Joint Design Considerations

1. Joint Gap:
A small joint gap enclosing a relatively small amount of brazing material will have less serious voids due to shrinkage on solidification than a joint with a large gap enclosing a larger volume. Hence use the smallest clearance that will fill properly.
Joint clearance has a significant effect on mechanical properties of the brazed joint, affecting static, fatigue and impact performance. For butt joints between steel using fine silver, brazed tensile strengths as high as 58Kg/mm2 have been observed whereas the tensile strength of silver by itself is only 15Kg/mm2. In the case of lap joints, tensile strength initially increases with joint clearance, peaks at around 0.08 to 0.15mm clearance and then decreases with increasing joint clearance. Shear strength decreases steadily with increasing joint gap from highest values at around 10 micron clearance.

RECOMMENDED JOINT GAPS mm:

Base Metal	Long Melting Range Filler	Short Melting Range Filler
Copper	0.05-0.25	0.04-0.15
Steel	0.05-0.15	0.04-0.15

2. Uniformity of Joint gap width (parallelism):
The rate of capillary flow is proportional to joint gap width so that with joints having non-uniform widths, the molten braze metal flows quickly through the wider portions of the gap and can envelop unfilled areas resulting in unfilled or flux filled cavities.

3. Inter-alloying and flux type have an effect on optimum joint gap - in the case of copper brazing of steel, there is very little inter-alloying, copper wets steel very well and the oxides formed are not refractory so that and even interference fits can produce sound joints.

4. Surface Finish: The recommended surface finish for joint faces is 0.7-2 microns Ra. Greater than 6 micron roughness can result in reduced joint strength as only the high points might braze, the amount of filler metal required also increases at larger values of roughness.

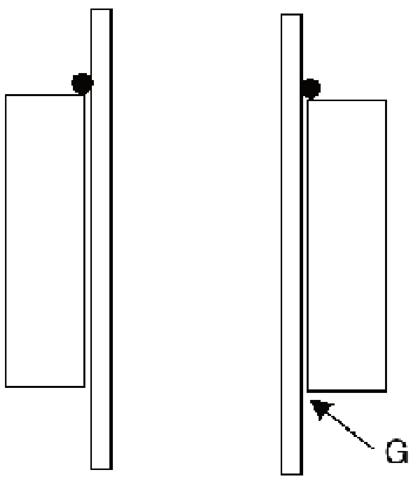
5. Entrapped flux: Flux pockets in the final joint can significantly reduce the mechanical properties of the joint. Oxide-saturated flux has higher viscosity and is less easily displaced by advancing molten braze metal. It is important to have initially clean joint faces, a reasonably short brazing time and sufficient flux to avoid excessive flux “loading” which increases its viscosity. Also, a brazing alloy that wets and flows well on the material is more effective in displacing flux and avoiding flux entrapment.

6. Gas cavities: Bubbles of gas formed due to chemical action between the metals being joined, too active a flux, unclean surfaces or unduly reducing flame in gas torch brazing are causes of gas porosity and cavities. The expected soundness of brazed joints produced under production conditions is unlikely to better than 85% in practice, but joints with less than 70% soundness can be improved.

Joint Design Considerations - Continued

Silver brazing alloys will not usually flow through a capillary gap to a length of more than about 20mm for single point application of brazing alloy, longer overlap joint lengths can be achieved using brazing alloy ring preforms.
A realistic rule-of-thumb for lap joints and tube-to-tube brazing is: "joint overlap length should normally be between 3 and 4 times thickness of the thinner component; it should not be less than 3 mm nor more than 20 mm for single point application of brazing alloy."
For tube-in-tube or plug-in-tube type of brazed assemblies involving different metals, it is highly recommended that the outer member should have the higher coefficient of thermal expansion which will result in the braze metal being in a state of compression after cooling down. The reverse will result in the joint being in a residual state of tension, impairing strength behaviour, especially under dynamic loading.

Braze Metal Calculations



The optimum volume of brazing alloy required in a joint is 25% more than the volume of the joint gap at the brazing temperature.

Preform ring wire diameter calculation

$$D = 1.27 \times \sqrt{L \times G}$$

where D=Ring wire diameter.
The value of joint gap G to be used in this calculation is the dimension at the brazing temperature, taking into consideration thermal expansion.

Mechanical Properties: The strength of the brazed joint is not directly related to the method of filler metal melting. Joint strength is dependant on joint design, metal cleanliness, brazing temperature, amount of brazing filler metal applied, location and method of application, heating rate and many other factors making up the brazing technique. Therefore a classification method based on mechanical properties would be misleading since it would only apply if the brazing filler metal were used on a given base metal with a specific joint design. If a user desires to determine the mechanical properties of a given base metal/filler metal combination, tests should be conducted using defined configurations and procedures eg AWS SC3.2 "Standard Method for Evaluating the Strength of Brazed Joints".

For more information, refer to the Brazing Handbook by the American Welding Society.