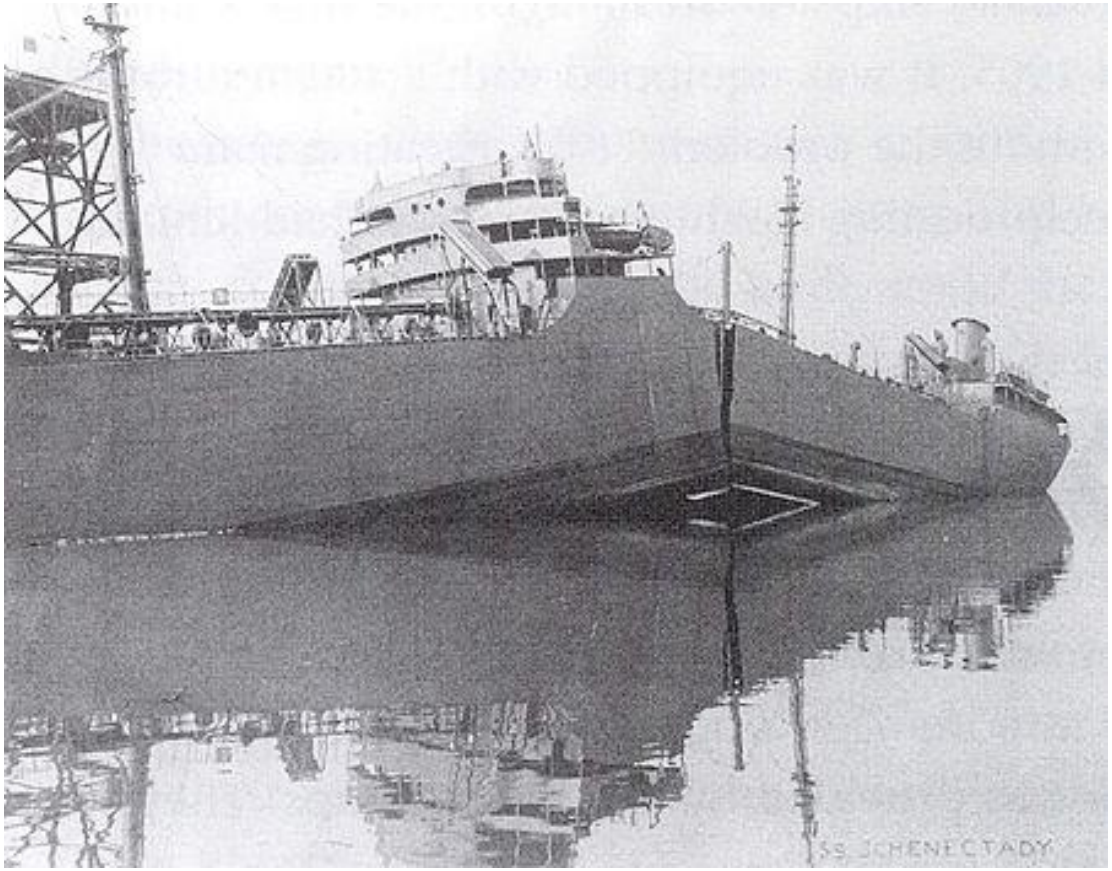
Welding

- **Types**
- **Symbols**



Methods of Joining Materials

- **Non-Permanent**
  - **Fasteners**

- **Permanent**
  - **Welding**
    - ✓ **Joining two materials by causing fusion**
    - ✓ **Base Material Melted**
  - **Soldering**
    - ✓ **Joining two or more metals by melting and flowing a material (solder) onto the joint**
    - ✓ **Melting point of solder lower than adjoining material**
  - **Brazing**
    - ✓ **Joining two or more metals by melting and flowing a material onto the joint**
    - ✓ **Higher temperature and considerably higher strength than solder**
  - **Adhesive Bonding**
    - ✓ **Applying an intermediate layer to connect sub-straights**

Types of Welding

- Arc
  - A process that creates an electric arc between an electrode and the base material to melt the metal at the welding point
- Oxy-Fuel
  - A process that uses fuel gases and oxygen to weld and cut metal
- Resistance
  - Spot and seam welding
  - The weld heat is generated by the electrical resistance of the materials being bonded combined with the time and the force used to hold the materials
- Solid-State
  - Bonds materials at temperatures below the melt points of the materials being joined without the addition of a filler material.
- Others

Types of Arc Welds

NAME	AWS	CHARACTERISTECS	APPLICATION
Atomic hydrogen welding	AHW	Two metal electrodes in hydrogen atmosphere	Historical
Bare metal arc welding	BMAW	Consumable electrode, no flux or shielding gas	Historical
Carbon arc welding	CAW	Carbon electrode, historical	Copper, repair (limited)
Flux cored arc welding	FCAW FCAW-S	Continuous consumable electrode filled with flux	Industry, construction
Gas metal arc welding	GMAW	Continuous consumable electrode and shielding gas	Industry
Gas tungsten arc welding	GTAW	Non-consumable electrode, slow, high quality welds	Aerospace, Construction (piping),Tool and Die
Plasma arc welding	PAW	Non-consumable electrode, constricted arc	Tubing, instrumentation
Shielded metal arc welding	SMAW	Consumable electrode covered in flux, can weld any metal as long as they have the right electrode	Construction, outdoors, maintenance
Submerged arc welding	SAW	Automatic, arc submerged in granular flux	
Magnetically Impelled Arc Butt	MIAB	both tube ends are electrodes; no protection gas; arc rotates fast along edge by applied magnetic field	pipelines and tubes

Types of Oxy-Fuel Gas Welds

NAME	AWS	CHARACTERISTECS	APPLICATION
Air acetylene welding	AAW	Chemical welding process, not popular	Limited
Oxyacetylene welding	OAW	Combustion of acetylene with oxygen	Maintenance, repair
Oxygen/Propane welding		Gas welding with oxygen/propane flame	
Oxyhydrogen welding	OHW	Combustion of hydrogen with oxygen produces flame	Limited
Pressure gas welding	PGW	Gas flames heat surfaces and pressure produces the weld	Pipe, railroad rails (limited)

Types of Resistance Welds

NAME	AWS	CHARACTERISTECS	APPLICATION
Resistance spot welding	RSW	Two pointed electrodes apply pressure and current to two or more thin workpieces	Automobile industry, Aerospace industry
Resistance seam welding	RSEW	Two wheel-shaped electrodes roll along workpieces, applying pressure and current	Aerospace industry, steel drums, tubing
Projection welding	PW	Semi-Automatic, Automatic, Welds are localized at predetermined points.	
Flash welding	FW		
Upset welding	UW	Butt joint surfaces heated and brought together by force	

Types of Solid State Welds

NAME	AWS	CHARACTERISTECS	APPLICATION
Coextrusion Welding	CEW	Dissimilar metals are extruded through the same die	Joining of corrosion resistant alloys to cheaper alloys
Cold pressure welding	CW	Joining of soft alloys such as copper and aluminum below their melting point	Electrical contacts
Diffusion welding	DFW	No weld line visible	Titanium pump impellor wheels
Explosion welding	EXW	Joining of dissimilar materials, e.g. corrosion resistant alloys to structural steels	Transition joints for chemical industry and shipbuilding. Bimetal pipelines
Electromagnetic pulse welding		Tubes or sheets are accelerated by electromagnetic forces. Oxides are expelled during impact	Automotive industry, pressure vessels, dissimilar material joints
Forge welding	FOW	The oldest welding process in the world. Oxides must be removed by flux or flames.	Damascus steel
Friction welding	FRW	Thin heat affected zone, oxides disrupted by friction, needs sufficient pressure	Aerospace industry, railway, land transport
Friction stir welding	FSW	A rotating non-consumable tool is traversed along the joint line	Shipbuilding, aerospace, railway rolling stock, automotive industry

Types of Solid State Welds Continued

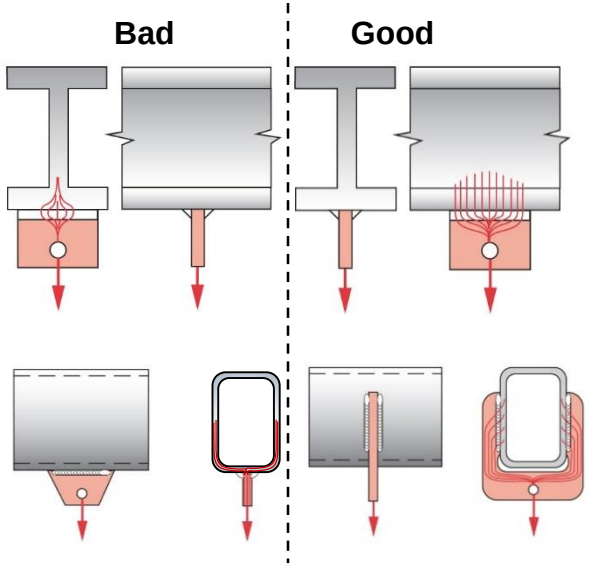
NAME	AWS	CHARACTERISTECS	APPLICATION
Hot pressure welding	HPW	Metals are pressed together at elevated temperatures below the melting point in vacuum or an inert gas atmosphere	Aerospace components
Hot isostatic pressure welding	HPW	A hot inert gas applies the pressure inside a pressure vessel, i.e. an autoclave	Aerospace components
Roll welding	ROW	Bimetallic materials are joined by forcing them between two rotating wheels	Dissimilar materials
Ultrasonic welding	USW	High-frequency vibratory energy is applied to foils, thin metal sheets or plastics.	Solar industry. Electronics. Rear lights of cars.

