



Welding Processes and Symbols

Welding Processes

Welding can be defined as the process of joining two or more pieces of similar materials together. Generally, welding processes are used to join metals, but other materials, such as plastics, can be welded by a variety of methods. By heating the material to a high temperature, the materials soften, melt, and combine. The parts become one at the point of application. A properly welded joint becomes as strong or stronger than the original materials. Welding processes can be done independently of pressure application to the materials.

There have been a significant number of welding processes developed in industry. Welding processes have many capabilities and advantages in manufacture of parts and structures. These processes are varied in their applications and abilities, and include arc welding, friction welding, soldering, solid state welding, laser beam welding, brazing, and so forth. Each welding process has an identifying abbreviation that can be included in a welding symbol on the drawing. Abbreviations for various welding and brazing processes are shown on the following chart (See Figure 1). The most common process categories used for welding are ARC welding, RESISTANCE welding, and GAS welding.

Process	Abbreviation	Process	Abbreviation
Shielded Metal Arc Welding	SMAW	Upset Welding	UW
Gas Metal Arc Welding	GMAW	Torch Brazing	TB
Gas Metal Arc Welding - Short Circuit	GMAW-S	Atomic Hydrogen Welding	AHW
Flux Cored Arc Welding	FCAW	Bare Metal Arc Welding	BMAW
Gas Tungsten Arc Welding	GTAW	Magnetically impelled Arc Butt	MIAB
Submerged Arc Welding	SAW	Air Acetylene Welding	AAW
Plasma Arc Welding	PAW	Resistance Spot Welding	RSW
Oxyfuel Welding	OFW	Resistance Seam Welding	RSEW
Resistance Welding	RW	Projection Welding	PW
Electron Beam Welding	EBW	Coextrusion Welding	CEW
Electroslag Welding	ESW	Cold Pressure Welding	CW
Friction Welding	FW or FRW?	Diffusion Welding	DFW
Laser Beam Welding	LBW	Explosion Welding	EXW
Oxy-Acetylene Welding	OAW	Forge Welding	FOW
Flash Welding	FW	Friction Stir Welding	FSW
Carbon-Arc Welding	CAW	Hot Pressure Welding	HPW
Oxy-Hydrogen Welding	OHW	Hot Isostatic Pressure Welding	HPW
Pressure Gas Welding	PGW	Roll Welding	ROW
Percussion Welding	PEW	Brazing	BZ
Thermite Welding	TW	Induction Brazing	IB
Ultrasonic Welding	USW	Resistance Brazing	RB
Induction Welding	IW		

Figure 1: Welding and Brazing Abbreviations

The most common Arc welding process is GMAW (Gas Metal Arc Welding) which is also known as MIG (Metal Inert Gas welding). The “G” refers to an inert GAS such as Argon or Carbon Dioxide which is used to shield the hot metal from oxidizing until it has had a chance to cool down sufficiently. The “M” refers to the filler METAL or wire which is being used as the electrode. This wire is automatically fed through the contact tip where it becomes electrified and creates an electric arc between itself and the work piece generating sufficient heat to melt not only itself but also a portion of the work piece. This metal wire is consumed in the process and is added to the molten metal on the work piece to build up the weld bead. The GMAW process is the most common because it is the easiest to learn and also lends itself to automated or robotic applications.

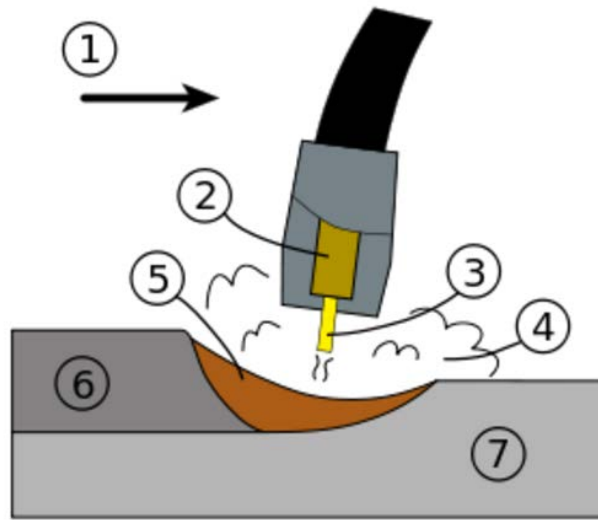


Figure 2: GMAW or MIG welding schematic (Reference: Wikipedia)

GTAW (Gas Tungsten Arc Welding) which is also known as TIG (Tungsten Inert Gas) is similar to GMAW in that it uses an inert gas to shield the hot metal from oxidizing. The electrode, however, is made from Tungsten which has a high enough melting point that it does not melt in the process and is therefore not consumed. A filler metal can be added to build up the weld bead but it is added to the side and is not used as the electrode as it is in GMAW.

