

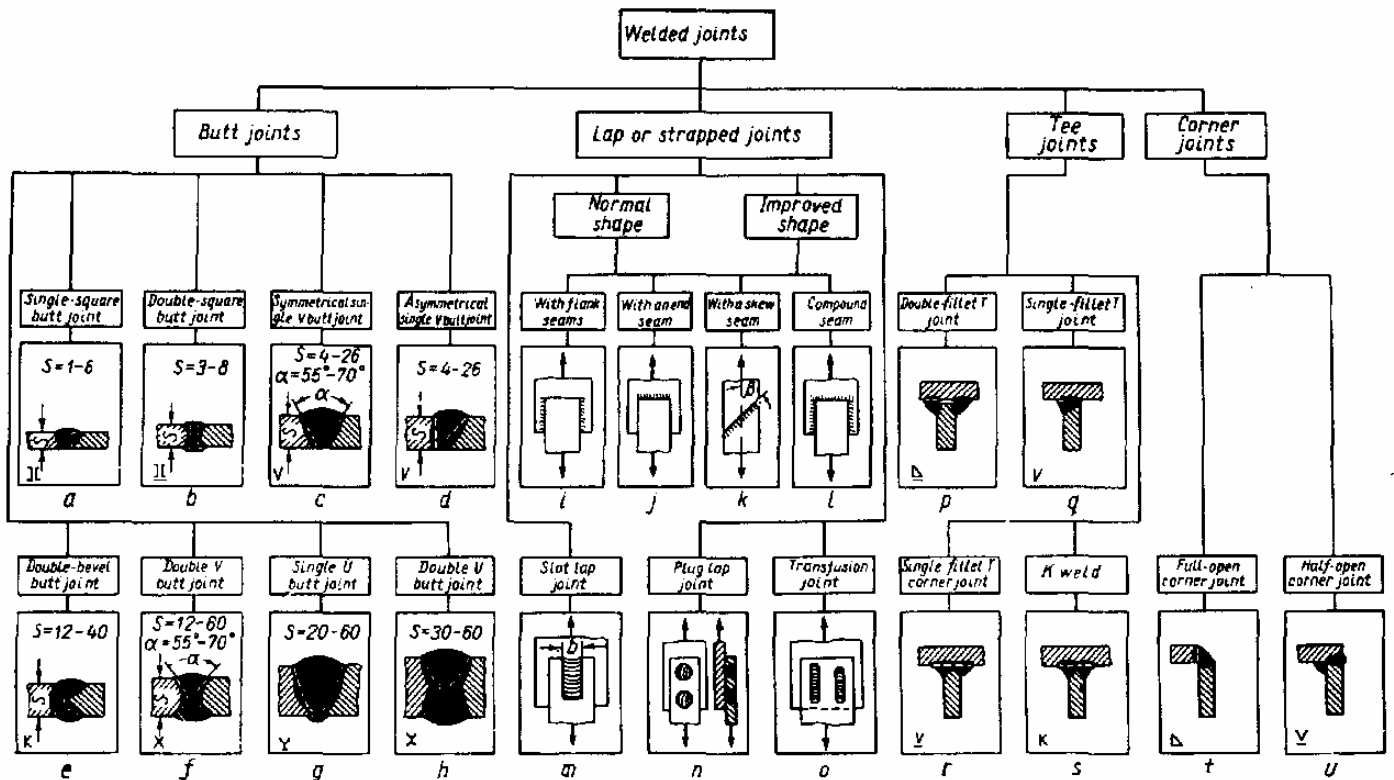
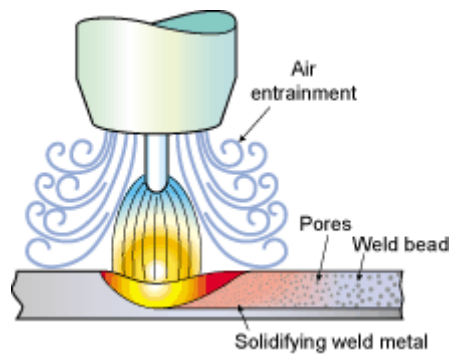
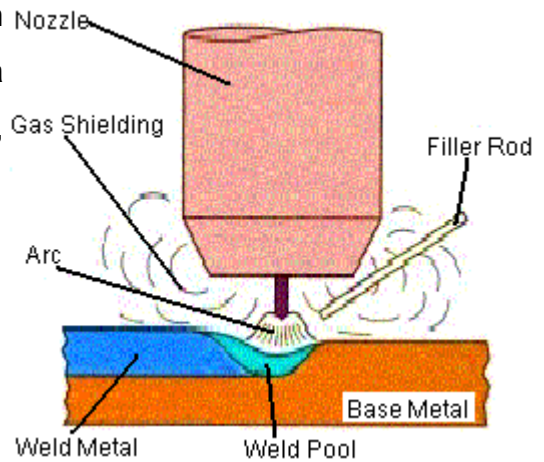