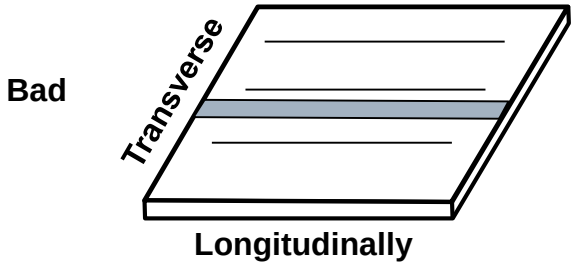
Other Types of Welds

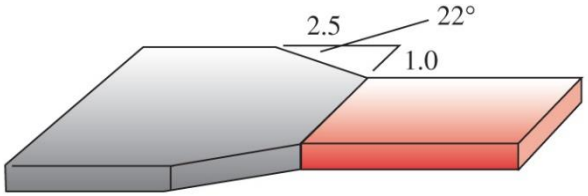
NAME	AWS	CHARACTERISTECS	APPLICATION
Electron beam welding	EBW	Deep penetration, fast, high equipment cost	
Electroslag welding	ESW	Welds thick workpieces quickly, vertical position, steel only, continuous consumable electrode.	Heavy plate fabrication, construction, shipbuilding.
Flow welding			
Induction welding	IW		
Laser beam welding	LBW	Deep penetration, fast, high equipment cost	Automotive industry
Laser-hybrid welding		Combines LBW with GMAW in the same welding head, able to bridge gaps up to 2mm (between plates), previously not possible with LBW alone.	Automotive, Shipbuilding, Steelwork industries
Percussion welding	PEW	Following an electrical discharge, pressure is applied which forges the materials together	Components of switch gear devices
Thermite welding	TW	Exothermic reaction between aluminum powder and iron oxide powder	Railway tracks
Electrogas welding		Continuous consumable electrode, vertical positioning, steel only	Storage tanks, shipbuilding
Stud arc welding		Welds studs to base material with heat and pressure	

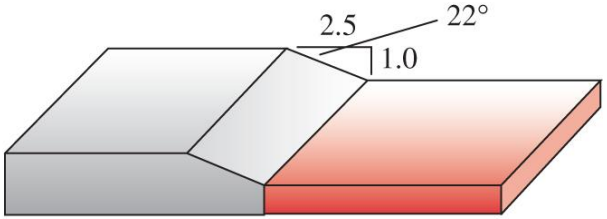
Weldment Design

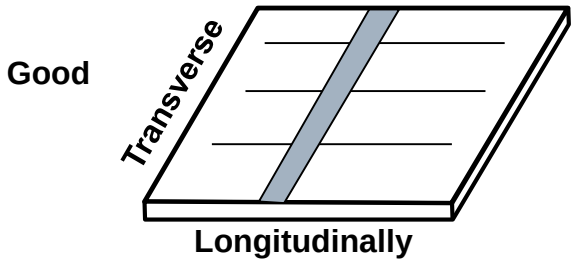
1. Provide a path for applied forces to enter into the section of the weldment that lie parallel to the direction of the applied force
2. Forces will follow the stiffest path to ground, so it is better to have relatively uniform stiffness to distribute reactions loads evenly in the weldment
3. A PRIMARY weld carries the entire load directly and its failure caused the weldment to fail.
4. SECONDARY welds just hold part together and have low forces on them
5. Do not put welds in bending
6. Where possible, do not apply tensile loads across a transverse thickness of the parent material.
7. Where section size changes across a joint, taper the material around the joint to improve force flow and reduce stress concentrations











The Five Basic Types of Joints

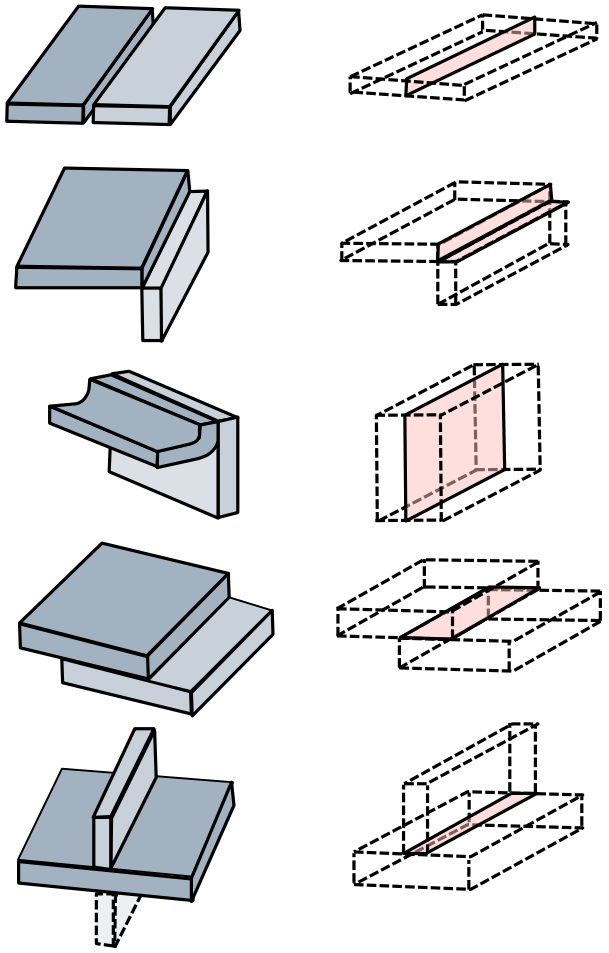
Butt Joint (B): A joint between two members lying approximately in the same plane

Corner Joint (C): A joint between two members located approximately at right angles to each other in the form of an angle

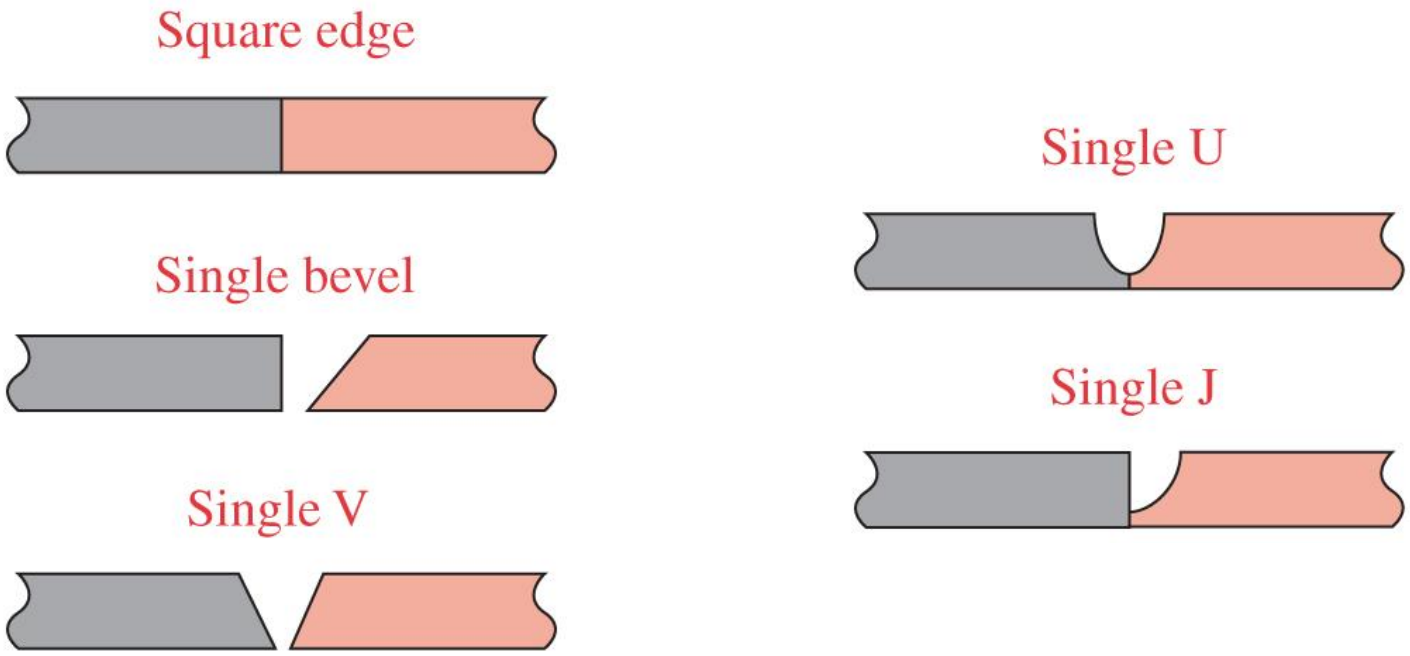
Edge Joint (E): A joint between the edge of two or more parallel or mainly parallel members

Lap Joint (L): A joint between two overlapping members

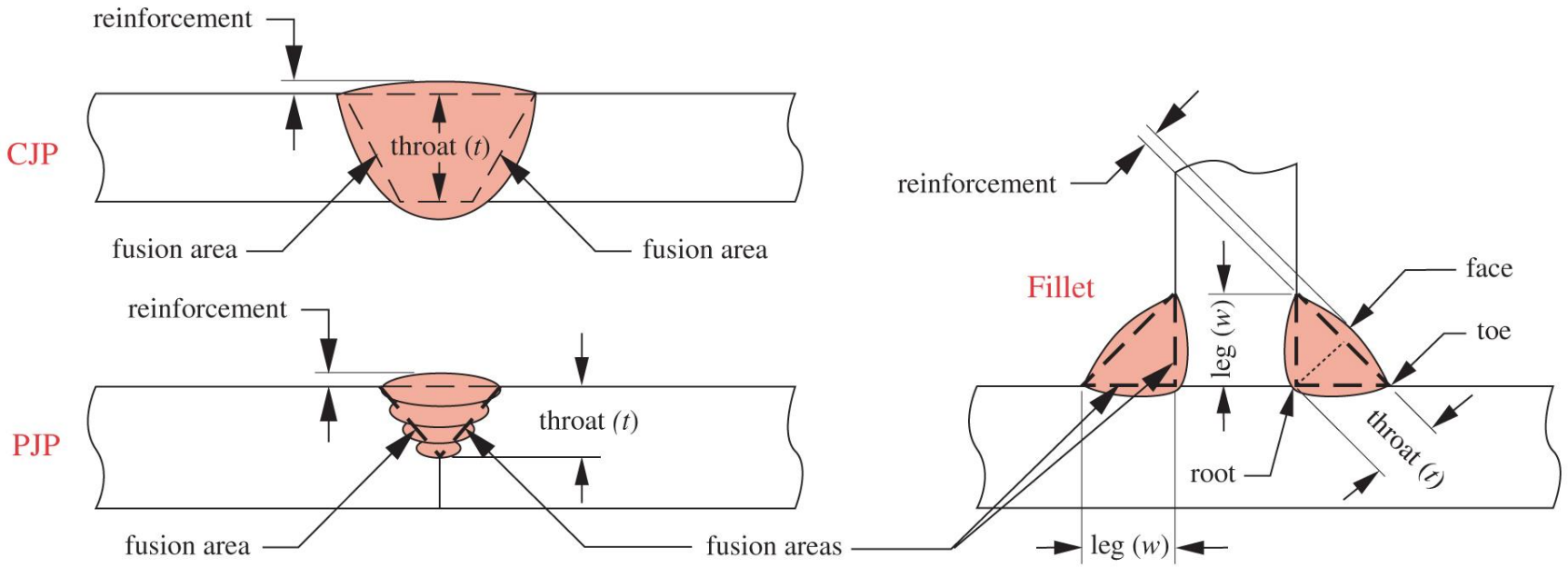
Tee Joint (T): A joint between two members located approximately at right angles to each other in the form of a T (Cruciform Joint)



