

CAST LIP OWNER'S MANUAL

HYDRAULIC SHOVELS



GENERAL WELDING GUIDELINES



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VERSION 1

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These Welding Guidelines are intended to assist customers with welding Hensley GET products. They are general guidelines and are not all inclusive. Your specific application may require different welding practices. This welding guide is **not** intended to be used for joint design of buckets or other attachments. Hensley accepts no responsibility for the misuse or misinterpretation of this information.

Preparation of the Plate Steel and the Steel Castings

The surfaces to be welded must be free from scale, grease, paint, water, etc. The basis here is to provide a good surface for welding. This is a very good practice and is mentioned in all welding codes including **AWS 14.3, the "Specification for Welding Earthmoving and Construction Equipment"**. The surfaces must be sufficiently clean so that there is nothing that might contain hydrocarbons, which break down in the heat of the arc producing hydrogen, which can be absorbed in the weld and cause cracks. Preparation of the weld surfaces may be achieved by sand blasting, shot blasting, grinding, sanding, air carbon arc gouging, or a combination of any these process.

Welding Processes

Welding may be done by any of the following processes:

- Shielded Metal Arc Welding (SMAW)
- Gas Metal Arc Welding (GMAW)
- Flux-cored Arc Welding (FCAW)

A combination of SMAW and GMAW or FCAW can be employed.

Filler Materials						
Process	AWS	JIS	NF	DIN	BS	Shielding Gas
SMAW	E7018 AWS A5.1	JIS Z3212 D5016	E515B12029(H) NF A 81 309	E51B10120 DIN 8556	E515B12029(H) BS 2926	N/A
GMAW	ER 70S-6 AWS A5.18	JIS Z3312 YGW12	GS 2 NF A 81-311	SG2 DIN8559	A18 BS2901-1	100 CO2 90%Ar/8%CO2
GMAW	E70C-6M AWS A5.18	JIS Z3313 YFW-A50DM				92%Ar/8%CO2 90%Ar/10%CO2
FCAW	E70T-5 AWS A5.20	JIS Z3313 YFW-C50DM	TGS 51 3.3 BH NF A 81-350	SG B1 CY4254 DIN 8559	T530 GBH BS7084	100% CO2 75%Ar/25%CO2
FCAW	E71T-1 AWS A5.2	JIS Z3312 YFW-C50DR	TGS 51 3.3 BH NF A 81-350	SG B1 CY4254 DIN 8559	T530 GBH BS7084	100%CO2 75%Ar/25%CO2 90%Ar/10%CO2

Electrical Characteristics

A. Polarity

All welding shall be done using direct current electrode positive (DCEP)

B. Current and Voltage Ranges

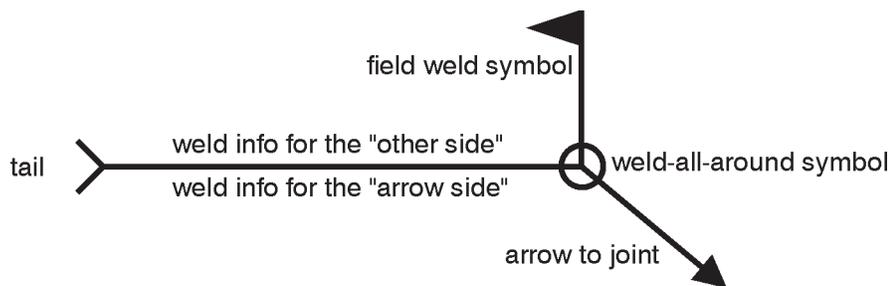
SMAW	
Electrode Diameter	Amperes
2.4mm / 3/32 in.	65 to 120
3.2mm / 1/8 in.	80 to 160
4.0mm / 5/32 in.	115 to 220
4.8mm / 3/16 in.	140 to 300

GMAW and FCAW		
Electrode Diameter	Voltage	Amperes
1.2mm / 0.045 in	22 to 30	220 to 320
1.4 mm / 0.052	25 to 30	250 to 325
1.6mm / 1/16 in.	25 to 35	250 to 360
2.4mm / 3/32 in	28 to 35	350 to 450