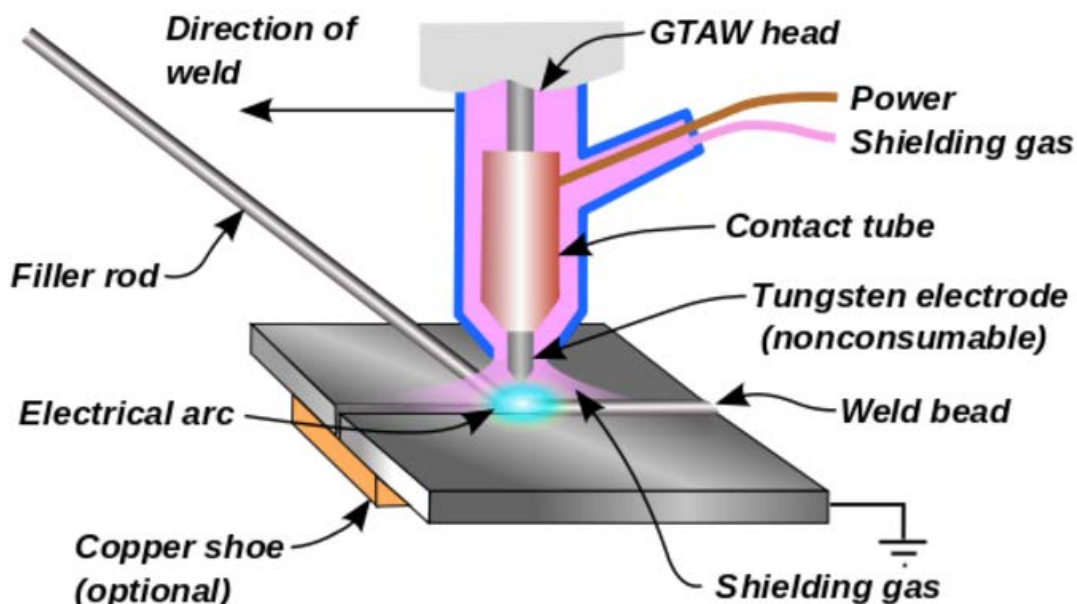


Figure 3: GTAW or TIG welding process (Reference: Wikipedia)

SMAW (Shielded Metal Arc Welding) is often called Stick Welding and is a flexible and relatively low-cost welding process. The filler metal is in the form of a rod which is also used as the electrode. The shielding is accomplished by a flux material which is placed onto the outside of the rod. Both the flux and filler rod melt and are consumed during the process. The flux combines with any impurities on the metal to create a slag and floats to the top of the weld bead to cover it and protect it from oxidizing. After it cools, the slag creates a hard brittle surface which needs to be chipped off the weld bead. SMAW can be done outdoors since shielding is accomplished with a flux rather than with an inert gas which would blow away in the wind.

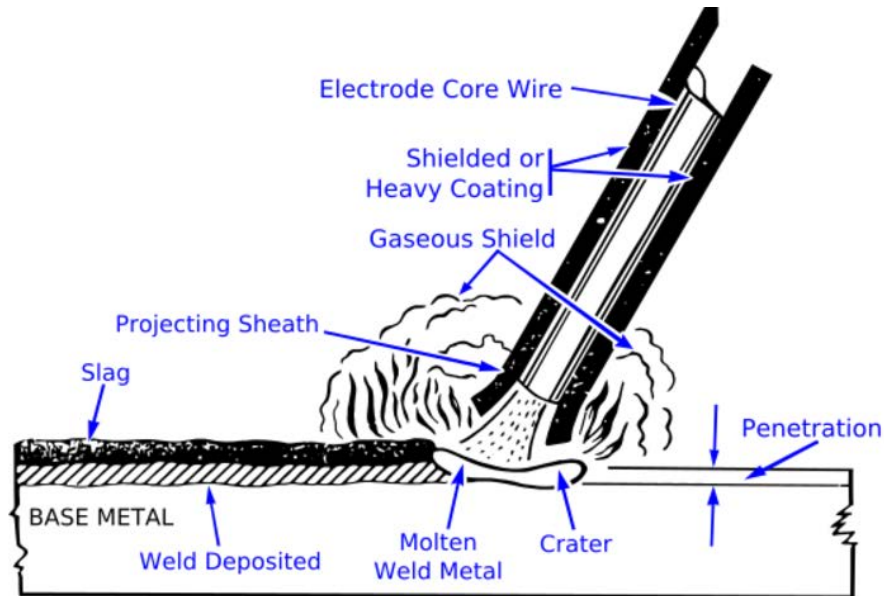


Figure 4: SMAW or Stick Welding process (Reference: Wikipedia)

Resistance welding involves holding two pieces of metal together under pressure and applying electrical current through the nodes. The resistance of the material to the current creates high heat buildup at the point where the nodes contact the parts. The end result is the pieces of metal are welded at the point of contact. The most common types of resistance welding are spot welding (RSW) and seam welding (RSEW). (See Figure 5) Resistance welding lends itself well to automation.

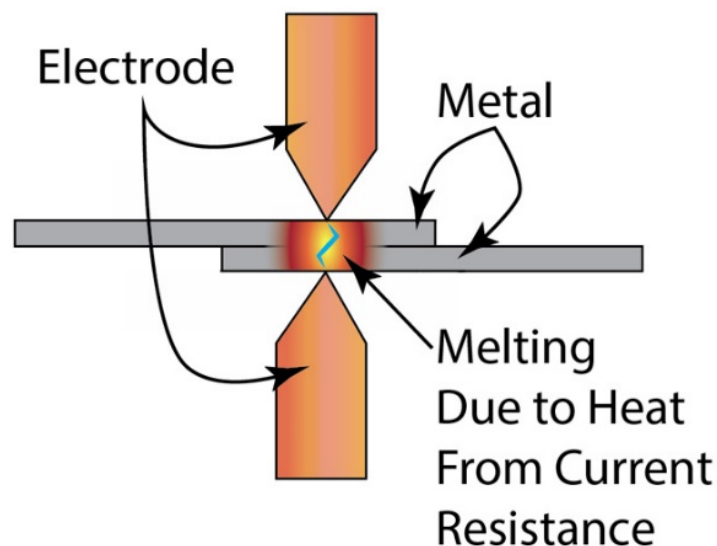


Figure 5: Spot Welding Process

Gas welding is generally done using oxyfuel or oxyacetylene which is a mixture of oxygen and acetylene gases. Other types of gases can be used as well, such as propane, natural gas, or propylene gas. The flame resulting from the burning fuel shields the hot metal from oxidizing. The abbreviation for oxyacetylene welding is OAW. It is useful for welding repair work.