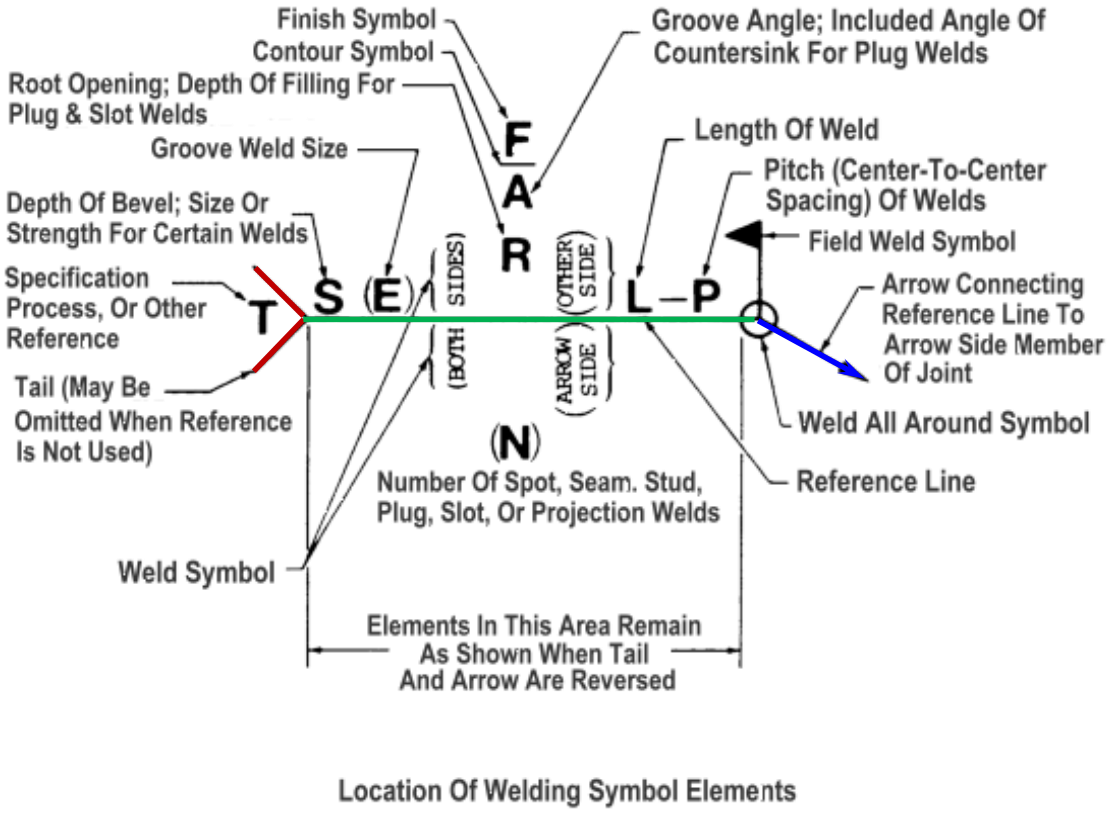
Joint Preparation



Throat Dimensions of Welded Joints



AWS Welding Symbols are Made up of Three Parts



Location Of Welding Symbol Elements

The Tail

- **Information on Weld**
- **Specifications/References**
- **If not used, may not appear**

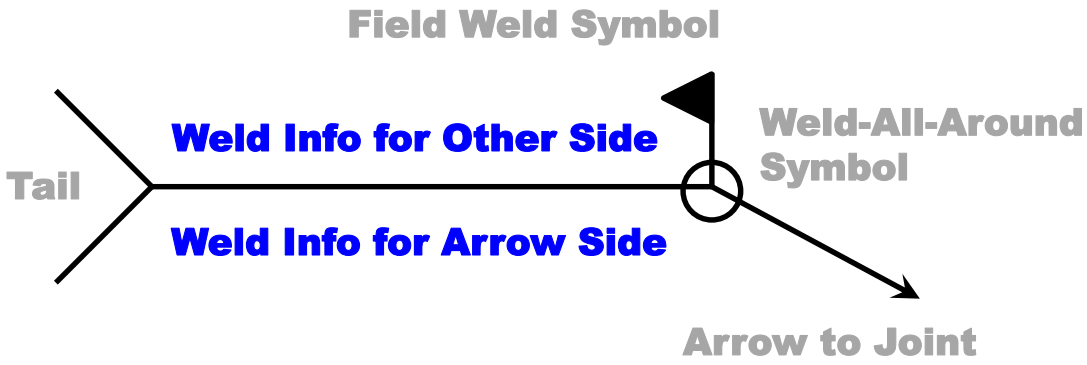
The Reference Line

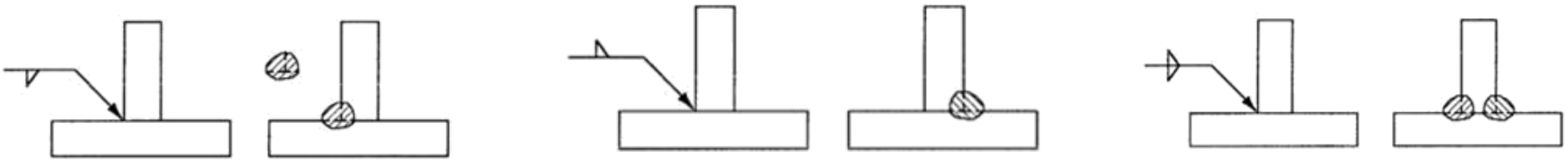
- **Main Foundation**
- **Anything written ABOVE refers to OTHER SIDE of weld**
- **Anything written BELOW refers to ARROW SIDE of weld**
- **Presents a sequence of welds or operations to be preformed**

The Arrow

- **Runs from the reference line and designates the joint to be welded**
- **Straight arrow is used for weld location**
- **Brocken arrow is used for joint preparation and breaks toward the piece that is to be beveled**