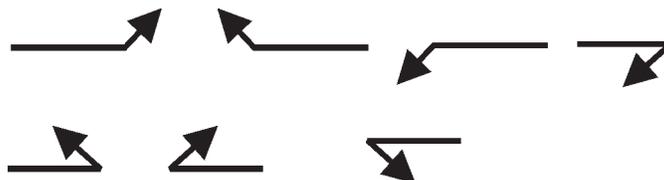
Welding Symbols

Weld symbols are used as a type of shorthand to indicate the type of weld, its size and other processing and finishing information. The following section will introduce you to the most common symbols you may encounter, while using our product, and their meaning. The complete set of symbols is given in a standard published by **American National Standards Institute (ANSI)** and the **American Welding Society (AWS)**: *ANSI/AWS A2.4, Symbols for Welding and Nondestructive Testing*.

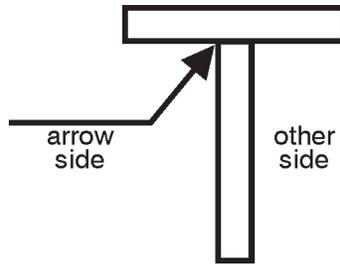
Welding Symbol Structure



The horizontal line, called the **reference line**, is the anchor to which all the other welding symbols are tied. The instructions for making the weld are strung along the reference line. An arrow connects the reference line to the joint that is to be welded. The example above has the arrow growing out of the right end of the reference line and heading down to the right, but other combinations may be encountered.



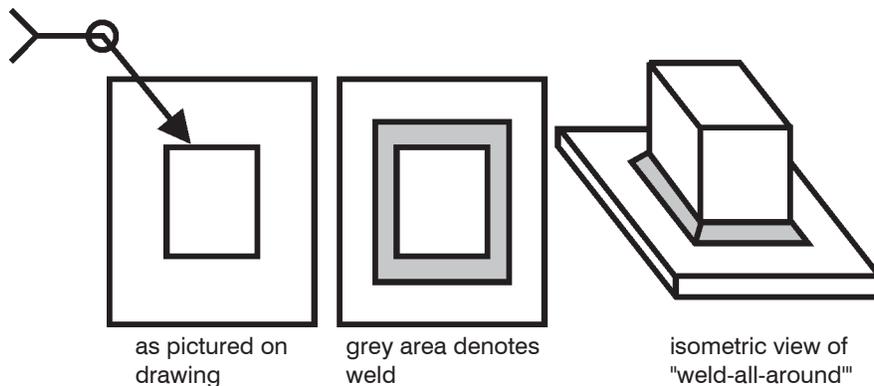
Quite often, there are two sides of the joint to which the arrow points, and therefore two potential places for a weld. For example, when two steel plates are joined together into a "T" shape, welding may be done on either side of the stem of the "T".



The weld symbol distinguishes between the two sides of a joint by using the arrow and the spaces above and below the reference line. The side of the joint to which the arrow points is known as the **arrow side**, and its weld is made according to the instructions given below the reference line. The other side of the joint is known as the **other side**, and its weld is made according to the instructions given above the reference line. The below=arrow and above=other rules apply regardless of the arrow's direction.

The flag (**field weld symbol**) growing out of the junction of the reference line and the arrow is present if the weld is to be made in the field during erection of the structure. A weld symbol without a flag indicates the weld is to be made in the shop.

The unfilled circle (**weld-all-around symbol**) at the junction of the reference line and the arrow indicates the joint is to be welded all the way around.



The tail of the weld symbol is the place for supplementary information on the weld. It may contain a reference to the welding process, the electrode, a detail drawing or any information that aids in the making of the weld that does not have its own special place on the symbol. If there is no additional information needed, the tail may be omitted.



