Weld poster Explanation
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Permissible stresses in welds

The permissible stress in welds is based on the American Institute of Steel Construction (AISC) building codes. AISC uses the yield strength to determine the max allowable stress. The comparable safety factors are also shown in the chart. These are minimum safety factors and maximum stress conditions. These permissible stresses could be used to determine the necessary size of the weld. If the fillet weld is loaded in torsion the following equations can then be back solved to find either the length or leg height of the weld.

$$\tau' = \frac{V}{A} \qquad \tau'' = \frac{M \cdot r}{J} \qquad J = .707 \cdot h \cdot Ju$$

The primary and secondary shear stress must be combined to obtain a total shear stress this will equal the max allowable shear stress. Then h can be found which is the leg height of the weld. Length of the weld is imbedded in Ju. Values of Ju can be found in table 9-2 (Shigley, page 392).

For fillet welds in bending:

$$\sigma = \frac{M \cdot y}{I} \qquad I = .707 \cdot h \cdot Iu$$

The stress is again known from the permissible shear stress calculation. The leg length (h) or other weld dimensions can then be solved for. Length of weld and/or distance between welds are again imbedded in Iu. Values of Iu can be found in table 9-3 (Shigley, page 396-397).

Type of loading	Type of weld	Permissible stresses	Safety factor (n)
Tension	Butt	0.60Sy	1.67
Bearing	Butt	0.90Sy	1.11
Bending	Butt	0.60-0.66Sy	1.52-1.67
Simple compression	Butt	0.06Sy	1.67
shear	Butt or fillet	0.40Sy	1.44

Stress Concentration Factors in Welds

Stress concentration factors should be use for parent metal as well as weld. There is often a trade off between stress concentration and over all size of weld. As the size of the weld grow so does the strength; unfortunately so dose the stress concentration, so the over all strength may be about the same. It is more important however, to focus design of weld process and components based on time and economic factors rather than machinability. For a reinforced butt weld the reinforcement on the top of the weld will increase the throat area thus decreasing stress in the weld. However, the stress concentration factor at the edge of the weld may negate any advantages gained from the reinforcement. Therefore it may be equal as strong to make a flat weld with out the reinforcement and with out the stress concentration. The same idea applies to the T-butt (fillet) weld. If the fillet weld is done in such a way to have a very concave shape the transitions will be much more gradual and the stress concentration less. However as the weld becomes more concave in shape the throat area becomes less and the stress then increases.

Post Weld Processes

Welding always causes some distortion, shrinkage or warpage along with changes to the micro-structure of the parent material. Welding processes can be grouped into two levels; common welds and critical welds. Common welds are still very high quality welds. However for such situations other factors drive the design (such as deflection) so the stress safety factor is quite high by the time the deflection is with in limits. Such would include welds on vehicles frames, bridges, buildings and steam pipes. Most welds fall into this category. For such applications a full re-heat-treatment of part after welding is impractical to impossible. The best post weld procedure for this level of welds is stress relieving. Critical welds would be welds subjected to very high stresses or weld on very exotic material. After the weld process is done the entire part is re-heat-treated (heat, quench, temper) so the weld and heat affected zone is restored to the properties of the parent metal. Such processes are slow, expensive and performed in only the most crucial applications.

Post weld processes temperatures will differ depending on the composition of the material. The specific processes/temperatures on the chart should be acceptable for common, low carbon, mild steels.

Process	**Procedure**	**Effects**
Stress Relieving (mild steel)	Heat to approximately 1125°F then slow cool (50°F per hour) back to room temperature	
Stress Relieving (alloy steel)	Heat to a temperature well below the temper temperature for the particular steel	Reduce or eliminate residual stresses caused by distortion and shirking from welding process No micro-structural changes
Stress Relieving (Al alloys)	Heat to a temperature well below the age temperature for the particular aluminum	
Annealing (most steels)	Heat to austenite, slow cool (50°F per hour) back to room temperature	Eliminate all effects of heat treatment or cold work due to manufacturing or welding Return material to softest weakest condition but increase % elongation and ductility
Normalizing (most steels)	Heat to austenite, quench in room temperature air	Increases tensile and yield strengths but decreases ductility

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