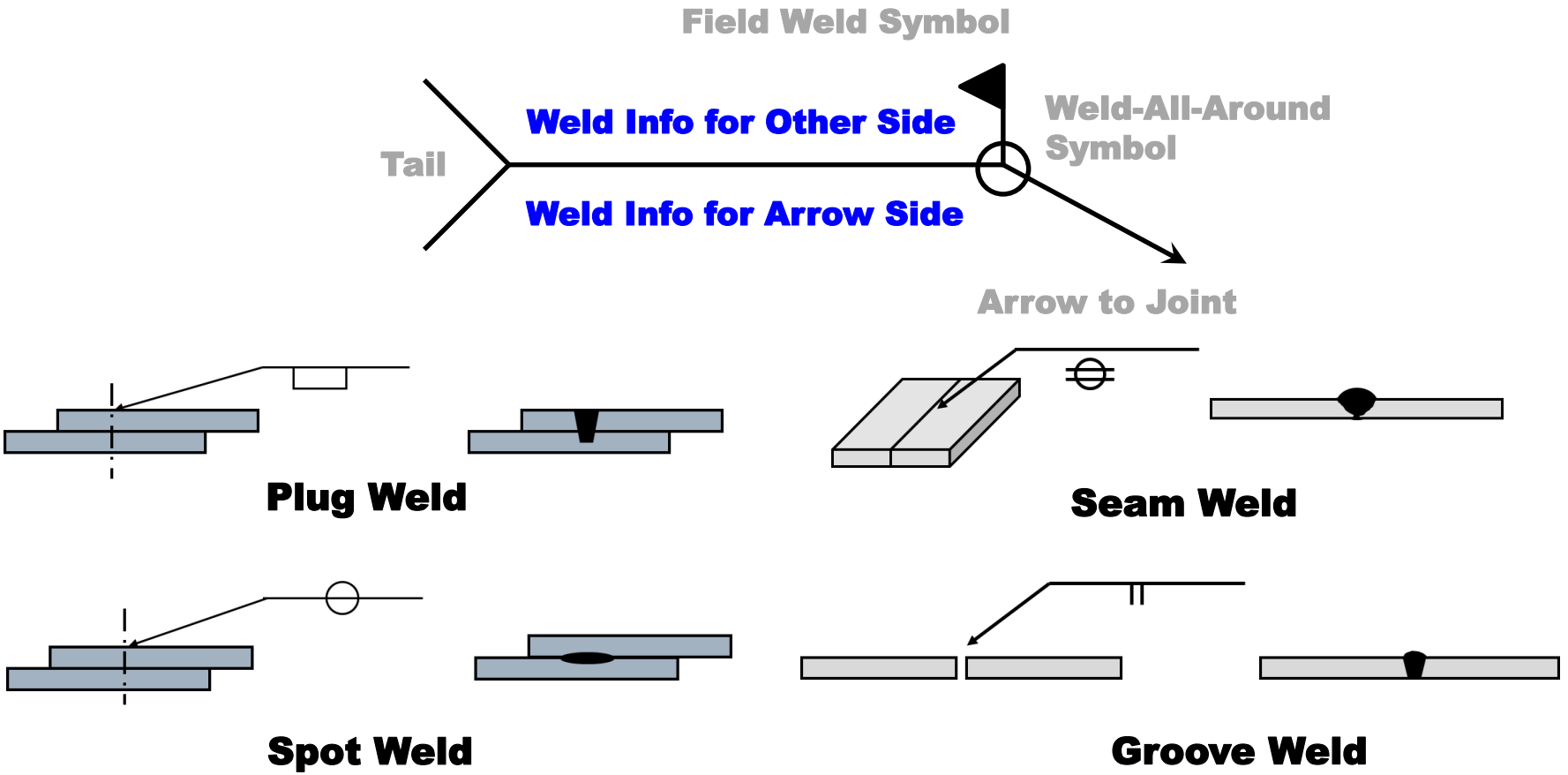
Use of Arrow
Top and Bottom of Ref Line



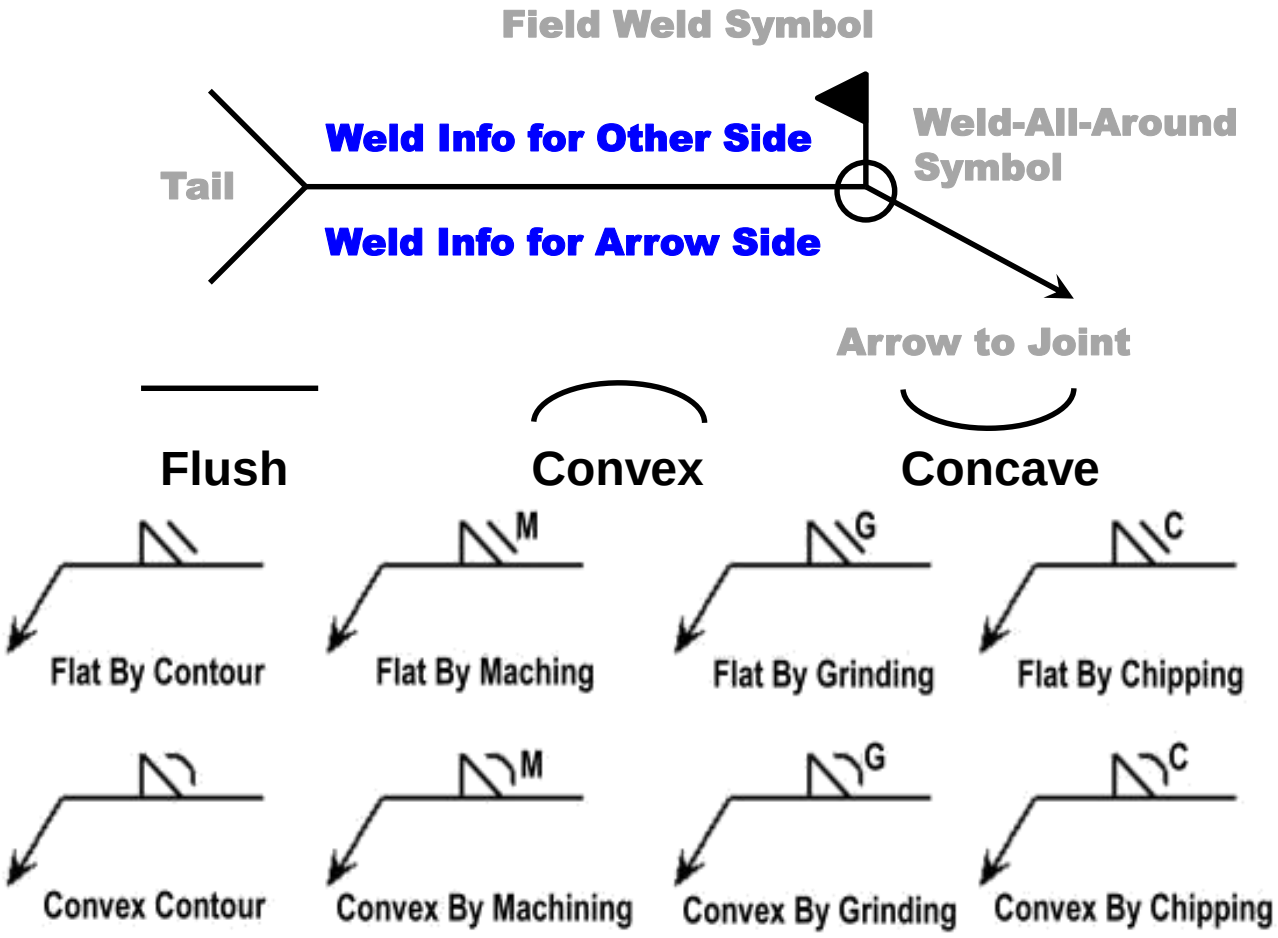


Fillet Weld

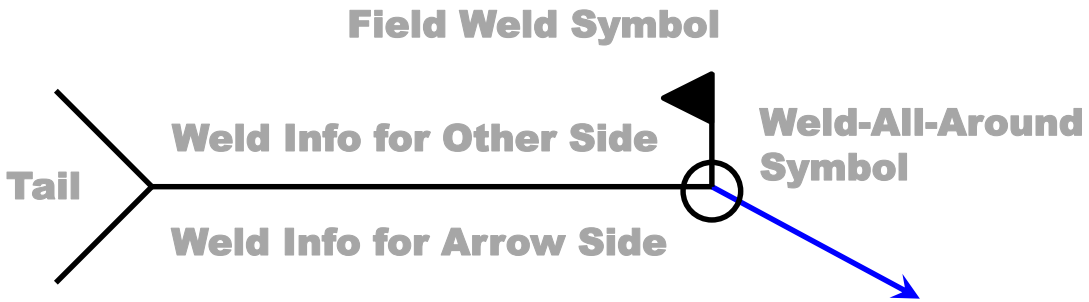
Use of Arrow
Top and Bottom of Ref Line



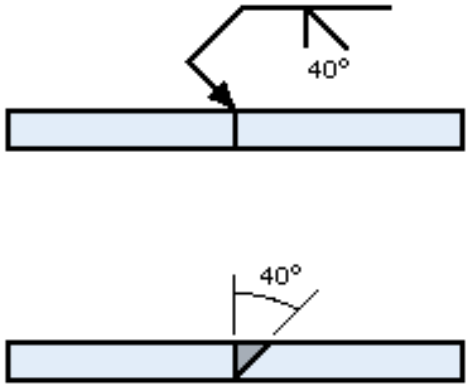
Fillet Welds Contours

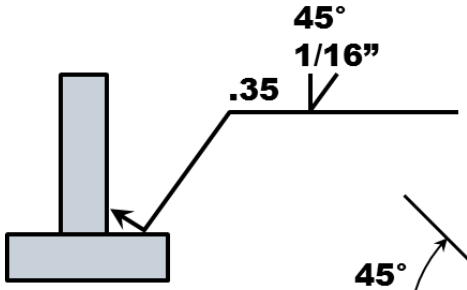


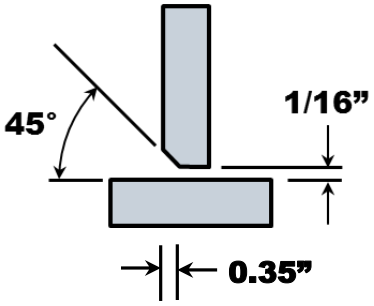
Use of Arrow Brocken-Arrow Line



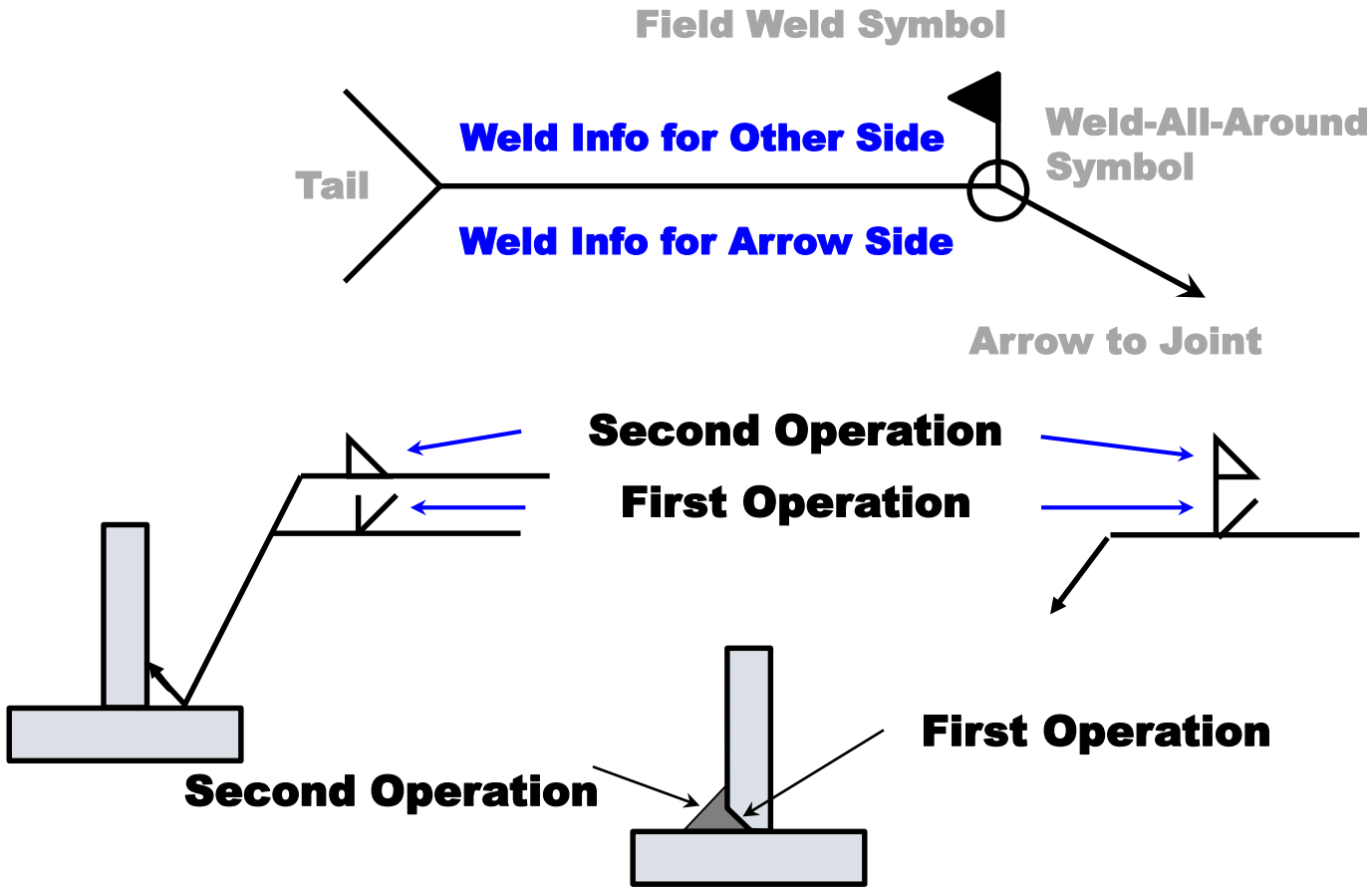
Used for joint preparation and breaks toward the piece that is to be beveled