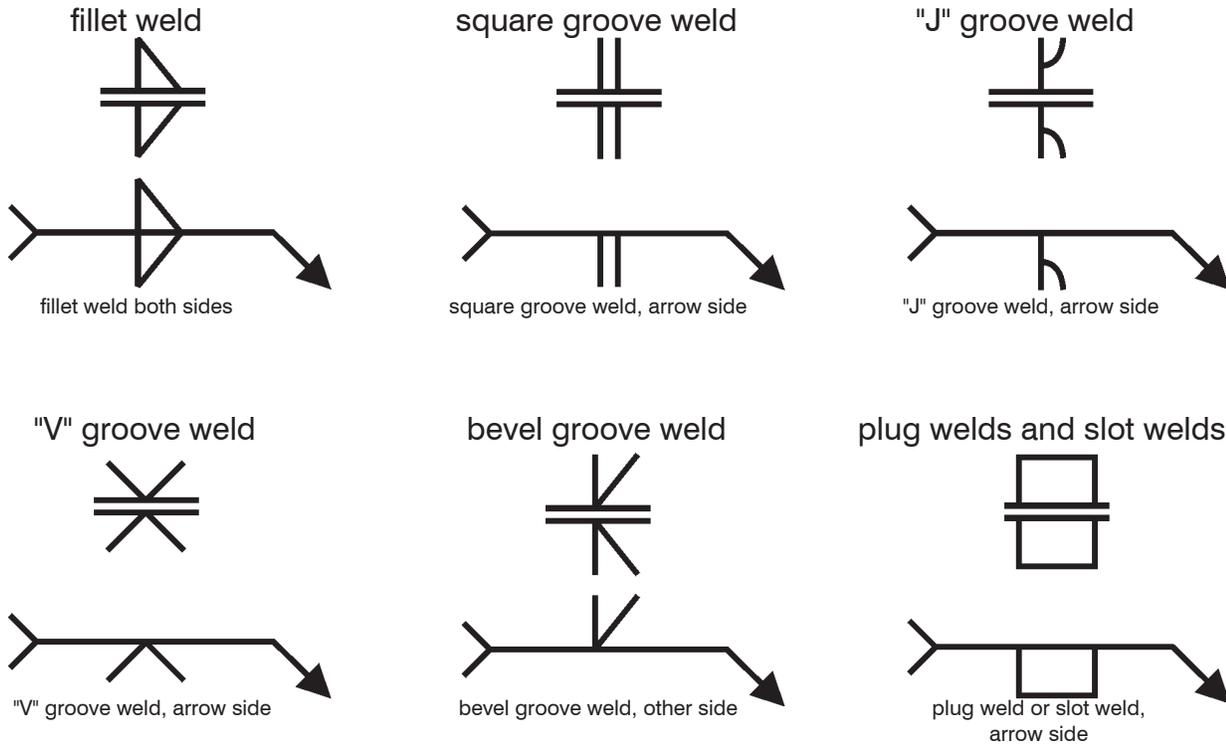
In this example, the tail contains information indicating the welding process that is to be used which in this case is Shielded Metal Arc Welding (stick welding).



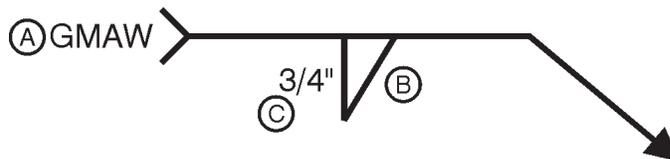
This example indicates that there is a drawing that needs to be referenced for additional information.

Types of Welds and Their Symbols

Each type of weld has its own basic symbol, which is typically placed near the center of the reference line (and above or below it, depending on which side of the joint it's on). The symbol is a small drawing that can usually be interpreted as a simplified cross-section of the weld. The examples below show the most common types of welds that may be utilized on our products. They are shown in both **arrow-side** and **other-side** position and how they would appear in a complete weld symbol. This is not meant to be an all-inclusive list of weld symbols. The complete set of symbols is given in a standard published by **American National Standards Institute (ANSI)** and the **American Welding Society (AWS)**: *ANSI/AWS A2.4, Symbols for Welding and Nondestructive Testing*.