Figure 8.26. Classification of welded joints and drawing symbols.

GTAW Welding

Gas Tungsten Arc Welding (GTAW) is frequently referred to as TIG welding. TIG welding is a commonly used high quality welding process. TIG welding has become a popular choice of welding processes when high quality, precision welding is required.

In TIG welding an arc is formed between a nonconsumable tungsten electrode and the metal being welded. Gas is fed through the torch to shield the electrode and molten weld pool. If filler wire is used, it is added to the weld pool separately.



TIG Welding Benefits

- Superior quality welds
- Welds can be made with or without filler metal
- Precise control of welding variables (heat)
- Free of spatter
- Low distortion

Shielding Gases

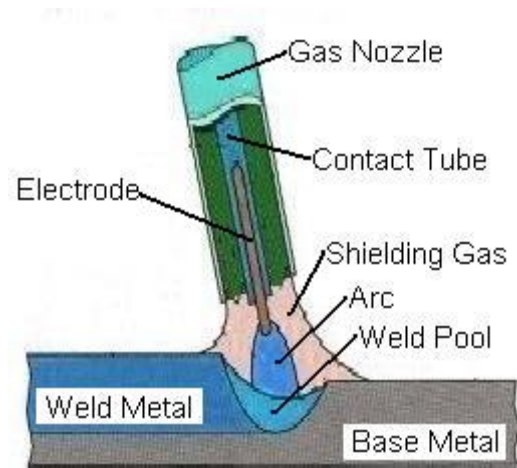
- Argon
- Argon + Hydrogen
- Argon/Helium

Helium is generally added to increase heat input (increase welding speed or weld penetration). Hydrogen will result in cleaner looking welds and also increase heat input, however, Hydrogen may promote porosity or hydrogen cracking.



MIG Welding

Gas Metal Arc Welding (GMAW) is frequently referred to as MIG welding. MIG welding is a commonly used high deposition rate welding process. Wire is continuously fed from a spool. MIG welding is therefore referred to as a semiautomatic welding process.



MIG Welding Benefits

- All position capability
- Higher deposition rates than SMAW
- Less operator skill required
- Long welds can be made without starts and stops
- Minimal post weld cleaning is required

MIG Welding Shielding Gas

The shielding gas, forms the arc plasma, stabilizes the arc on the metal being welded, shields the arc and molten weld pool, and allows smooth transfer of metal from the weld wire to the molten weld pool.

The primary shielding gasses used are:

- Argon
- Argon - 1 to 5% Oxygen
- Argon - 3 to 25% CO₂
- Argon/Helium

CO₂ is also used in its pure form in some MIG welding processes. However, in some applications the presence of CO₂ in the shielding gas may adversely affect the mechanical properties of the weld.



Symbols for arc and gas welds

Type of weld							
Bead	Fillet	Plug or slot	Groove				
			Square	V	Bevel	U	J

(a)

(b)

Fillet weld.

Arrow side

Other side

Must specify *leg length*.