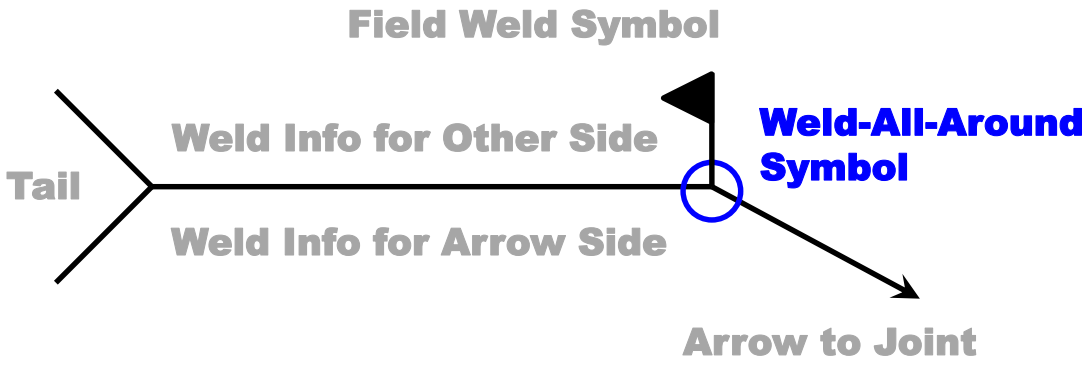


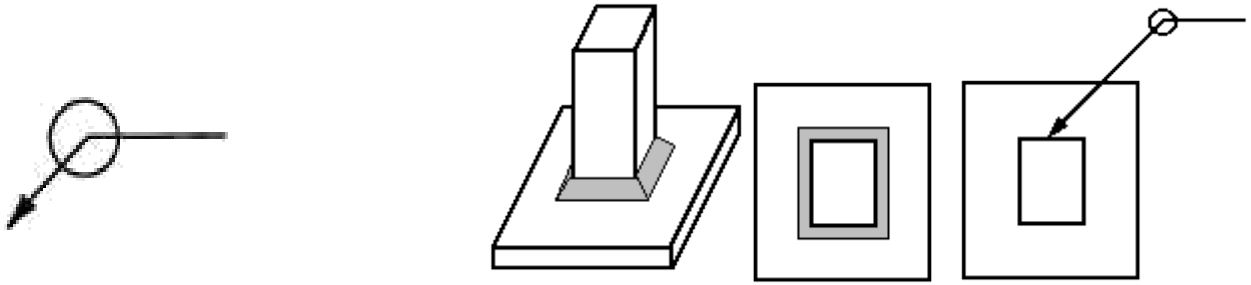


Use of Arrow
Additional Reference Lines

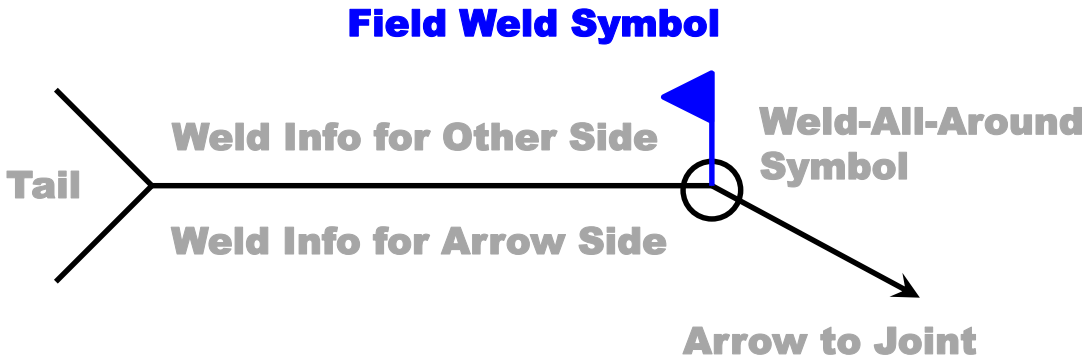


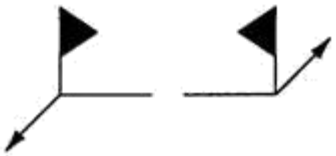
Use of Arrow
Weld All Around Symbol





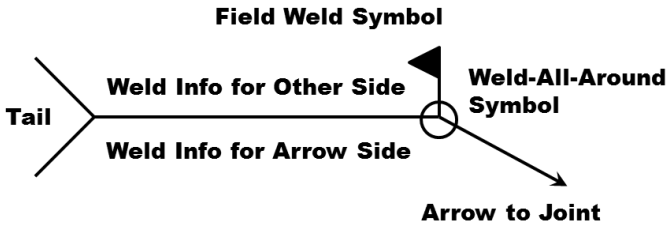
Use of Arrow
Field Weld Symbol





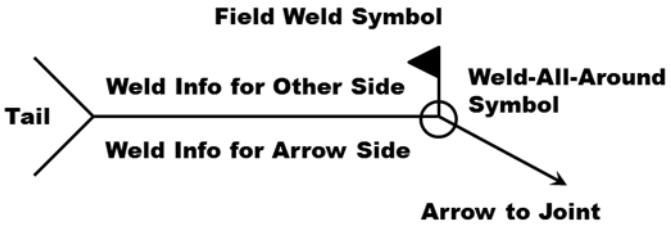
"Field Weld" means the weld will be done in another location. Sometimes clarification will be given in the welding symbol tail or as a specification on the print

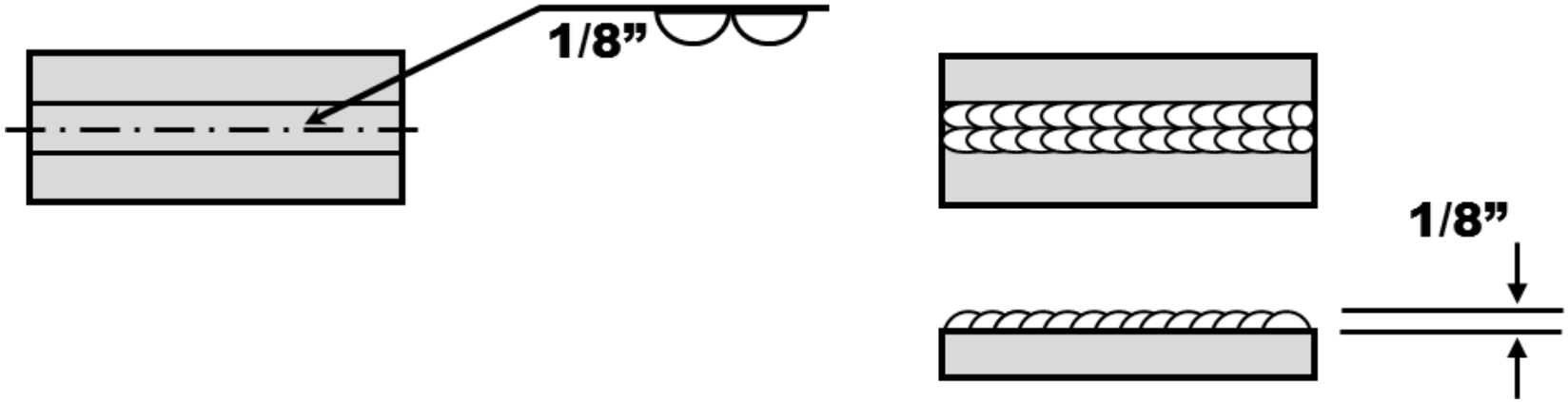
Basic Welding Symbols



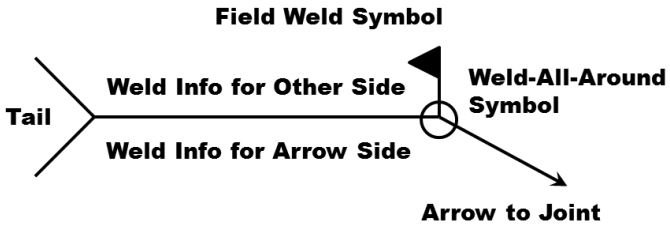
Bead	Fillet	Plug or Slot	Groove or Butt						
			Square	V	Bevel	U	J	Flare V	Flare Bevel

Surfacing/Handfacing Welds



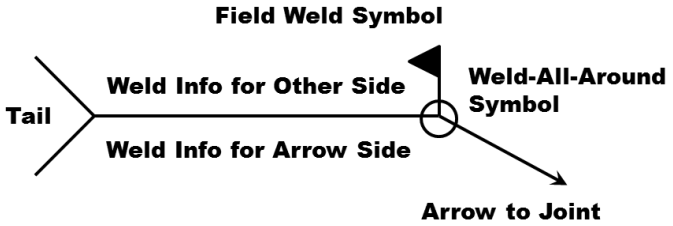


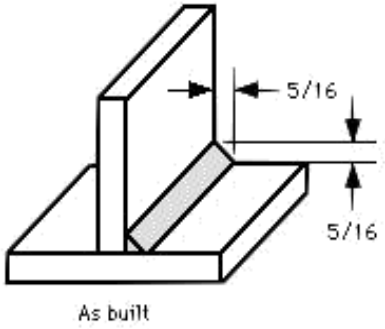
Basic Welding Symbols

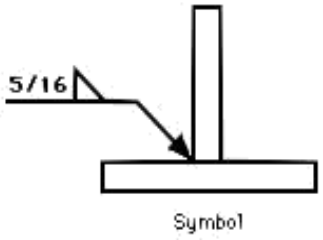


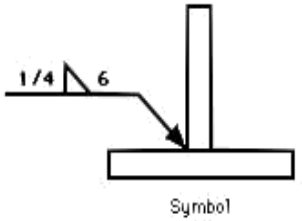
Bead	Fillet	Plug or Slot	Groove or Butt						
			Square	V	Bevel	U	J	Flare V	Flare Bevel