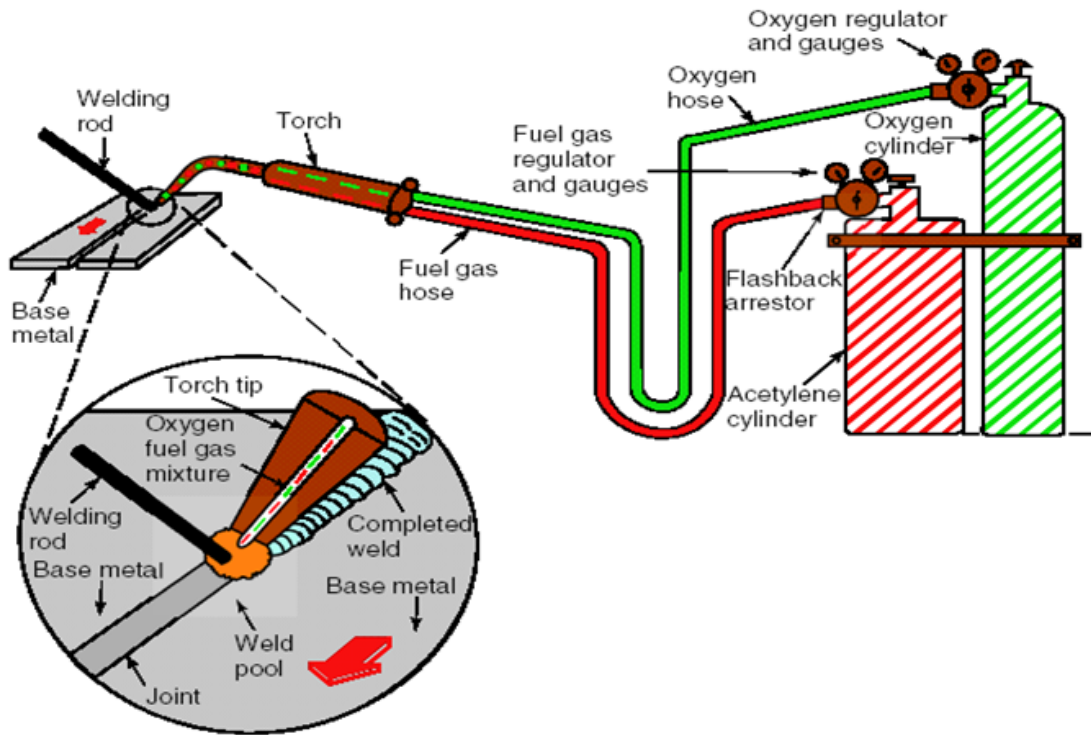


Figure 6: OAW -- Oxyacetylene Welding (Reference: www.zoombd24.com)

Welding Drawings and Symbols

Welding drawings are called weldments. They show the parts together in orthographic views with all the manufacturing dimensions, weld symbols, and welding specifications. The American Welding Society (AWS) has standardized the drawing symbol for specifying weld processes on weldment drawings. The weld symbol is used to indicate the complete information about the type and specifications of the required weld.