All around

Electrode Properties

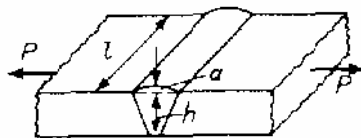
Electrode Number	Ultimate tensile strength, S_u , ksi	Yield strength, S_y , ksi	Elongation, $e_{\%}$, percent
E60XX	62	50	17-25
E70XX	70	57	22
E80XX	80	67	19
E90XX	90	77	14-17
E100XX	100	87	13-16
E120XX	120	107	14

- Use electrode that is stronger than the parent metal.
- Groove welds are not critical sections. Weldments fail in the parent metal.
- Fillet welds may be critical. Must calculate weld size.
- Use allowable shear stress

$$\tau_{allow} = 0.40s_y$$

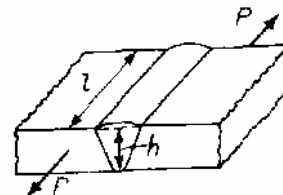
(3.14) Use only for welds

Text Reference: Table 15.10, page 705



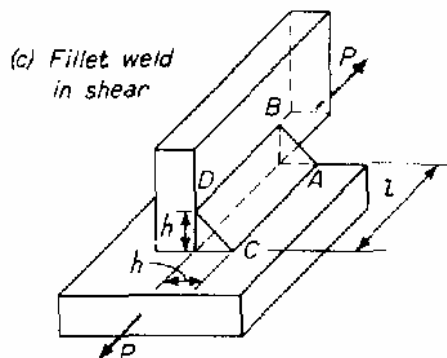
(a) Butt weld in tension

$$\text{Stress, } \sigma = \frac{P}{hl}$$



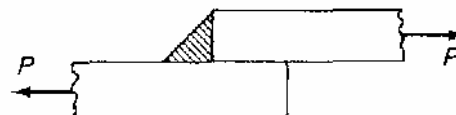
(b) Butt weld in shear

$$\text{Av. stress, } \tau = \frac{P}{hl}$$



(c) Fillet weld in shear

$$\text{Av. stress, } \tau = \frac{P}{.707hl} = 1.414 \frac{P}{hl}$$



(d) Fillet weld in tension perpendicular to its length

Various types of welds and loadings.

Fillet Welds under Transverse and Parallel Loads

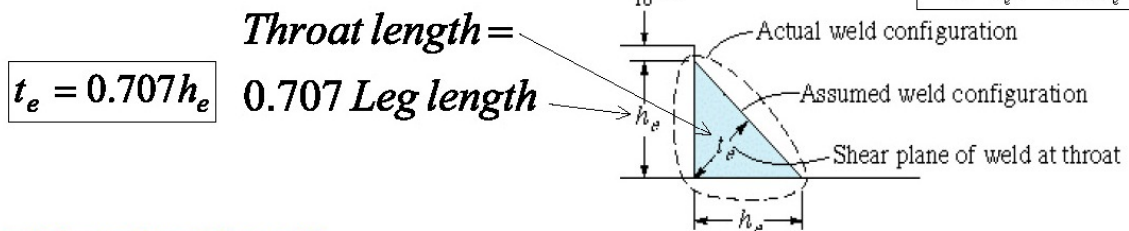
- Failure is in *shear planes*.

Transverse load:

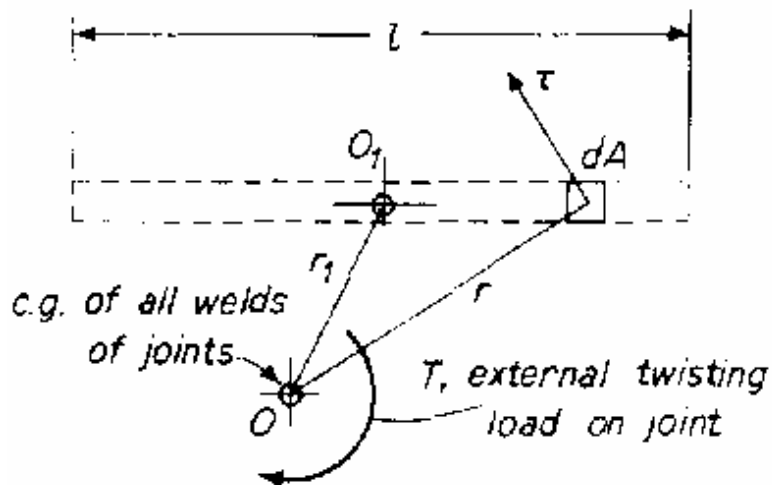
$$\tau \approx \frac{P}{A} = \frac{P}{t_e L} = \frac{P}{0.707 h_e L}$$

Parallel load:

- Smallest shear area is at *throat*.