Complete Weld Symbol Example

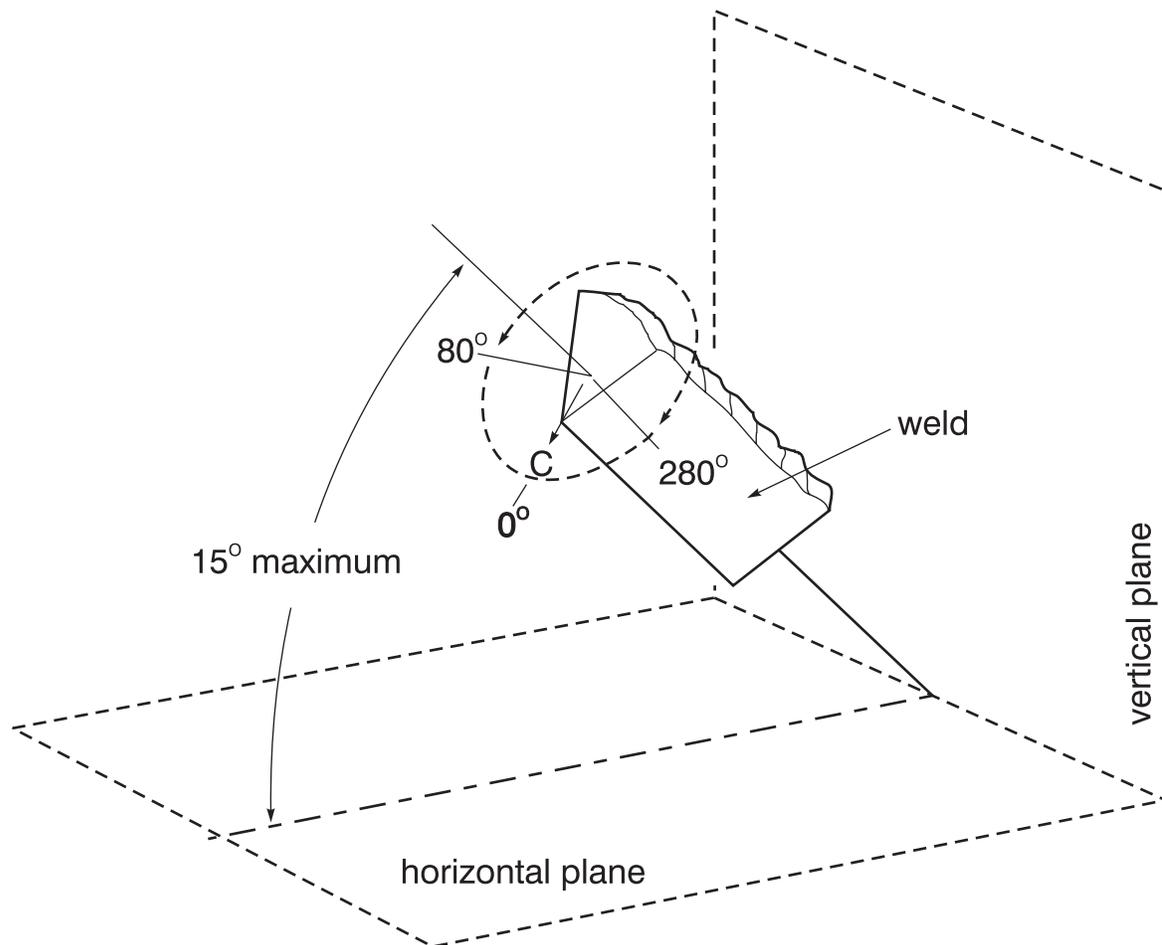


A = welding process B = weld type C = weld size

The above symbol is read as: deposit a 3/4" fillet weld on the arrow-side of the joint utilizing the Gas Metal Arc Welding Process (Mig).

Welding Position

All welding should be done in the flat or horizontal position. Deviation from the flat or horizontal position is permissible following the figure shown below which is adapted from AWS D1.1, Structural Welding Code – Steel, figure 4.2 "Positions of fillet welds"



The longitudinal axis of the weld may be inclined no more than 15° with respect to the horizontal plane. The center of the weld face © must lie within the rotational limits of 80° to 280° as shown.

Preheat and Interpass Temperatures

Preheat is the application of heat to the work piece prior to welding, cutting, or gouging. All cutting and welding processes use a high temperature heat source. These high temperatures exceed the melting point of the base metal. This creates the problem of a traveling high temperature, localized heat source, and the effect that it has on the surrounding base metal.

A large temperature differential causes thermal expansion and contraction, high stresses, hardened areas, and a very small area for hydrogen gases to escape from the steel. Preheating will reduce the danger of weld cracking, reduce maximum hardness of the heat affected zone, minimize shrinkage stresses, lessen distortion, and create a larger area for hydrogen gases to escape from the metal.

Prior to any cutting, gouging, tacking, or welding operation, the following preheat temperatures must be achieved and maintained.