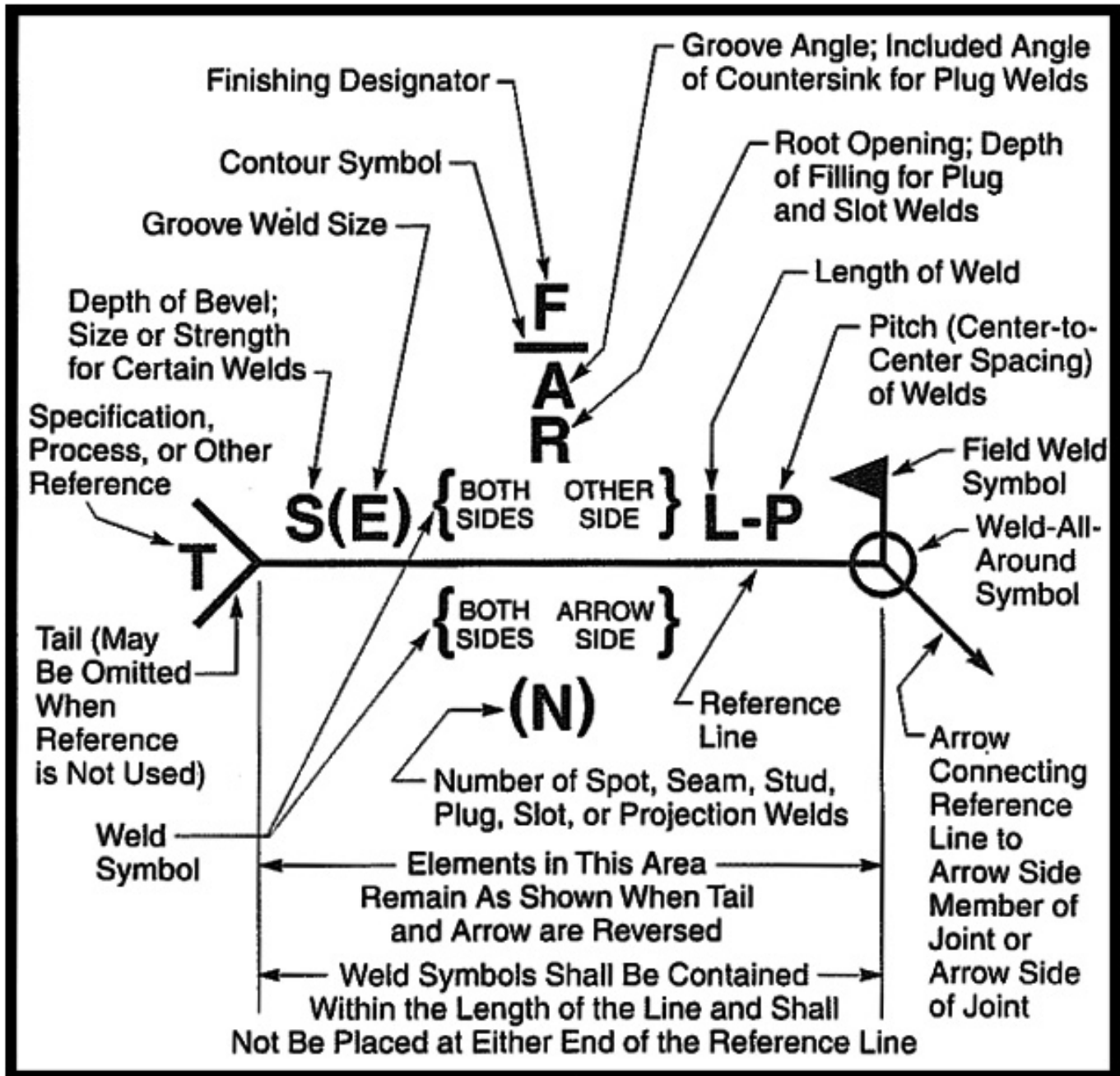


Figure 7: Weld Symbol (Reference: Engineering Drawing and Design, David A Madsen, Chapter 21, page 698)

There are three main components associated with the weld symbol.

- (A) The leader line – the leader line is similar to other components of the drawing using leader lines. It is drawn at any necessary angle, although angles less than 15 degrees or greater than 75 degrees can lead to confusion and should be avoided. (See Figure 8 – A)
- (B) The reference line – The reference line includes all the welding details which are placed above or below this line. (See Figure 8 – B)
- (C) The tail – the tail is used to designate specific welding processes to be used on the part joint. Additional reference information is placed within the tail. (See Figure 8 – C)

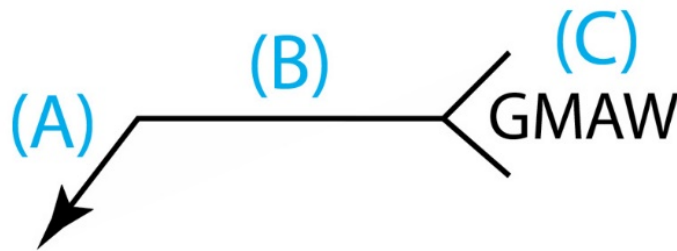


Figure 8: Basic AWS Weld Symbol

Welding specifications are placed on the symbol instead of writing the specifications as lengthy notes. Each type of weld has specific standard symbols to represent the weld bead and specific placement on the weld callout. CAD systems have a weld symbol command that corresponds to the layout of the AWS welding symbol.

The leader line for fillet and groove welds should point to the weld joint. The placement of the weld type symbol on the reference line will indicate which side of the weld joint receives the weld. If the weld is to be placed on the arrow side of the joint the appropriate symbol is placed below the reference line in the symbol. If the weld is to be placed on the opposite side of the joint from the leader line arrowhead, then the weld type symbol is placed above the reference line indicating the other side of the joint receives the weld. (See Figure 10.2.3)

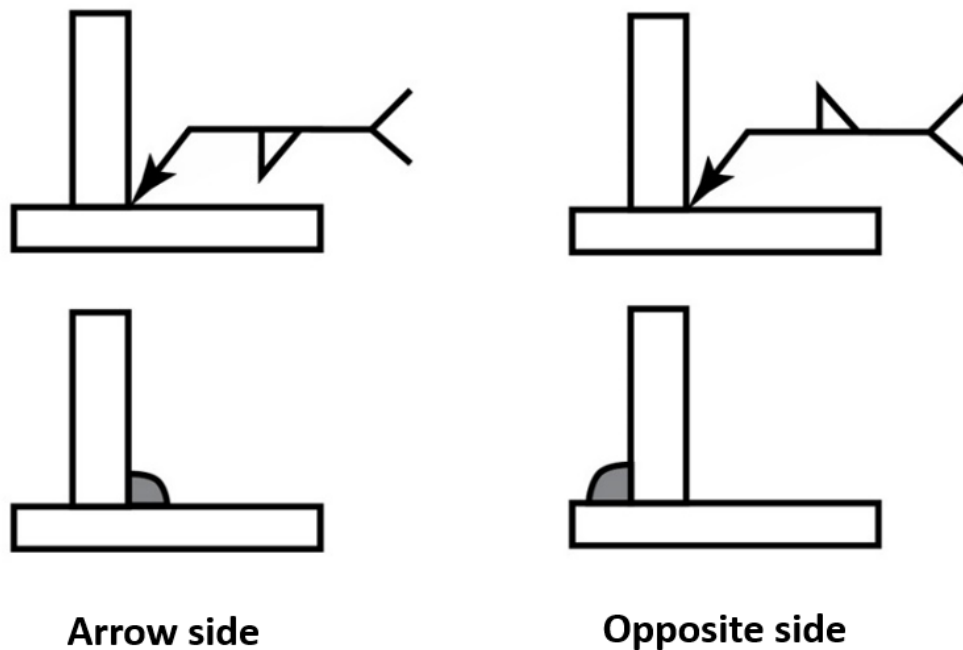
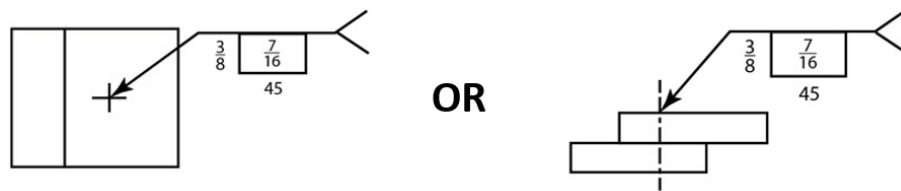