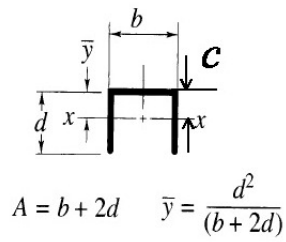
Text Reference: Figure 15.21, page 701



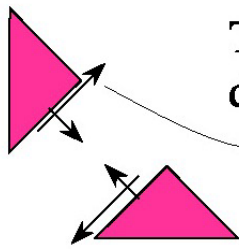
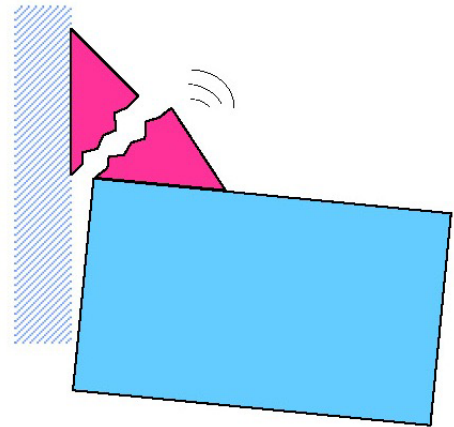
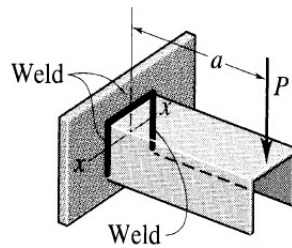
Stress on element of eccentrically loaded welded joint.

Fillet weld under bending stress

Dimensions
of weld



Bending



Theory and experiments show that what damages weld is the shear stress at the throat

$$\tau = \frac{Mc}{I} = \frac{Pac}{0.707h_e I_u}$$

Fillet Welds under Torsion (offset) loads

• Offset load can shear welds around a **centroid**.

Split into:

Direct shear:
Assume uniform force per unit area.

$$\tau_d = \frac{P}{\sum A}$$

Torsional shear:

$$\tau_t = \frac{Tr}{J}$$

Large r , large τ
Small r , small τ

Text Reference: Figure 15.22, page 706

Torsional shear: $\tau_t = \frac{Tr}{J}$

Distance from centroid

Polar moment of inertia

Area = A_2 . Polar moment of inertia about own centroid = J_2 .

Area = A_1 . Polar moment of inertia about own centroid = J_1

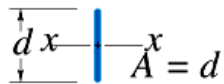
Total polar moment of inertia of weld about weld centroid =

$$J = J_1 + d_1 A_1^2 + J_2 + d_2 A_2^2.$$

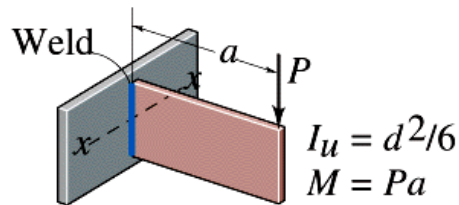
• Moment of inertia J can be calculated from tables.

• Tables assume $J_1 \ll d_1 A_1^2$, and $J_2 \ll d_2 A_2^2$.