Preheat and Interpass Temperatures			
Material	Thickness	Minimum Preheat Temperature	Maximum Interpass Temperature
Hensley Castings	N/A	300°F / 150°C	450°F / 230°C
ASTM A514 (T1) Bisalloy 80 Weldox 100	Thru 1-1/2" / 38mm	125°F / 50°C	450°F / 230°C
	1-1/2" / 38mm thru 2-1/2" / 63mm	175°F / 80°C	450°F / 230°C
	Over 2-1/2" / 63mm	250°F / 120°C	450°F / 230°C
400 BHN Abrasion Resistant Steel- Hardox 400	All thicknesses between 1" / 25mm and 5" / 127mm	300°F / 150°C	450°F / 230°C

The chart shown above lists common materials used on buckets and attachments that utilize Hensley Ground Engaging Tools (GET). It is not an all inclusive list of materials. To determine the pre-heat and interpass temperatures for materials not listed here:

- 1) Consult the material manufacturer or supplier.
- 2) Use the Carbon Equivalency Formula (CE).

Carbon Equivalency Formula

$$CE = C + \frac{(Mn + Si)}{6} + \frac{(Cr + Mo + V)}{5} + \frac{(Ni + Cu)}{15} = \text{(percent)}$$

The elemental values (e.g. Mn, Si etc.) can be obtained from the material's *mill cert* (mill certification) from the manufacturer or supplier.

The result of the CE formula is then compared to charts that may be provided by the steel manufacturer or listed in *American Welding Society publication D14.3*. The charts will indicate the amount of preheat that is required for that particular steel's composition and thickness.

Notes: If the ambient humidity is high and or the temperature is below 40°F / 4°C, the tabulated value should be increased by 80°F / 27°C. At no time should any material type or thickness be welded when the temperature of the steel is at or below 40°F / 4°C.

Preheating with burners or torches is much more effective when the heat is applied from the bottom side of the work piece with insulating blankets on the topside. The blankets help to disperse the heat evenly as well as retain the heat that has been input. Measure the temperature with a temperature indicating crayon or an infrared thermometer from the topside. This will insure that the preheat is not just on the surface of the material, but a complete preheat through the thickness of the materials to be welded. All material within 4" / 100mm of the weld zone must be within the specified temperature.

Cool slowly. Do not allow drafts or cool ambient temperatures to cool the parts or assembly. Cool down rate should not exceed 130°F / 55°C, per hour. If the ambient temperature is at or below 40°F / 5°C, the part should be covered in a thermal blanket to insure the cool down rate listed above is achieved, or the entire part can be post-heated to 300°-400°F / 149°-204°C for four hours and then air cooled.

Welding Technique

Stringer beads are recommended for higher strength and to minimize distortion. The use of weave or wash beads should not be used, however weaving is permitted to the extent that bead widths are no greater than 1/2" / 12mm.

Craters: When a weld pass is terminated within the finished product, the crater shall be filled to at least 85% of the full cross section of the weld. This will help eliminate the possibility of crater cracks. When welding with the SMAW process, the easiest way to achieve this is to stop the travel of the electrode and pause briefly before breaking the arc. When welding with the GMAW or FCAW processes, stop the travel and extinguish the arc, initiate the arc briefly, then extinguish.

Porosity: Porosity is a cavity-type discontinuity or defect that is formed by gas entrapment during solidification. Porosity reduces the strength of a weld and should be removed and replaced if the sum of the visual or surface porosity, including piping porosity, is greater than 1/4" / 6mm in any 4" / 100mm length of weld. A single void shall not exceed 1/16" / 1.6mm.

Overlap and Undercut: Weld overlap shall not exceed 1/16" / 1.6mm beyond the fusion line of the weld. Undercut shall not exceed 1/16" / 1.6mm in any joint or 10% of the base metal whichever is less. In addition, the accumulative length is not to exceed 1-1/2" / 38mm over a 24" / 610mm continuous section of weld.

Arc Strikes: A discontinuity resulting from an arc, consisting of any localized re-melted metal. Arc strikes should be avoided. Arc strikes that occur inside or outside the weld zone should be ground out.