Figure 9: Weld bead placement – Arrow Side versus Opposite Side

For plug, seam, spot, or other resistance welding types, the leader arrowhead connects the welding symbol reference line with the outer surface of one of the joint members. The member that the arrowhead points to is considered the arrow side member. (See Figure 10.2.4)



MEANING

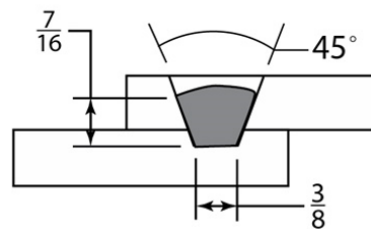


Figure 10: Plug Weld Symbol and Meaning

Specific welding types have their own symbol that is placed on the AWS standard symbol. This indicates the weld type and location. It also gives lengths, depths, and finishing processes for the joint weld. The type of weld is associated with the weld profile and the groove type. The following chart shows the weld type symbols. (See Figure 11)

Basic Weld Symbols and Their Location Significance within the Welding Symbol									
Location Significance	Fillet	Plug	Slot	Spot or Projection	Stud	Seam	Back or Backing	Surfacing	Edge
Arrow Side									
Other Side					Not Used			Not Used	
Both Sides		Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	
No Arrow Side or Other Side Significance	Not Used	Not Used	Not Used		Not Used		Not Used	Not Used	Not Used
Location Significance	Groove							Scarf for Brazed Joint	
	Square	V	Bevel	U	J	Flare-V	Flare-Bevel		
Arrow Side									
Other Side									
Both Sides									
No Arrow Side or Other Side Significance	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	

Figure 11: Standard Weld Symbols (Reference: Engineering Drawing and Design, David A Madsen, Figure 21.13)

Field weld – a field weld is a weld performed in the field or on location as opposed to welding the parts together in the shop. Often parts are cumbersome and large - making joining pieces together on site much easier and less costly. The field weld symbol is a flag attached to the intersection of the reference line and the leader line. (See Figure 10.5.1)

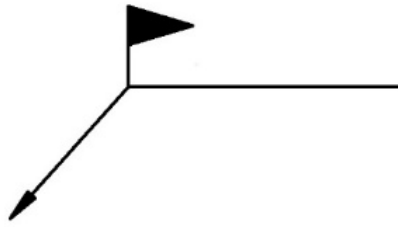


Figure 12: Field Weld Identifier on Weld Callout

Weld all-around – If a welded connection requires the weld be performed all around the feature joint then the all-around symbol is included on the welding symbol. It is attached at the intersection of the leader line and the reference line. (See Figure 10.5.2)

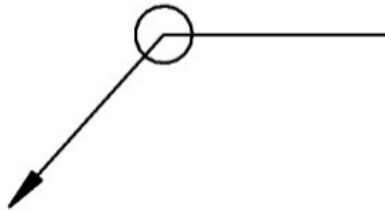


Figure 13: All Around Identifier on Weld Callout

Weld shape/finish – Often the weld bead will need to be processed to provide a surface finish for the application. The surface of a weld finish is generally above the surface of the face of the parts. It may be more desirable for the final surface to be processed to a finished shape. The finishing process shape may be flush to the part surface, contoured to a concave finish shape, or to a convex finish shape (See Figure 10.5.3). If necessary a contour surface shape symbol can be applied to the general weld symbol – it is indicated above the weld symbol (or below if weld symbol is under reference line). A letter designator is placed above the contour symbol for other side considerations and below for arrow side applications. Options for finishing a contour shape are chipping (C), grinding (G), machining (M), rolling (R), or hammering (H). (See Figure 10.5.4)

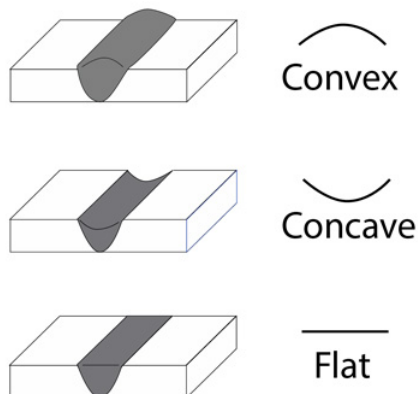


Figure 14: Typical Weld Contours

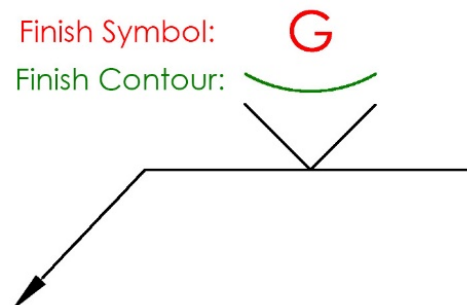


Figure 15: Countour and Finish Symbols on a Weld Callout

Weld length and pitch/increment – Often weld beads do not need to be continuous along the entire length of the part. If this is the case then the length of the weld should be shown on the weld symbol. The weld along a feature is shown in lengths space a given distance apart. The distance from a point on one weld bead to the exact same point on the next weld bead is called the pitch. Most often the pitch is given as the center-to-center distance on a weld. The weld length and increment are shown to the right of the weld symbol. (See Figure 10.5.5)