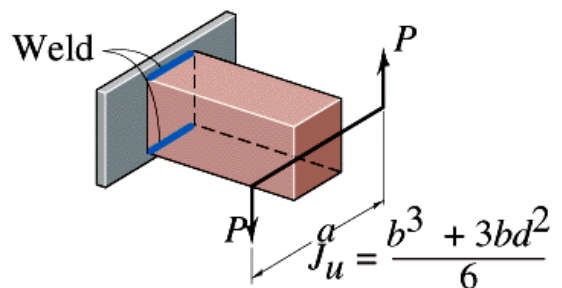
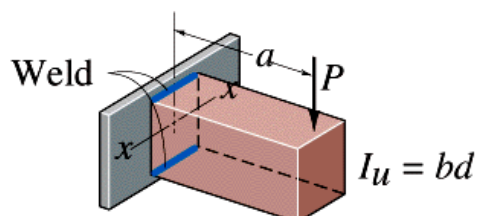
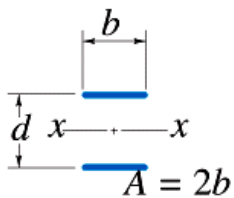
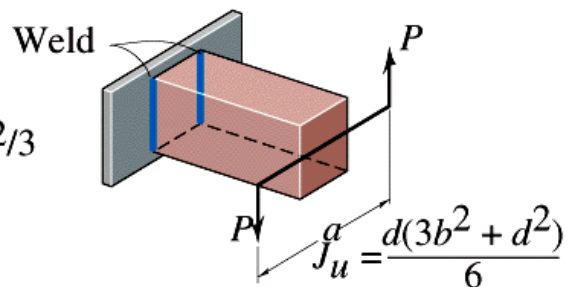
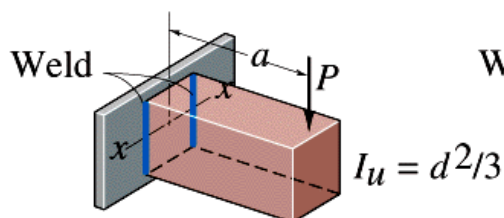
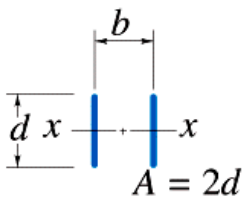
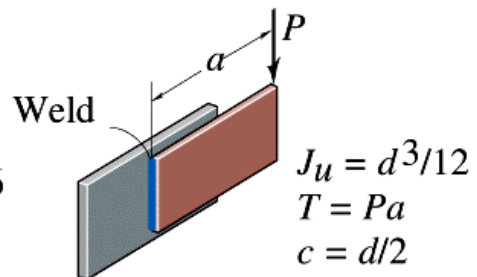
Dimensions of weld



Bending



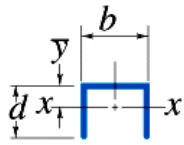
Torsion



Dimensions of weld

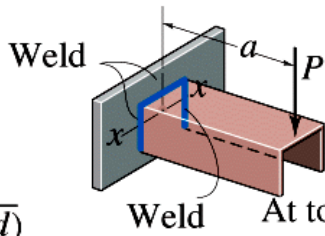
Bending

Torsion



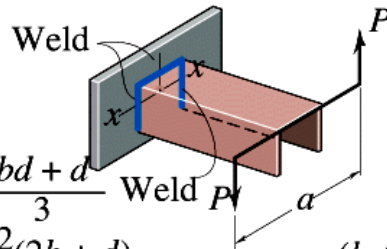
$$A = b + 2d$$

$$y = \frac{d^2}{(b + 2d)}$$

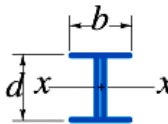


At top $I_u = \frac{2bd + d^3}{3}$

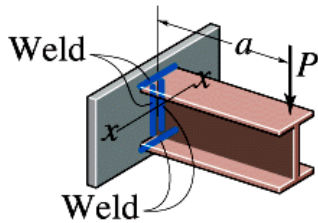
At bottom $I_u = \frac{d^2(2b + d)}{3(b + d)}$



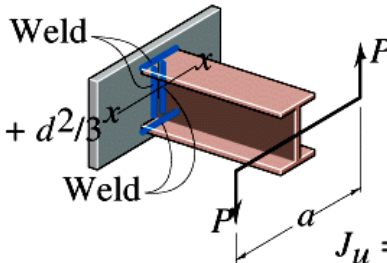
$$J_u = \frac{(b + 2d)^3}{12} - \frac{d^2(b + d)^2}{(b + 2d)}$$