Each weld shall merge smoothly into adjoining bead or base metal surface. Remove all unacceptable defects (crater cracks, porosity, overlap, undercut, etc.) on the weld surface or groove sidewalls before proceeding with the next weld pass. Removal may be accomplished by grinding with abrasive wheels, stones, or carbide burrs. Air carbon arc gouging may also be used, followed by grinding to remove all carbon slag.

Clean each pass of deposited weld metal before depositing the next weld pass. Using manual slag hammers, pneumatic needle gun, wire brushes or any combination of these tools may accomplish cleaning.

General Weld Crack Repair Instructions

Cracks can develop in welded assemblies for multiple different reasons and in different areas. Cracks can appear in the weld itself or adjacent to the weld in the base metal. Cracks are a very serious defect that will reduce the strength of any weldment. Cracks can also propagate and cause sudden and catastrophic failure. Cracks must be repaired. The typical repair method is as follows:

Step 1

Preheat the crack and surrounding area in a range from 180°F (82°C) to 225°F (107°C). The preheat should be a through heat and not just a surface heat. Heat an area that extends 4" (100mm) from the crack. Preheat temperature should be measured with a temperature indicating crayon or infrared thermometer.

Step 2

Use the Air Carbon Arc Gouging process to remove the crack. The crack must be completely removed both in length and in depth. Taper the ends of the gouged groove so that there is a gradual transition between the groove and the outside surface. Sides of the gouged groove should be angled to create a bevel that is accessible for the welding process used.

Step 3

Grind all gouged surfaces to remove carbon slag and to create a smooth, clean, surface for welding.

Step 4

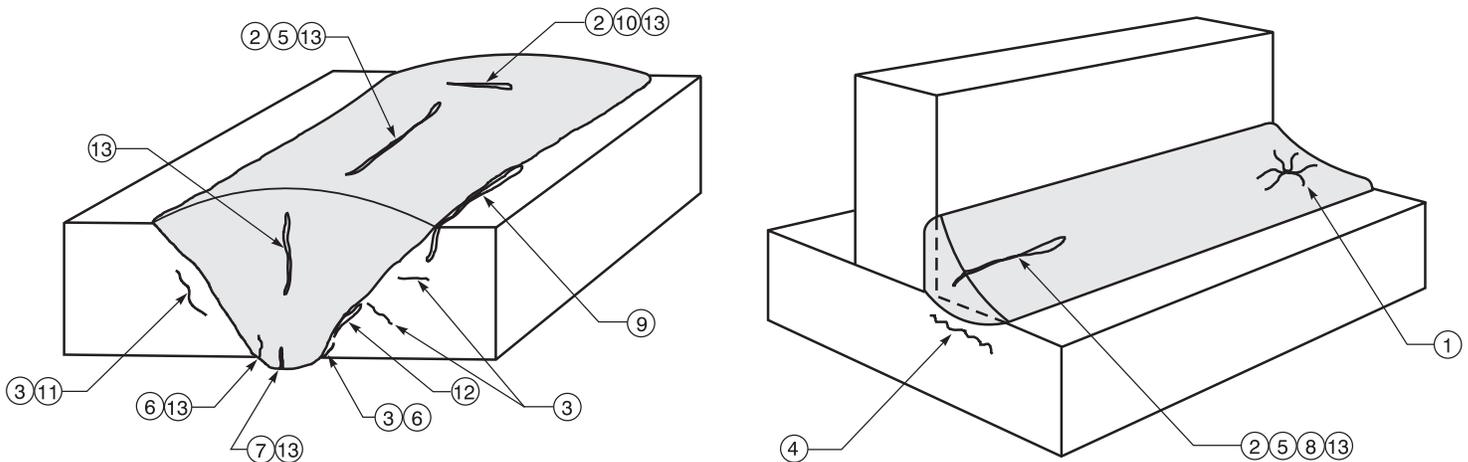
Non-Destructive Testing should be used at this point to insure that the crack has been completely removed. If a crack or indication of a crack is still present, grind out and re-test.

Step 5

Perform repair welding per the preheat requirements, filler material suggestions, and welding techniques that are described within this welding guide. Weld finish or blend per instructions.

Note: The above mentioned crack repair instruction is only a suggestion. Each crack or cracks should be analyzed individually and specific instructions should be created based on the analysis. Depending on the type of crack, location, length, depth, etc. changes or modifications to these instructions may be required.