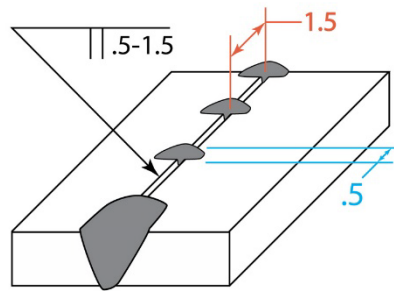


Figure 16: Weld Length and Pitch

Welds that need to be **built-up** are shown with built-up symbol and the height of the buildup. (See 10.5.6)

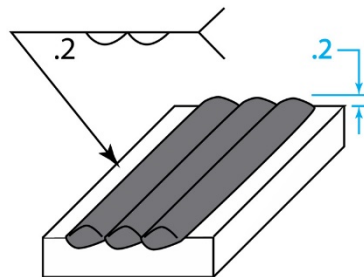


Figure 17: Weld Buildup

Weld penetration is generally through the thickness of the part unless otherwise specified. A weld with a partial penetration may specify a depth of the groove followed by the depth of the penetration in parentheses with both terms placed to the left of the weld symbol. (See Figure 10.5.7)

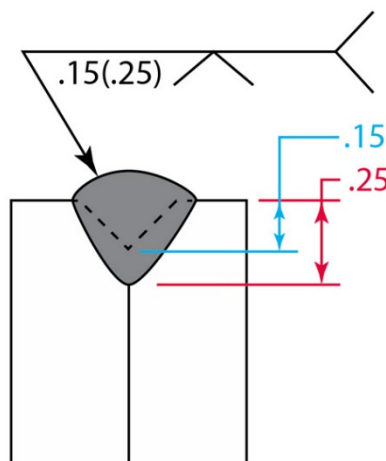


Figure 18: Weld Depth and Penetration

Weld Types

Understanding weld types and joints is important to understanding welding symbols.

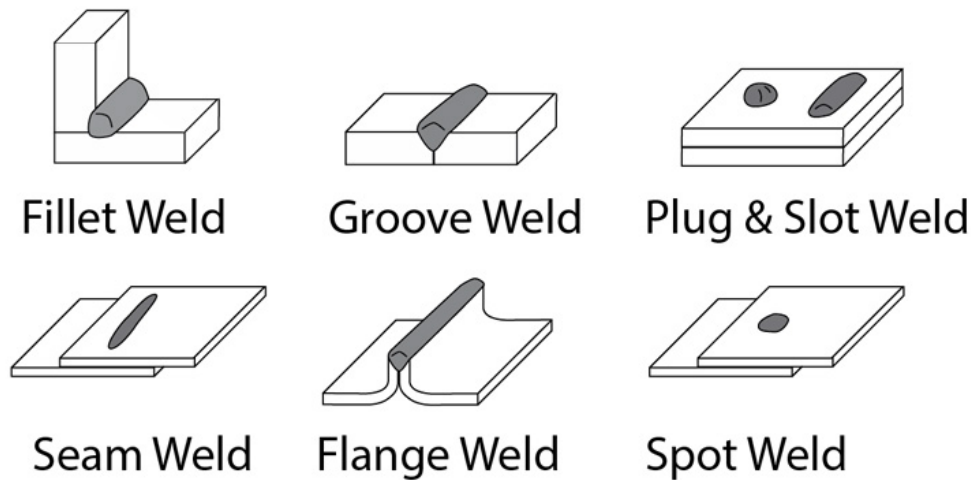


Figure 19: The Six Basic Types of Weld Joints

Fillet welds are used to join metal pieces that meet at right angles to each other. The weld is placed on the inside corner of the joint. It has a triangular cross section. A fillet weld has several components that make up the weld bead cross section and relate to the drawing symbol (See Figure 10.3.3). They are the 1) toe, 2) face, 3) throat, and 4) leg.

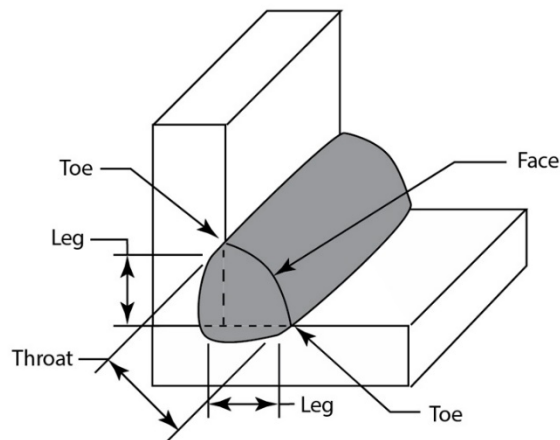


Figure 20: Fillet Weld Profile

A groove weld is made between two pieces of metal that have been prepared to allow the weld penetration. Generally, a butt joint would be welded with a groove weld. A groove weld has the following components: 1) the toe, 2) face, 3) throat, and 4) root. A root opening, or distance the two butt ends are apart, should be dimensioned if not already set as a standard value on the drawing. The groove weld may include a backing bar, back weld, or 100% penetration applied from one side of the weld.

Groove welds and joint preparation are as follows:

- Square – does not require any preparation of either side of the joint. Material thickness is under .25 inches.
- V groove – both sides of the joint will be angled to allow access to the root. The opening will form a V shape.

- Bevel – one side of the joint will be prepared by angling or beveling the edge to allow better access to the root of the joint.
- U groove – this groove will have both sides prepared by a machining process in order to create a U shaped profile.
- J groove – this groove will have only one side machined. The final shape of the prepared side is a J.