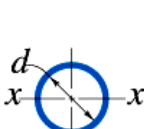
$$A = 2b + 2d$$



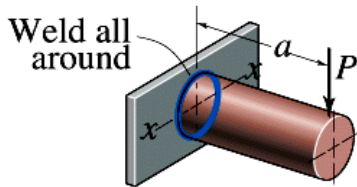
$$I_u = bd + d^2/3$$



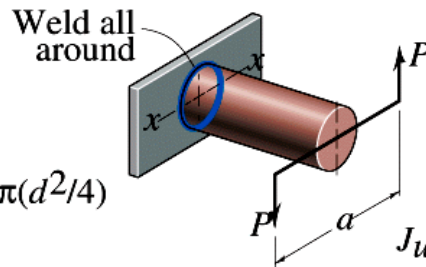
$$J_u = \frac{b^3 + 3bd^2 + d^3}{6}$$



$$A = \pi b$$

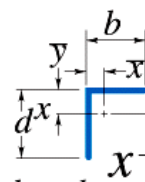


$$I_u = \pi(d^2/4)$$



$$J_u = \pi(d^3/4)$$

Dimensions of weld

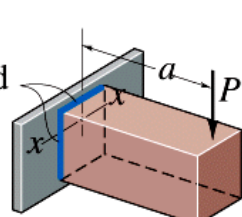


$$A = b + d$$

$$x = \frac{b^2}{2(b+d)}$$

$$y = \frac{d^2}{2(b+d)}$$

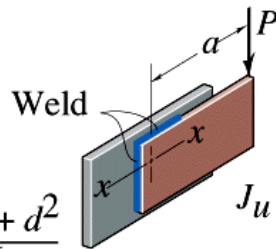
Bending



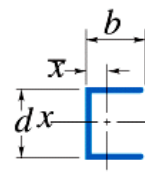
At top $I_u = \frac{4bd + d^2}{6}$

At bottom $I_u = \frac{d^2(4b + d)}{6(2b + d)}$

Torsion

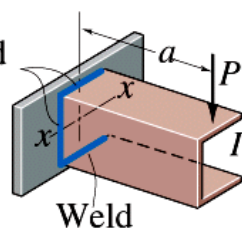


$$J_u = \frac{(b+d)^4 - 6b^2d^2}{12(b+d)}$$

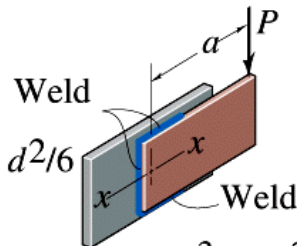


$$A = d + 2b$$

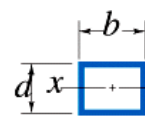
$$x = \frac{b^2}{2(b+d)}$$



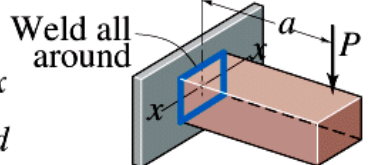
$$I_u = bd + d^2/6$$



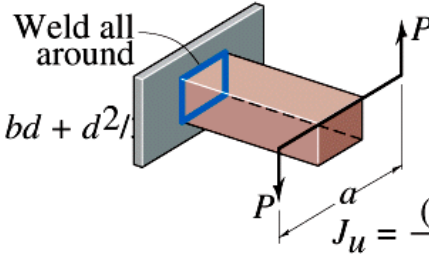
$$J_u = \frac{(2b+d)^3}{12} - \frac{b^2(b+d)^2}{(2b+d)}$$



$$A = 2b + 2d$$



$$I_u = bd + d^2/6$$



$$J_u = \frac{(b+d)^3}{6}$$

Electrode Number	Ultimate tensile strength, S_u , ksi	Yield strength, S_y , ksi	Elongation, e_k , percent
E60XX	62	50	17-25
E70XX	70	57	22
E80XX	80	67	19
E90XX	90	77	14-17
E100XX	100	87	13-16
E120XX	120	107	14