TYPES OF WELD CRACKS



- | | | |
|-----------------------------|-----------------------|--------------------------|
| 1. Crater Crack | 6. Root Crack | 11. Underbead Crack |
| 2. Face Crack | 7. Root Surface Crack | 12. Weld Interface Crack |
| 3. Heat Affected Zone Crack | 8. Throat Crack | 13. Weld Metal Crack |
| 4. Lamellar Tear | 9. Toe Crack | |
| 5. Longitudinal Crack | 10. Transverse Crack | |

Welding Terms and Definitions

- Air Carbon Arc Gouging – A carbon arc process that removes molten metal with a jet of air.
- American Weld Society (AWS) – A nonprofit technical society organized and founded for the purpose of advancing the art and science of welding. The AWS publishes codes and standards concerning all phases of welding.
- British Standards Institute (BSI) – A nonprofit concern. The principal object is to coordinate the efforts of producers and users for the improvement, standardization, and simplification of engineering and industrial material.
- Crater – A depression in the weld face at the termination of a weld bead.
- Defect – A discontinuity or discontinuities that by nature or accumulated effect (for example, accumulative length of undercut not to exceed 1.5" / 38mm over a 24" / 609mm section of weld) render a part or product unable to meet minimum applicable acceptance standards.
- Deutsches Institute fuer Normung (DIN) – German Standard
- Direct Current Electrode Positive (DCEP) – The arrangement of direct current arc welding leads in which the electrode is the positive pole and the workpiece is the negative pole of the welding arc.
- Discontinuity – An interruption of the typical structure of a material, such as lack of homogeneity in its mechanical, metallurgical, or physical characteristics.
- Electrode – A component of the electrical circuit that terminates at the arc, molten conductive slag, or base metal.
- Filler Material – The material to be added in making a welded joint.
- Fillet Weld – A weld of approximately triangular cross section joining two surfaces approximately at right angles to each other in a lap joint, T-joint, or corner joint.
- Flux Cored Arc Welding (FCAW) – An arc welding process that uses an arc between a continuous filler metal electrode and the weld pool. The process is used with shielding gas from a flux contained within the tubular wire electrode, with or without additional shielding from an externally supplied gas and without the application of pressure.
- Francaise de Normalisation (NF) – French Standard
- Gas Metal Arc Welding (GMAW) – An arc welding process that uses an arc between a continuous filler metal electrode and the weld pool. The process is used with shielding from an externally supplied gas and without the application of pressure.
- Japanese Industrial Standards (JIS) – The Japanese Standards Association publishes standards, including metals, welding filler materials, etc.
- Layer – A stratum of weld metal consisting of one or more weld beads.

Welding Terms and Definitions

- Overlap – The protrusion of weld metal beyond the weld toe or weld root.
- Porosity – A cavity-type discontinuity or defect formed by gas entrapment during solidification.
- Preheat – The application of heat to the work piece prior to welding cutting or gouging.
- Root – The point, shown in cross section, at which the weld metal extends furthest into a joint and intersects the base metal.
- Run-off Weld Tab – Additional material that extends beyond the end of the joint, on which the weld is terminated.
- Shielded Metal Arc Welding (SMAW) - An arc welding process with an arc between a covered electrode and the weld pool. The process is used with shielding from the decomposition of the electrode covering, without the application of pressure, and with filler metal from the electrode.
- Shielding Gas – Protective gas used to prevent or reduce atmospheric contamination of a weld, especially by oxygen and nitrogen.
- Starter Weld Tab – Additional material that extends beyond the beginning of the joint, on which the weld is started.
- Stringer Bead – A type of bead made without appreciable weaving motion.
- Tack Weld – A weld made to hold the parts of a weldment in proper alignment until the final welds are made.
- Undercut – A groove melted into the base metal adjacent to the weld toe or root and left unfilled by weld metal.
- Weld Groove – A channel in the surface of a work piece or an opening between two joint members that provides space to contain weld.
- Weld Toe – The junction of the weld face and the base metal.
- Welding Sequence – The order of making welds in a weldment.

SAFETY FIRST: Hensley recommends that you use a soft-faced hammer and ANSI-approved (Z87.1) eye protection while using our products.



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