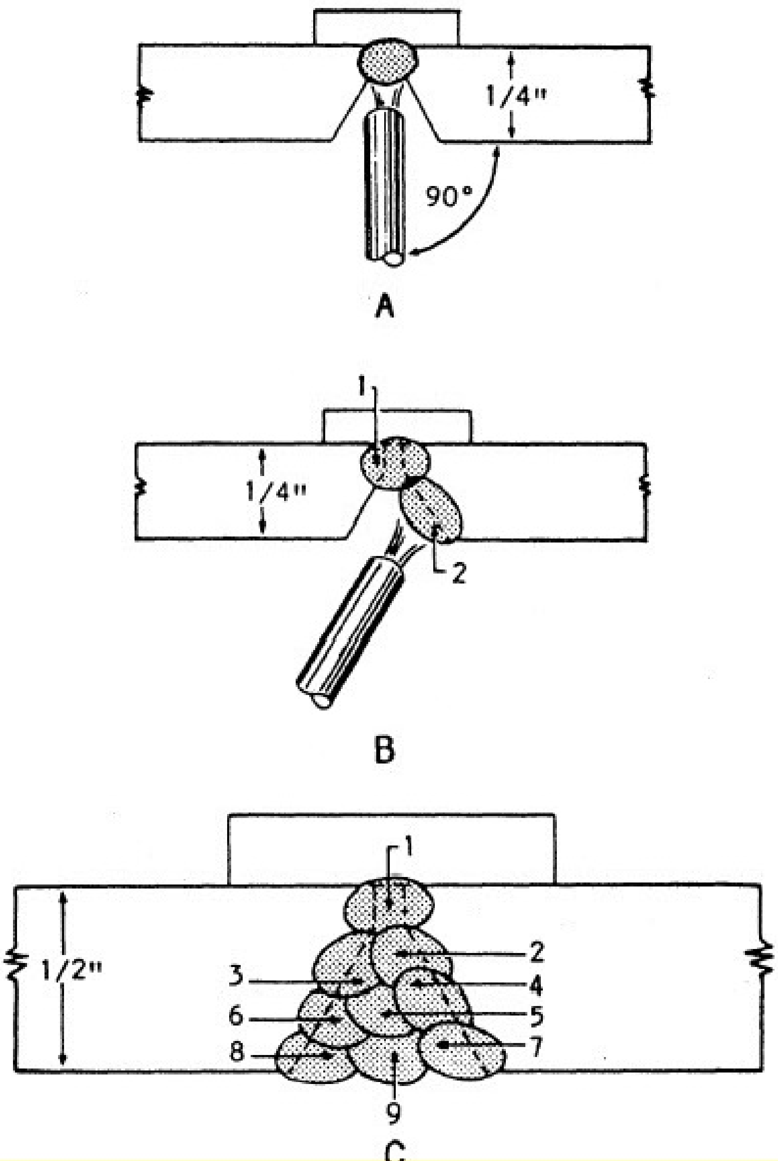


Fig: Recommended groove dimensions for copper backing strip

Bead welding is best for the overhead arc welding position. When you lay your head be sure to remove any rough parts of it with a chipper and clean it prior to your next bead.

The electrode position and the order of deposition of the weld beads when welding on 1/4- or 1/2-inch plate are shown in fig, views B and C. Make the first pass with the electrode held at 90 degrees to the plate, as shown in figure, view A. Do not make use of too large electrode because due to too large electrodes you cannot hold a short arc in the root area as a result there is insufficient root penetration and poor weld quality.

Since root penetration is crucial you want to be sure your stick is at a ninety degree angle as seen in illustration A below on your first bead. The travel angle should be 10 to 15 degrees in the direction of welding.



Chapter 04

WELDING DEFECTS AND THEIR REMEDIES

Welding Defects are the irregularities formed in the given weld metal due to improper welding techniques, incorrect welding positions, improper angle of travel, improper angle of electrode holding etc. The defect may differ from the desired weld bead shape, size, and intended quality. Welding defects may occur either outside or inside the weld metal. Some common welding defects are described below.