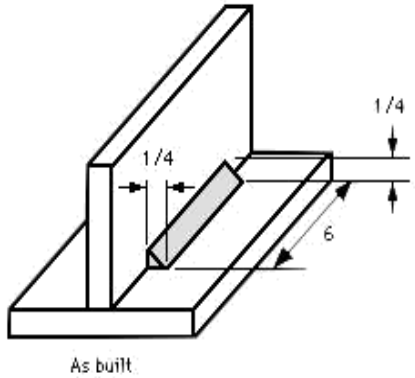
Fillet Welds

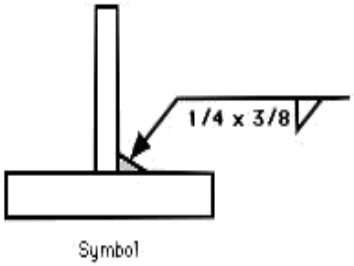


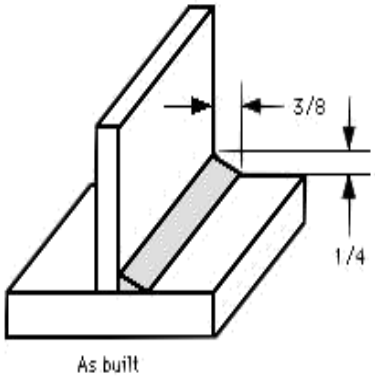


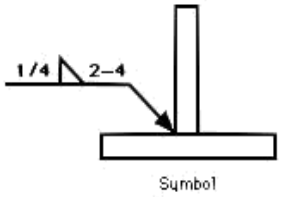


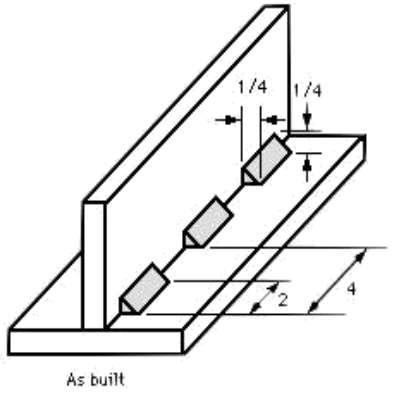




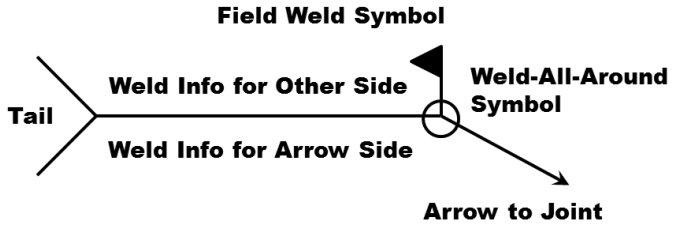


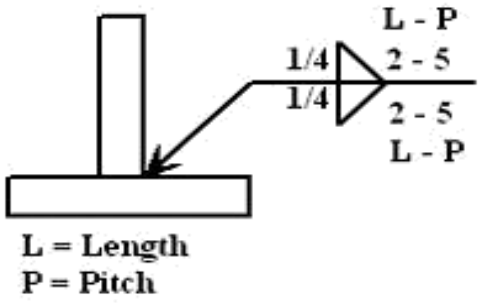


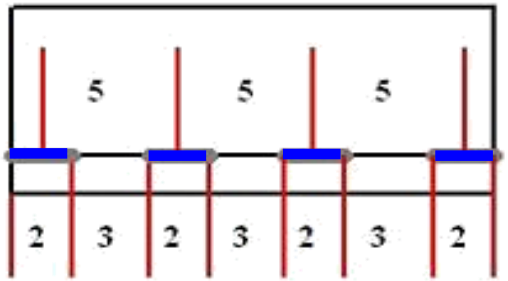




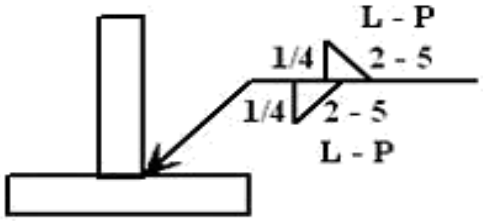
Fillet Welds



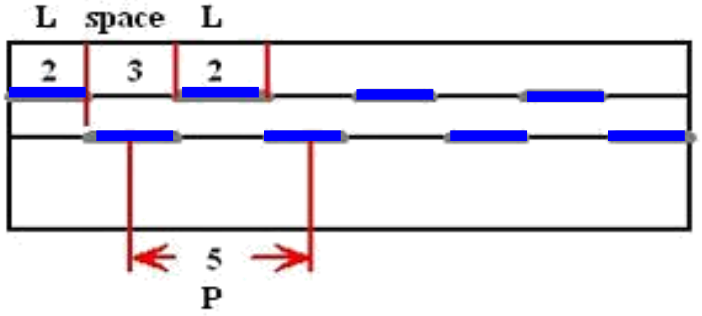




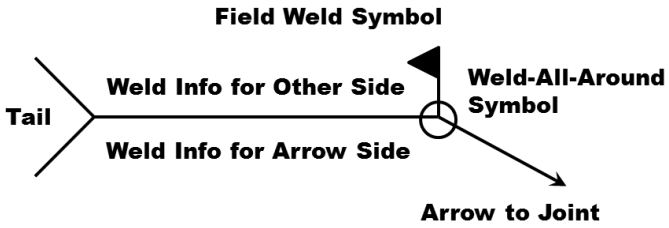
Length of weld 2''
Pitch 5''
Space between 3''



Staggered
Note offset symbol

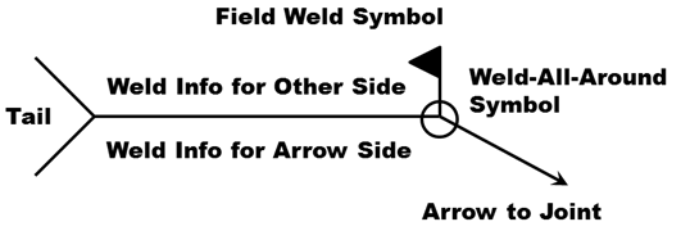


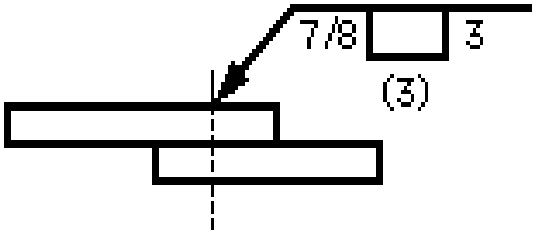
Basic Welding Symbols

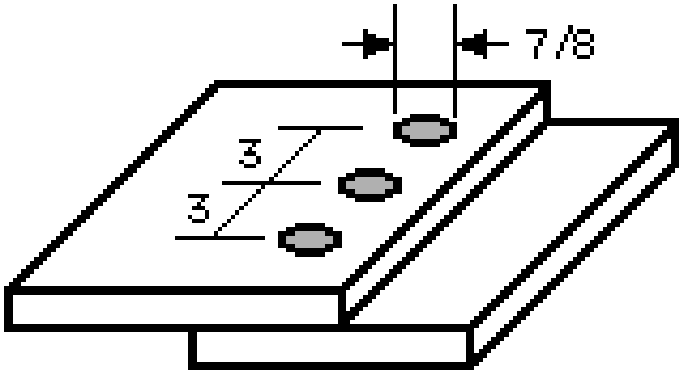


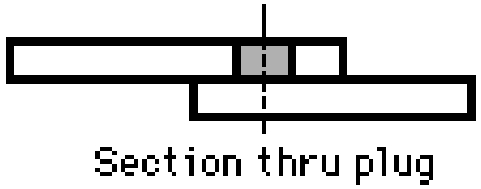
Bead	Fillet	Plug or Slot	Groove or Butt						
			Square	V	Bevel	U	J	Flare V	Flare Bevel

Spot Welds

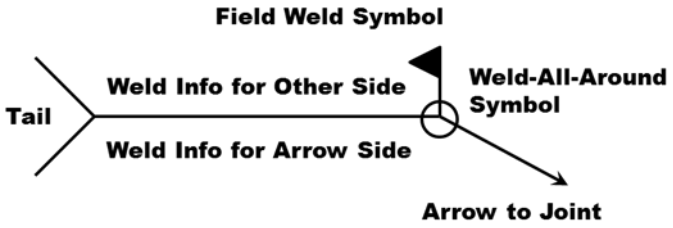

Field Weld Symbol
Tail
Weld Info for Other Side
Weld Info for Arrow Side
Weld-All-Around Symbol
Arrow to Joint

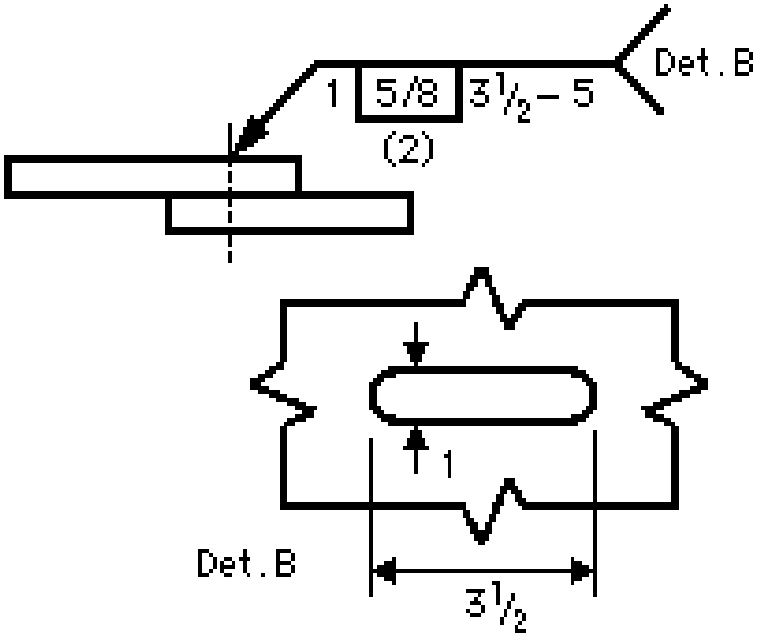

7/8
3
(3)

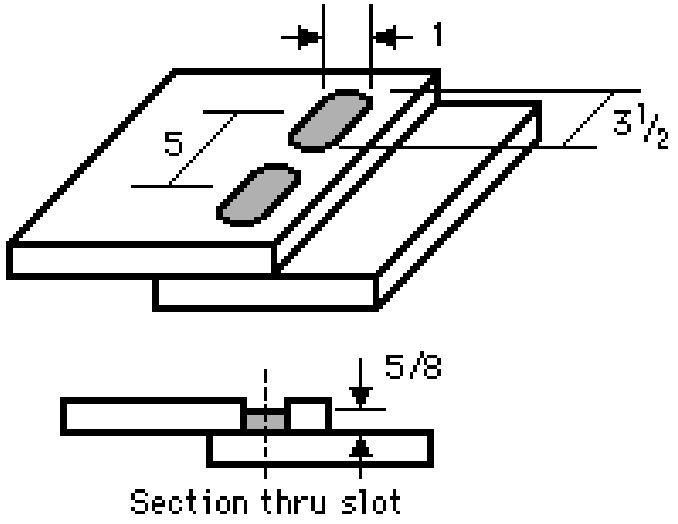

7/8
3
3


Section thru plug

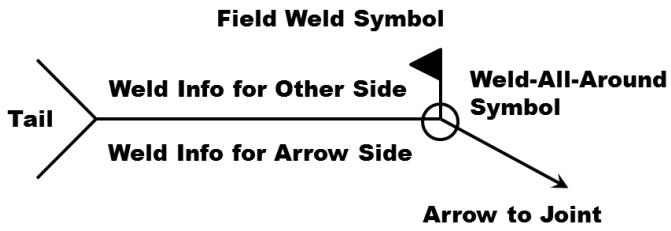
Spot Welds


Field Weld Symbol
Tail
Weld Info for Other Side
Weld Info for Arrow Side
Weld-All-Around Symbol
Arrow to Joint


