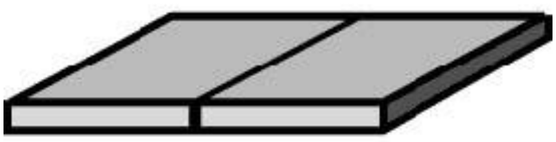
LucasMilhaupt® A Handy & Harman Company Global Brazing Solutions℠ Knowledge Base

Topics related to brazing to aid with learning and understanding the technical aspects of brazing, how brazing works, why it works, along with useful hints and tips.

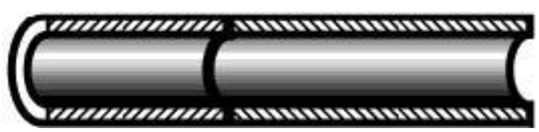
Joint Design

What type of brazed joint should you design? There are many kinds of joints. But our problem is simplified by the fact that there are only two basic types the butt and the lap. The rest are essentially modifications of these two. Let's look first at the butt joint, both for flat and tubular parts.

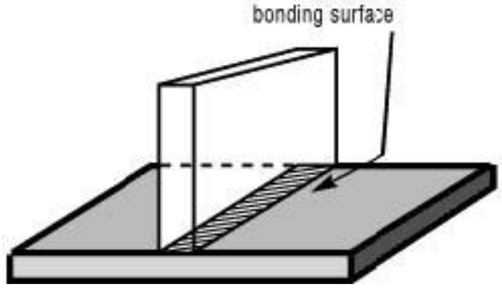
Butt joint - flat parts



Butt joint - tubular parts (cutaway)

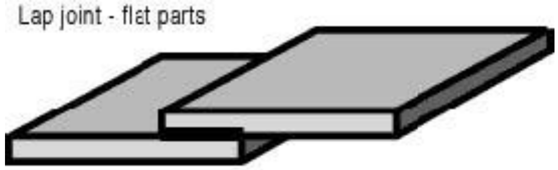


As you can see, the butt joint gives you the advantage of a single thickness at the joint. Preparation of this type of joint is usually simple, and the joint will have sufficient tensile strength for a good many applications. However, the strength of the butt joint does have limitations. It depends, in part, on the amount of bonding surface, and in a butt joint the bonding area can't be any larger than the cross section of the thinner member.

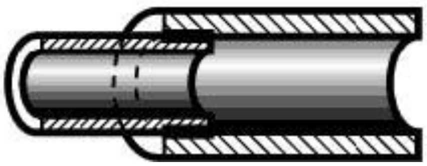


Now let's compare this with the lap joint, both for flat and tubular parts.

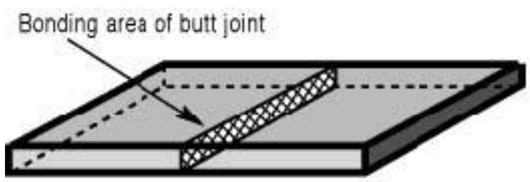
Lap joint - flat parts

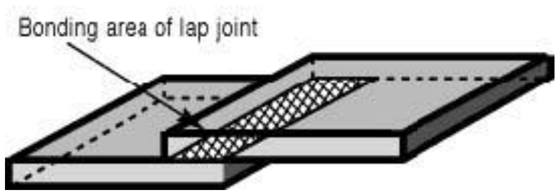


Lap joint - tubular parts (cutaway)



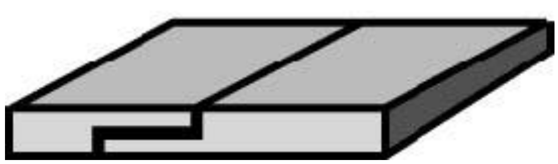
The first thing you'll notice is that, for a given thickness of base metals, the bonding area of the lap joint can be larger than that of the butt joint and usually is. With larger bonding areas, lap joints can usually carry larger loads.





The lap joint gives you a double thickness at the joint, but in many applications (plumbing connections, for example) the double thickness is not objectionable. And the lap joint is generally self-supporting during the brazing process. Resting one flat member on the other is usually enough to maintain a uniform joint clearance. And, in tubular joints, nesting one tube inside the other holds them in proper alignment for brazing. However, suppose you want a joint that has the advantages of both types; single thickness at the joint combined with maximum tensile strength. You can get this combination by designing the joint as a buttlap joint.

