Q: We braze a steel fitting to a steel tube and occasionally have failures where the fittings blow off the tube when pressure tested. Upon inspection, there is no bonding in the joint. They appeared visually acceptable after heating and could be handled without falling apart, but they actually had no filler metal in the joint. We caught this type of failure because these assemblies are pressure tested 100% of the time. I have included photos showing the parts. We have been making these parts for a long time and need to ensure that these random, but catastrophic, results do not occur. We use induction heating and BAg-24 braze rings. The flux is black and the label says it conforms to AWS A5.31, Specification for Fluxes for Brazing and Braze Welding. We buy the fittings in a finished condition. The tube stock is cut to size and fabricated into the final configuration in our facility. We assemble the tube and fitting, place a ring around the tube on the outside of the joint, and brush the entire area with flux. What should we be looking for in our process?

A: Thanks for sending me the photo of a failed braze joint to look at — Fig. 1. It is always troubling when a seemingly random variation comes on the scene.

From looking at the photos, you can see that the filler metal melted but stayed outside the joint on top of the fitting. There are several things that can cause or contribute to the braze filler metal not pulling into the joint.

1) If there is oil or some other contaminant in the joint, flux may not penetrate the joint clearing. The flux is formulated to melt and flow into the joint at a lower temperature than the braze filler metal. Once the flux has pulled into the joint and reduced the oxides present, the braze alloy should follow. This sequence may not occur if significant contamination is present. Even if it penetrates into the joint, flux may not successfully remove the contamination. Flux is designed to remove light oxide layers and absorb oxygen during heating. It may push a contaminant out of the joint but will not “clean it up.” The contaminant may stay in the joint and affect joint quality. In Fig. 2, it would seem the alloy did not go into the joint and some sort of contamination is present.

2) Too loose or too tight a joint can be a contributing factor. Molten silver brazing filler metal needs closely fitted surfaces for capillary attraction to occur. An optimal clearance for capillary attraction and maximum strength would be 0.0015 in. (0.038 mm). You can increase the joint clearing, but at some point, you lose capillarity. Too small a joint clearance can also eliminate capillary. Silver brazing filler metals need a sufficient joint clearance to flow. Keep in mind, we are talking about the joint clearance at brazing temperature. You should understand the base metal’s coefficients of thermal expansion and the coefficients of thermal conductivity for the material combination you are using. A good joint clearance at room temperature may be quite unacceptable at brazing temperature.

Incorrect heating can cause the braze alloy to not melt and flow properly. The braze alloy flows toward the hottest section of a joint. In the case of this joint, you want to heat the fitting in such a way to pull the molten braze filler metal into the joint. You want to make sure that the fixture and the induction coil are fixed in the proper position. These processes are usually very consistent, but varying the placement of the assembly in the coil can affect where the braze alloy flows.

3) Poor fluxing can cause this type of failure. You need to use the correct flux, in the correct consistency, in the correct amount, and put it on the parts consistently to ensure it is where it is needed and in the proper amount. Different braze operators mix the flux differently, and it will vary over the course of a day or a season due to temperature and humidity differences.

4) A loose-fitting braze ring or one that is placed on the part incorrectly can cause this. The braze ring needs to be tight to the tube and sitting in physical contact with the fitting. The induction coil should heat the tube and fitting, and the braze ring should melt via conduction. If the braze preform fits poorly, with the physical contact between it and the tube being loose, the preform can melt and just sit on top of the fitting without pulling into the joint.

You mentioned the parts looked okay visually on the outside of the joint. It is certainly possible flux residue was capable of holding the joint together or you had a small fillet. It is fortunate that you perform pressure testing. Sometimes these joints have enough integrity to pass a low-pressure leak test. Not out of the question at all. Fluxes are salts, and after melting, they dry to a glassy residue. It’s troubling because assemblies can get out the door and you get the failure in the field.

In the submitted photographs, it would appear there is evidence of a burnt substance in the fitting and against the tube in the joint area. Contamination would be a prime suspect.
in the search for the root cause of the failure on this assembly. Fabrication lubricants, rust preventatives, and similar materials need to be removed prior to brazing. A review of procedures and methods should be performed.

Even though contamination is suspected, I would still expect to see some braze filler metal flow into the joint. Operators need to understand the importance of how a braze ring should fit on an assembly. Because the braze filler metal puddled on top of the joint after melting, I suspect it may never have been in good contact with the tube when the preform melted.

A thorough review of part tolerances, equipment, and process procedures should be undertaken to look for unacceptable sources of variation. We always preach these six steps for successful brazing:

1) Good fit and proper clearance,
2) Prebrazing cleaning,
3) Assembly and fixturing,
4) Proper fluxing,
5) Heating the assembly, and
6) Postbrazing cleaning.

I grew up watching Vince Lombardi’s Green Bay Packers. I remember him talking about blocking and tackling and that all you needed to do was to perform these better than your opponent. Just like in football, in brazing, you need to pay attention to the fundamentals. They are the six steps listed above. Throughout my career, I believe it is fair to say that, when there is a brazing problem, you can trace the root cause to a lack of attention to one of these steps.

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