1
5/8
3 1/2 – 5
(2)
Det. B
1
Det. B
3 1/2

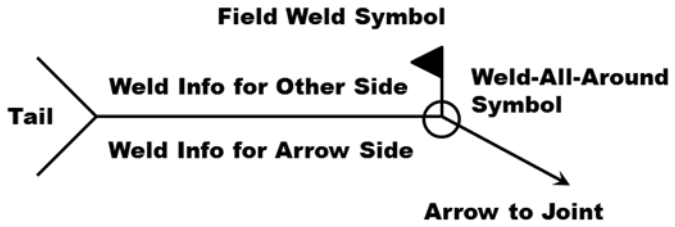

1
5
3 1/2
5/8
Section thru slot

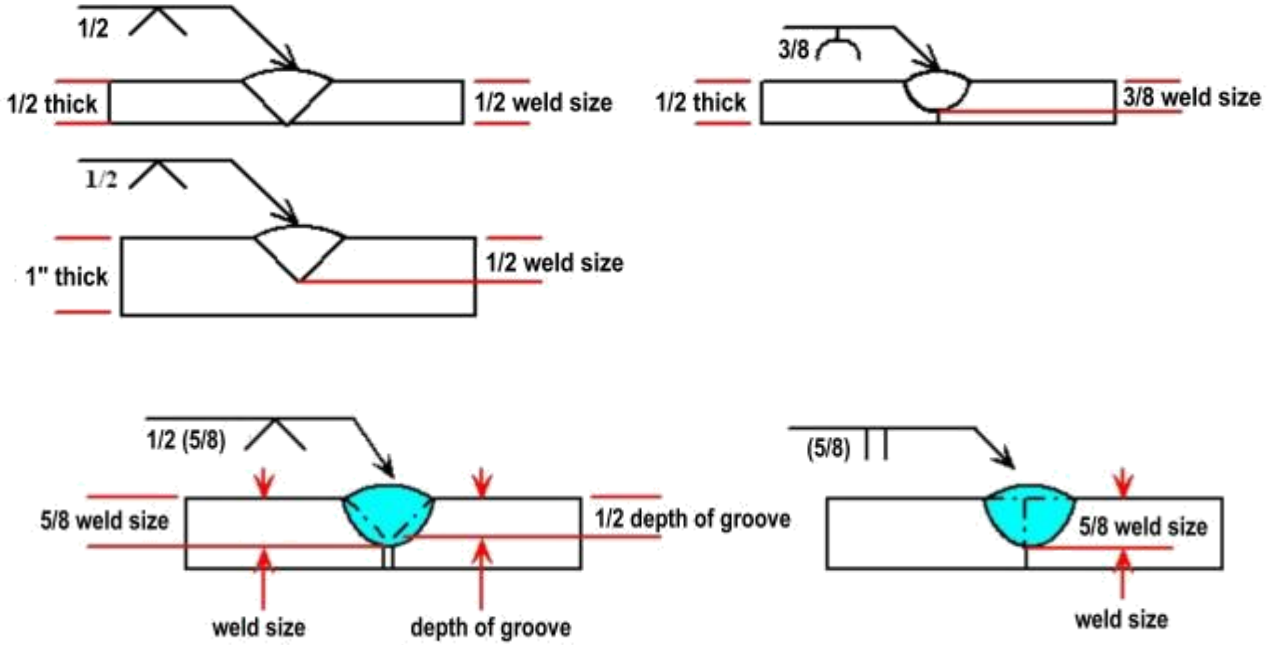
Basic Welding Symbols



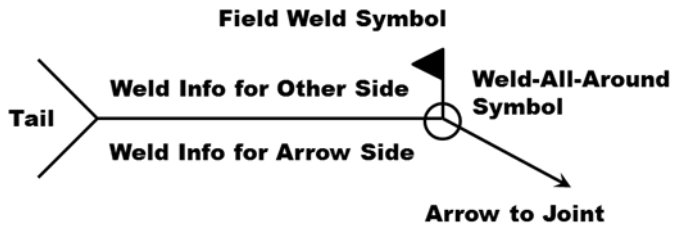
Bead	Fillet	Plug or Slot	Groove or Butt						
			Square	V	Bevel	U	J	Flare V	Flare Bevel