Lack Of Penetration

Incomplete penetration or lack of penetration occurs when the groove of the metal is not filled completely, meaning the weld metal doesn’t fully extend through the joint thickness.

Causes:

1. There was too much space between the metal you’re welding together.
2. You’re moving the bead too quickly, which doesn’t allow enough metal to be deposited in the joint.
3. You’re using a too low amperage setting, which results in the current not being strong enough to properly melt the metal.
4. Large electrode diameter.
5. Misalignment.
6. Improper joint.

Remedies:

1. Use proper joint geometry.
2. Use a properly sized electrode.
3. Reduce arc travel speed.
4. Choose proper welding current.
5. Check for proper alignment.

Slag inclusion

Slag inclusion is one of the welding defects that are usually easily visible in the weld. Slag is a vitreous material that occurs as a byproduct of stick welding, flux-cored arc welding and submerged arc welding. It can occur when the flux, which is the solid shielding material used when welding, melts in the weld or on the surface of the weld zone.

Causes:

1. Improper cleaning.
2. The weld speed is too fast.
3. Not cleaning the weld pass before starting a new one.
4. Incorrect welding angle.
5. The weld pool cools down too fast.
6. Welding current is too low.

Remedies:

1. Increase current density.
2. Reduce rapid cooling.
3. Adjust the electrode angle.
4. Remove any slag from the previous bead.
5. Adjust the welding speed.

Undercut

This welding imperfection is the groove formation at the weld toe, reducing the cross-sectional thickness of the base metal. The result is the weakened weld and work piece.

Causes:

1. Too high weld current.
2. Too fast weld speed.
3. The use of an incorrect angle, which will direct more heat to free edges.
4. The electrode is too large.
5. Incorrect usage of gas shielding.
6. Incorrect filler metal.

7. Poor weld technique.

Remedies:

1. Use proper electrode angle.
2. Reduce the arc length.
3. Reduce the electrode's travel speed, but it also shouldn't be too slow.
4. Choose shielding gas with the correct composition for the material type you'll be welding.
5. Use of proper electrode angle, with more heat directed towards thicker components.
6. Use of proper current, reducing it when approaching thinner areas and free edges.
7. Choose a correct welding technique that doesn't involve excessive weaving.

Blow holes

It is formed due to the gas phenomenon in liquid metal. The weld cannot escape when metal puddles solidified

Blow hole can be appeared:

Inside (1) or weld surface (2)

Located at the boundary between base metal and filler metal

Can be distributed, concentrated (4) or discrete in the weld

Causes:

1. Welds existing porosities will reduce their effectiveness and tightness
2. C content in basic metals and in weld materials is too high
3. Welding material is damp; the surface of the welding is dirty
4. The arc length is large; the welding velocity is too high

Remedies:

1. Adjust the short arc length; reduce the welding speed of the MIG welding machine
2. After welding, do not knock the slag immediately to prolong the heat retaining time for the weld
3. Provide enough MAG welding / MIG gas, gas shooting distance

4. Automatic welding flux is not moist, providing enough flux in the welding process

Weld Crack

The most serious type of welding defect is a weld crack and it’s not accepted by almost all standards in the industry. It can appear on the surface, in the weld metal or the area affected by the intense heat.

Causes:

1. Use of hydrogen when welding ferrous metals.
2. Residual stress caused by the solidification shrinkage.
3. Base metal contamination.
4. High welding speed but low current.
5. No preheating before starting welding.
6. Poor joint design.
7. A high content of sulfur and carbon in the metal.

Remedies:

1. Preheat the metal as required.
2. Provide proper cooling of the weld area.
3. Use proper joint design.
4. Remove impurities.
5. Use appropriate metal.
6. Make sure to weld a sufficient sectional area.
7. Use proper welding speed and amperage current.
8. To prevent crater cracks make sure that the crater is properly filled.