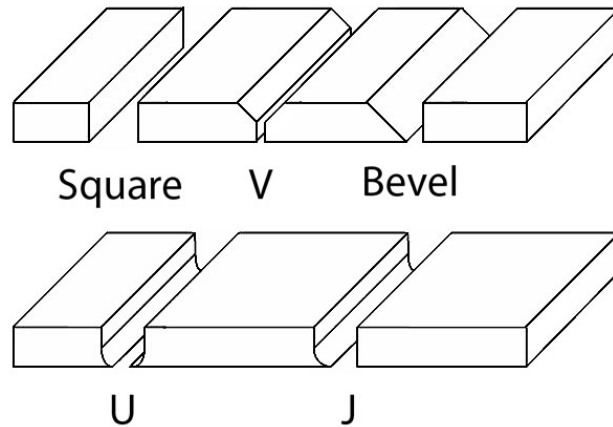


Figure 21: Groove welds and joint preparation

Groove welds that are applied from both sides of the joint are referred to as double groove welds. The information regarding the root opening, angle cut, and all other items are placed in the normal location on the symbol. (See Figure 10.3.5)

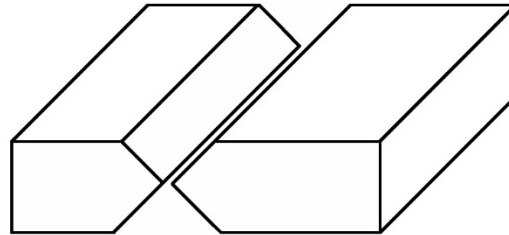


Figure 22: Double Groove Weld Joint Preparation

It is possible to have two different weld types on a joint. This is referred to as a combination weld. The welding symbol would indicate which side of the joint has the welds. The weld type symbols will be stacked in line showing the proper order of the welds (the closest weld type to the reference line is first). (See Figure 10.3.6)

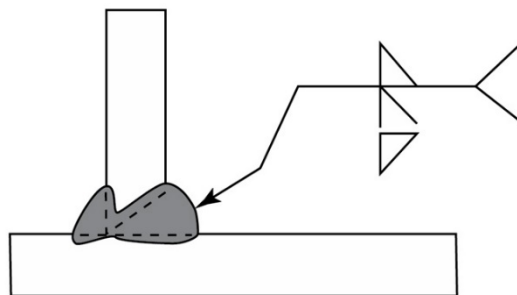


Figure 23: Combination Weld Example

Plug and slot welds are used to join overlapping material. One piece of material will have a hole or slot cut into the part. When the parts are placed together the weld fills the hole thus joining the parts. A slot weld will be a stronger weld as a result of more weld metal being deposited. (See Figure 10.3.7 & 10.3.8)

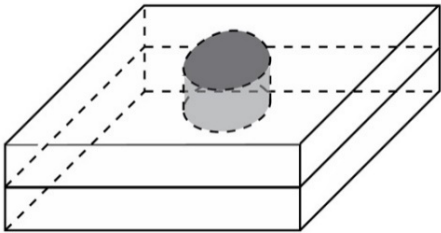


Figure 24: Plug Weld Example

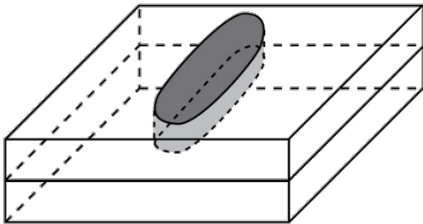


Figure 25: Slot Weld Example

Flange welds join parts where the joint edges have a flange or flare. Generally, flange welds would be used to join thin metal parts. (See Figure10.3.2 “Flange Weld”)

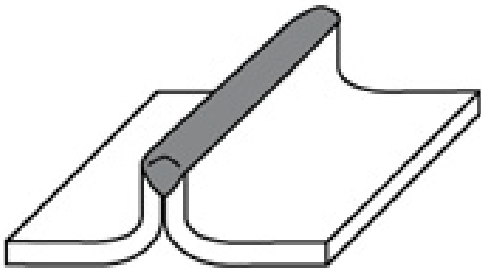


Figure 26: Flange Weld Example

Spot welding is a common resistance type welding process. The materials are clamped between two electrode nodes and current is applied momentarily. A spot the size and shape of the electrode is heated to temperatures which allow the weld to take place (See Figure 10.3.9). This process is generally used to join overlapping sheet metal parts. The size of the spot weld is given to the left of the weld symbol on the drawing. The center-to-center distance between welds (or pitch) is given to the right of the symbol. When a number of spot welds are required on the part joint, the drawing symbol will have the specified number shown in parentheses above or below the symbol. (See

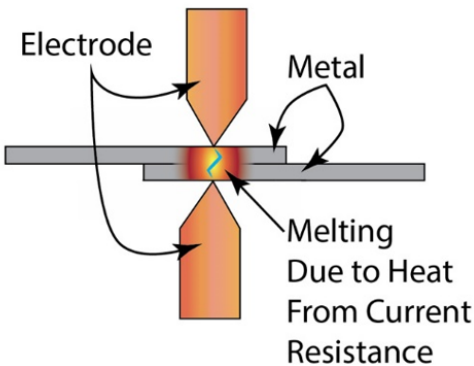


Figure 27: Spot Welding Schematic

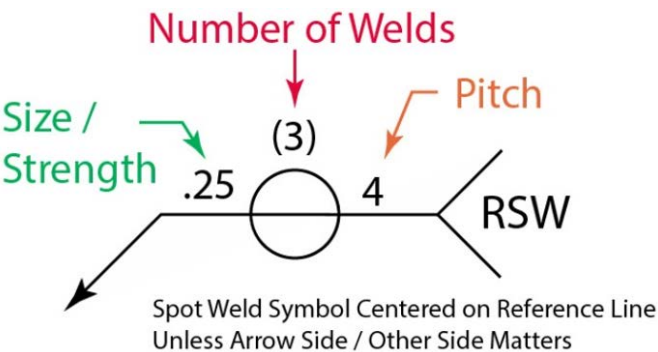


Figure 28: Spot Welding Symbol

Seam welding is another common resistance type welding process similar to spot welding. Instead of a clamping electrode heating up a single spot or point on the parts, a continuous seam is created. The electrode is a roller and follows the contour of the parts to be welded. The weld size is shown to the left of the symbol, and the length is placed to the right of the symbol. (See Figure 10.3.11)