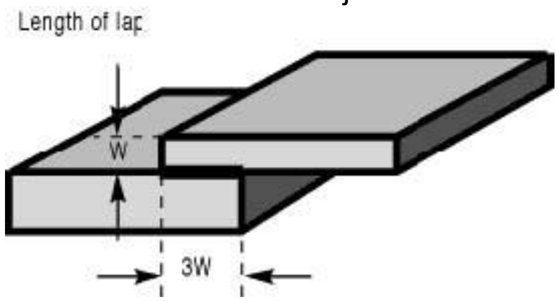
Butt-lap joint - flat parts



True, the buttlap is usually a little more work to prepare than straight butt or lap, but the extra work can pay off. You wind up with a single thickness joint of maximum strength. And the joint is usually self supporting when assembled for brazing.

Figuring the proper length of lap

Obviously, you don't have to calculate the bonding area of a butt joint. It will be the cross-section of the thinner member and that's that. But lap joints are often variable. Their length can be increased or decreased. How long should a lap joint be? The rule of thumb is to design the lap joint to be three times as long as the thickness of the thinner joint member.

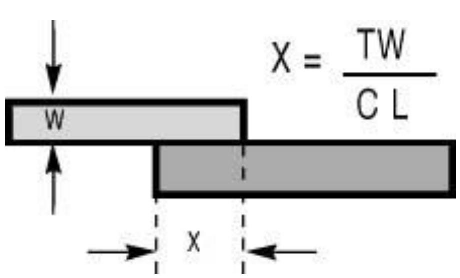


A longer lap may waste brazing filler metal and use more base metal material than is really needed, without a corresponding increase in joint strength. And a shorter lap will lower the strength of the joint. For most applications, you're on safe ground with the "rule of three." More specifically, if you know the approximate tensile strengths of the base members, the lap length required for optimum joint strength in a silver brazed joint is as follows:

Tensile strength of weakest member	Lap length = factor x W (W = thickness of weakest member)
35,000 psi 241.3 MPa	2 x W
60,000 psi 413.7 MPa	3 x W
100,000 psi 689.5 MPa	5 x W
130,000 psi 896.3 MPa	6 x W
175,000 psi 1,206.6 MPa	8 x W
Note: ksi x 6.8948 = 1 MPa	

If you have a great many identical assemblies to braze, or if the joint strength is critical, it will help to figure the length of lap more exactly, to gain maximum strength with minimum use of brazing materials. The formulas given below will help you calculate the optimum lap length for flat and for tubular joints.

Figuring length of lap for flat joints



X = Length of lap

T = Tensile strength of weakest member

W = Thickness of weakest member

C = Joint integrity factor of .8

L = Shear strength of brazed filler metal Let's see how this formula works, using an example.

Problem: What length of lap do you need to join .050" annealed Monel sheet to a metal of equal or greater

strength?

Solution:

C = .8

T = 70,000 psi (annealed Monel sheet)

W = .050"

L = 25,000 psi (Typical shear strength for silver brazing filler metals)

X = (70,000 x .050) /(.8 x 25,000) = .18" lap length

Problem in metric: What length of lap do you need to join 1.27 mm annealed Monel sheet to a met al of

equal or greater strength?

Solution:

C = .8

T = 482.63 MPa (annealed Monel sheet)

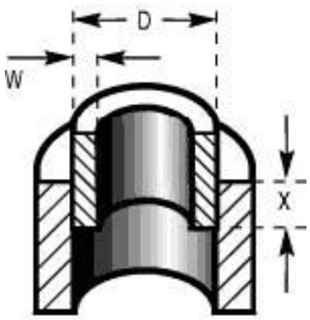
W = 1.27 mm

L = 172.37 MPa (Typical shear strength for silver brazing filler metals)

X = (482.63 x 1.27) /(.8 x 172.37)

X = 4.5 mm (length of lap)

Figuring length of lap for tubular joints



$$X = \frac{W\ (D-W)\ T}{C\,L\,D}$$

X = Length of lap area W = Wall thickness of weakest member D = Diameter of lap area

T = Tensile strength of weakest member C = Joint integrity factor of .8 L = Shear strength of brazed filler metal Again, an example will serve to illustrate the use of this formula.