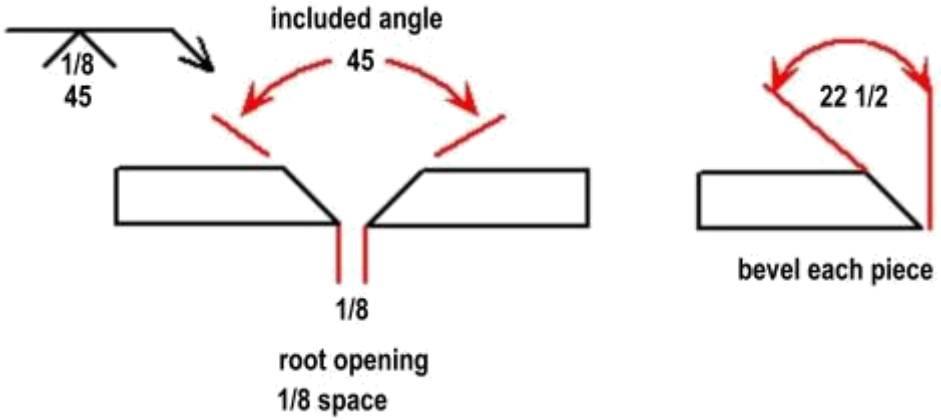
Groove Weld Size



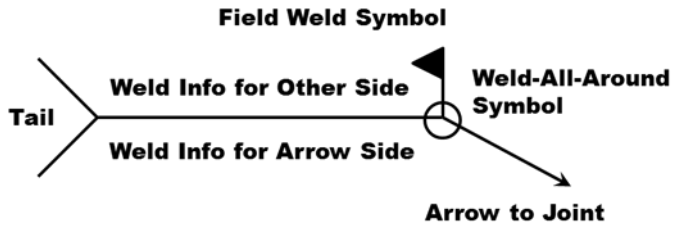


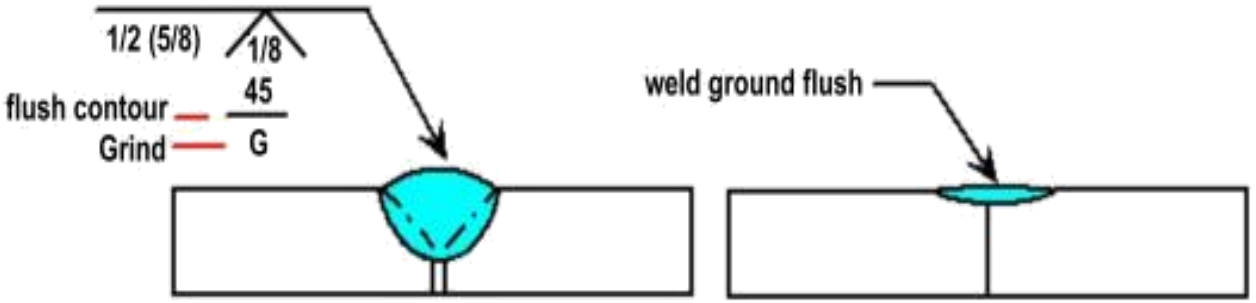
Groove Opening and Angle



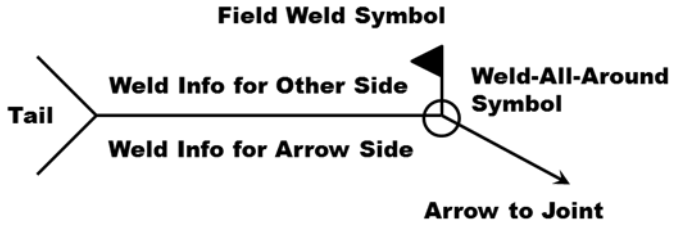


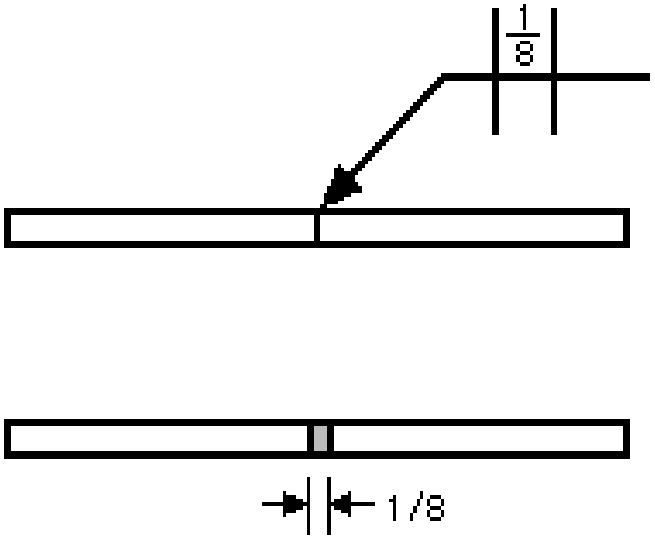
Groove Contour & Finish



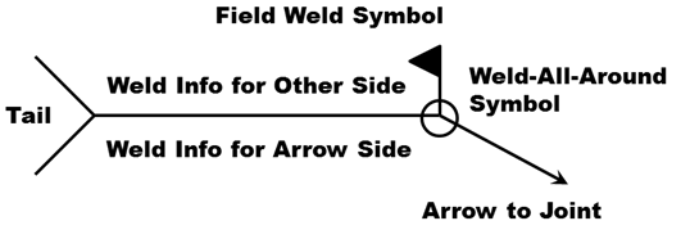


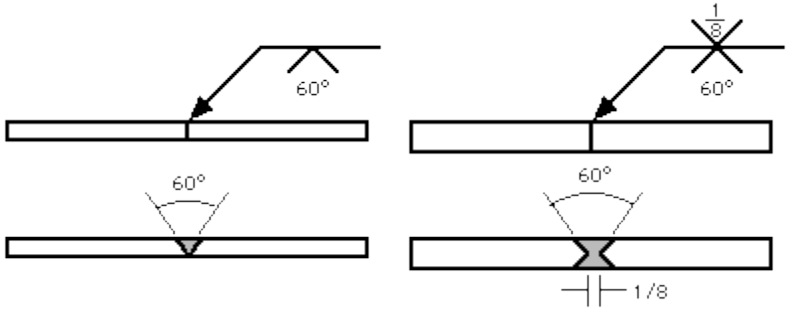
Square Groove

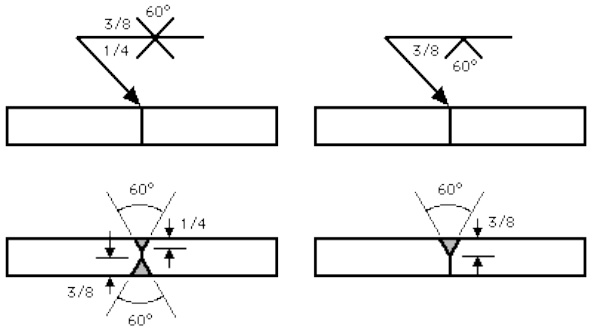


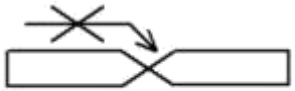


V-Groove

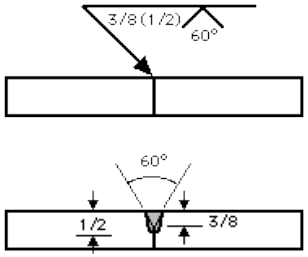






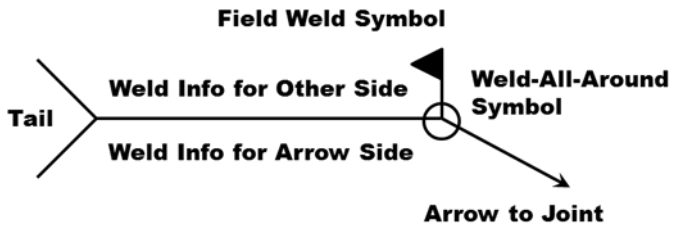


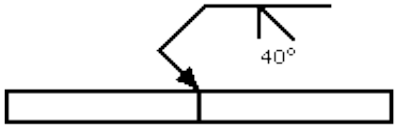
Double V Groove

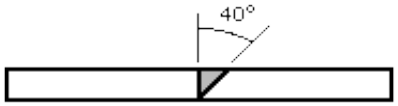


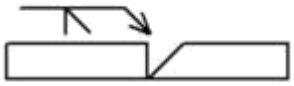
Weld Penetration In “( )”

Bevel Groove

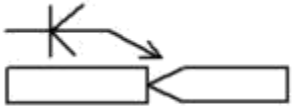








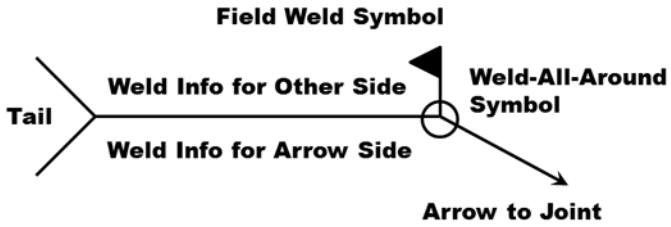
Bevel Groove

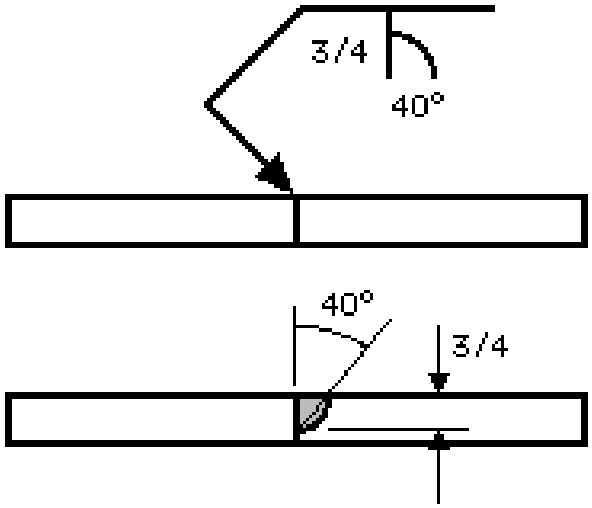


Double Bevel

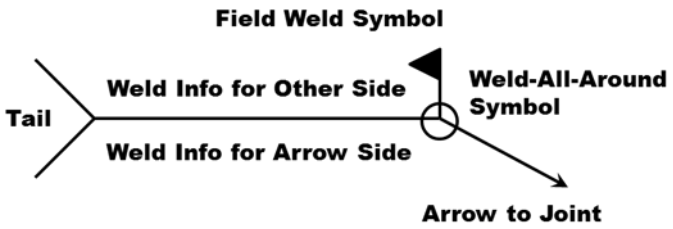
- Edge of one of the pieces is chamfered and the other is left square
- Bevel symbol's perpendicular line is always drawn on the left side, regardless of the orientation of the weld
- The arrow points toward the piece that is to b chamfered
- Extra significance is emphasized by a break in the arrow line

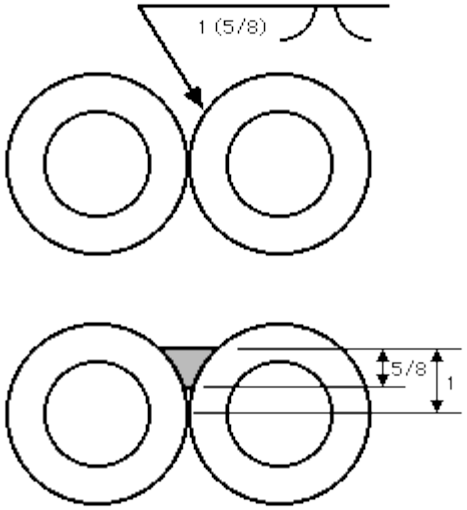
J-Groove


Field Weld Symbol
Tail
Weld Info for Other Side
Weld Info for Arrow Side
Weld-All-Around Symbol
Arrow to Joint

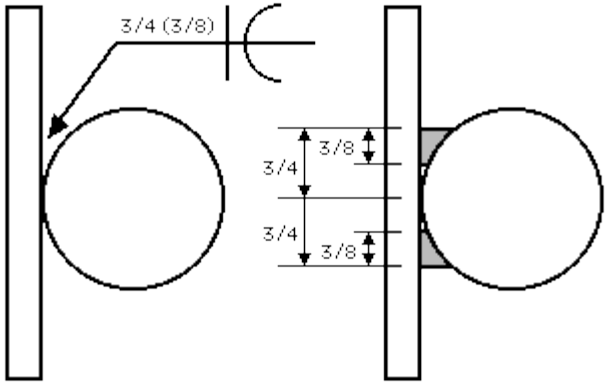

3/4
40°
40°
3/4

Flare Groove



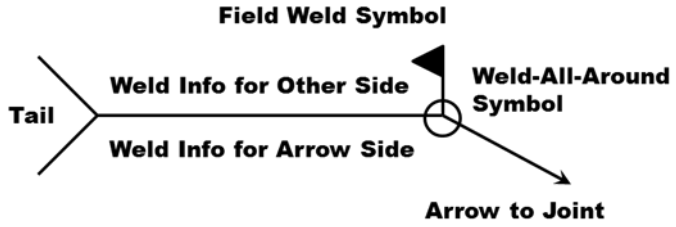


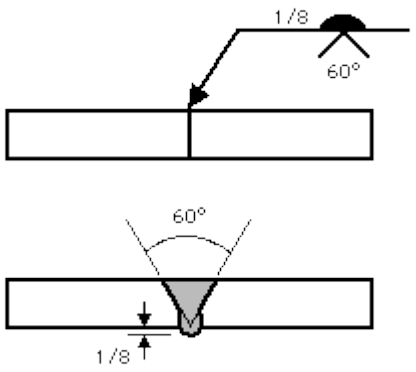
Flare V Groove



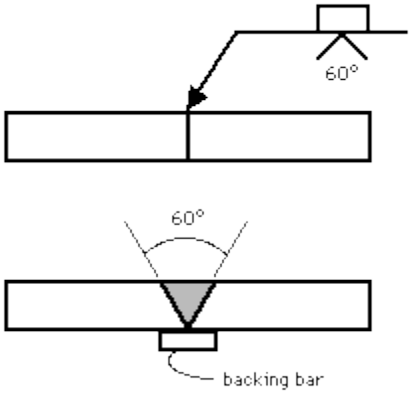
Flare Bevel Groove

Common Supplementary Symbols for Groove Welds





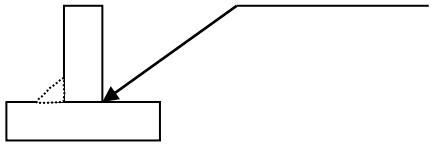
Melt-Thru Symbol



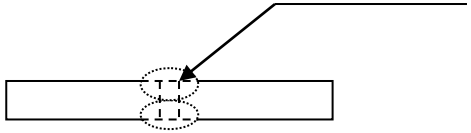
Backing Bar Symbol

QUIZ 1:
Draw the Proper Symbols

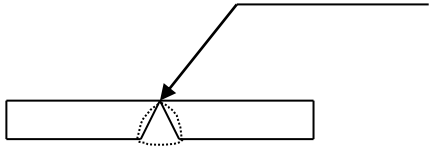
1.



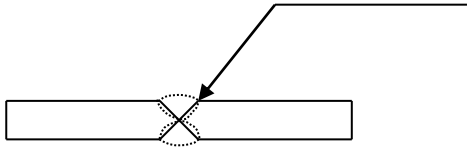
2.



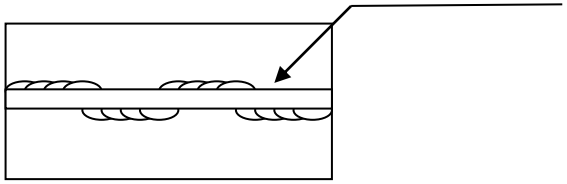
3.



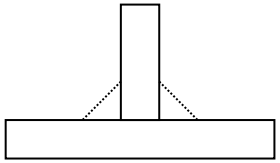
4.



5. (Top View)



(End View)



QUIZ 2: Solution
Identify Parts of Weld Symbols

A._____

B._____

C._____

D._____

E._____