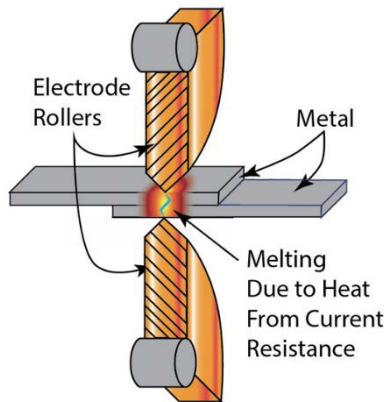


Figure 29: Seam Welding Schematic

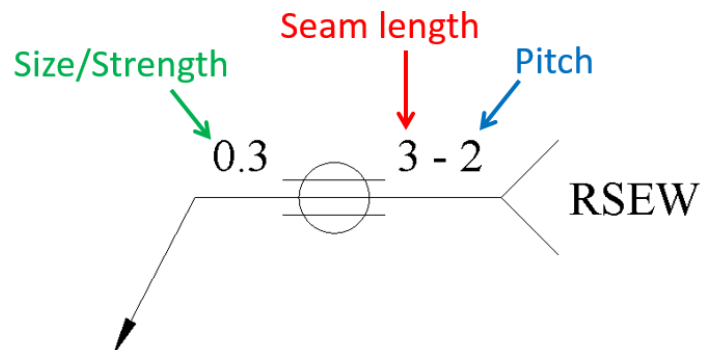


Figure 30: Seam Weld Symbol

Weld Joints

An understanding of the meaning of welding symbol types requires an understanding of basic joint design and terminology. There are five basic joint types used to weld parts together (See Figure 10.4.1).

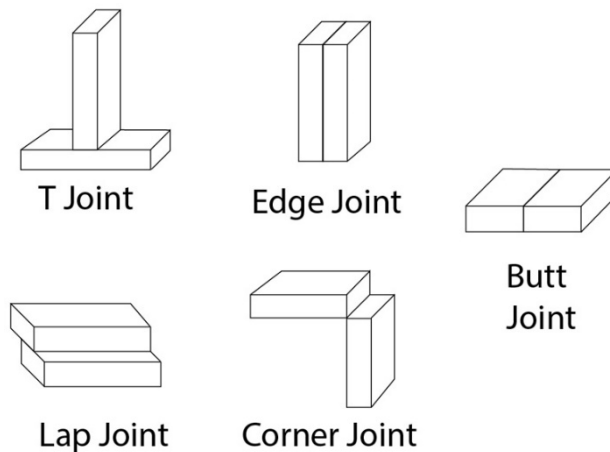


Figure 31: Welding Joint Types

The butt joint brings two structural members together by placing them butt to butt. Flat bar stock or piping can be joined in this fashion.

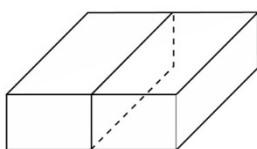


Figure 32: But Joints are used for welding plate

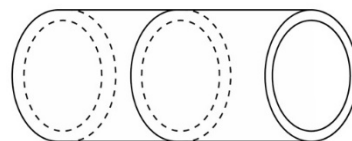


Figure 33: Butt Joint are used for welding pipe

The corner joint places two structural members at an angle to one another to form a corner. The angle of the corner is generally 90° , but can be different if necessary. The member ends can overlap or touch corner edge to corner edge.

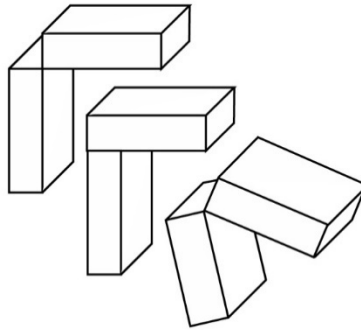
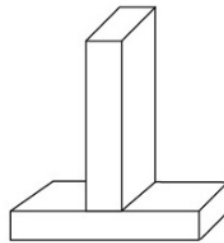


Figure 34: Corner Joint Examples

A T-joint is a type of joint where two members are placed in contact with each other at a right angle. This joint is not a corner joint as the joint forms an interior angle of 90 degrees on both sides of the joining pieces.



T Joint

Figure 35: Tee Joint Example

A lap joint is made by overlapping two members the specified distance. It can be made using sheet metal or flat bar stock.

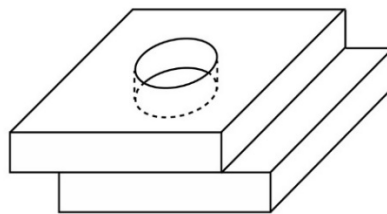


Figure 36: Lap Joint with hole for plug weld

An edge joint is a joint that has pre-formed edges (flanges). The flanges are generally at right angles. Sheet metal is a common material for this type of joint.

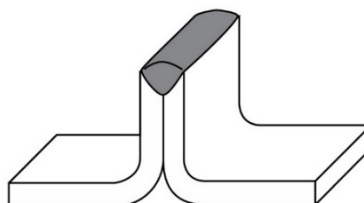


Figure 37: Edge Joint