Problem: What length of lap do you need to join 3/4" O.D. copper tubing (wall thickness .064") to 3 /4" I.D.

steel tubing?

Solution:

W = .064"

D = .750"

C= .8

T = 33,000 psi (annealed copper)

L = 25,000 psi (a typical value)

X = (.064 x (.75 .064) x 33,000)/(.8 x .75 x 25,000)

X = .097" (length of lap)

Problem in metric: What length of lap do you need to join 19.05 mm O.D. copper tubing (wall thick ness

1.626 mm] to 19.05 mm I.D. steel tubing?

Solution:

W = 1.626 mm

D = 19.05 mm

C = .8

T = 227.53 MPa (annealed copper)

L = 172.37 MPa (a typical value)

X = (1.626 x (19.05 1.626) x 227.53)/(.8 x 19.05 x 172.37)

X = 2.45 mm (length of lap)

Designing to distribute stress

When you design a brazed joint, obviously you aim to provide at least minimum adequate strength for the given application. But in some joints, maximum mechanical strength may be your overriding concern. You can help insure this degree of strength by designing the joint to prevent concentration of stress from weakening the joint. Motto - spread the stress. Figure out where the greatest stress falls. Then impart flexibility to the heavier member at this point, or add strength to the weaker member. The illustrations below suggest a number of ways to spread the stress in a brazed joint.

To sum it up when you're designing a joint for maximum strength, use a lap or scarf design (to increase joint area) rather than a butt, and design the parts to prevent stress from being concentrated at a single point. There is one other technique for increasing the strength of a brazed joint, frequently effective in brazing small part assemblies. You can create a stress-distribution fillet, simply by using a little more brazing filler metal than you normally would, or by using a more "sluggish" alloy. Usually you don't want or need a fillet in a brazed joint, as it doesn't add materially to joint strength. But where it contributes to spreading joint stresses, it pays to create the fillet.

Designing for service conditions

In many brazed joints, the chief requirement is strength. And we've discussed various ways of achi eving joint strength. But there are frequently other service requirements which may influence the joint design or filler metal selection. For example, you may be designing a brazed assembly that needs to be electrically conductive. A silver brazing filler metal, by virtue of its silver content, has very little tendency to increase electrical resistance across a properlybrazed joint. But you can further insure minimum resistance by using a close joint clearance, to keep the layer of filler metal as thin as possible. In addition, if strength is not a prime consideration, you can reduce length of lap. Instead of the customary "rule of three," you can redu ce lap length to about 11/2 times the crosssection of the thinner member. If the brazed assembly has to be pressure tight against gas or liquid, a lap joint is almost a must, since it withstands greater pressure than a butt joint. And its broader bonding area reduces any chance of leakage. Another consideration in designing a joint to be leak proof is to vent the assembly. Providing a vent during the brazing process allows expanding air or gases to escape as the molten filler metal flows into the joint. Venting the assembly also prevents entrapment of flux in the joint. Avoiding entrapped gases or flux reduce the potential for leak paths. If possible, the assembly should be self-venting. Since flux is designed to be displaced by molten filler metal entering a joint, there should be no sharp corners or blind holes to cause flux entrapment. The joint should be designed so that the flux is pushed completely out of the joint by the filler metal. Where this is not possible, small holes may be drilled into the blind spots to allow flux escape. The joint is completed when molten filler metal appears at the outside surface of these drilled holes.

To maximize corrosion resistance of a joint, select a brazing filler metal containing such elements as silver, gold or palladium, which are inherently corrosion resistant. Keep joint clearances close and use a minimum amount of filler metal, so that the finished joint will expose only a fine line of brazing filler metal to the atmosphere. These are but a few examples of service requirements that may be demanded of your brazed assembly. As you can see both the joint design and filler metal selection must be considered. Fortunately, there are many filler metals and fluxes available to you - in a wide range of compositions, properties and melting temperatures. The selector charts that appear later in this book can help you choose filler metals and fluxes that best meet the service requirements of the joints you design. The Technical Services Department at Handy & Harman/Lucas-Milhaupt is available to help answer any questions you may have with regard to your specific brazing application, joint design and/or filler metal selection.