Q: Our company is planning to produce a product requiring electrical contacts to be brazed. We have experience in welding and mechanically joining contacts to their base metal holders, but some applications require a braze. Our volume is not large enough to use a furnace, so we are considering resistance brazing. The material of the holder is produced from C102 copper and the contacts are made from a silver-based material containing tin oxide. We’d like to braze at as high a temperature as possible, but we have seen a good deal of melting in our initial tests. What can you recommend?

A: As I am sure you know, these types of joints are produced in the millions of pieces. High volume would normally be done in a furnace or with an automated resistance brazing process, but you indicate the volumes are low. Manual resistance brazing is a common approach, so I will assume this is the direction you will be taking. You indicated having experience alongside welding contacts with resistance welding equipment. Typically, the same power supplies and cabling can be used for resistance brazing.

Prior to addressing the selection of a filler metal, refer to Fig. 1 for a schematic of the resistance brazing process. It shows a braze joint being compressed by a force exerted by electrodes placed on both sides of the joint. The electrodes and materials being joined, including the braze alloy that is preplaced in the joint, form an electric circuit. The heat for brazing is generated by resistance to the current flowing through the assembly. This heat can be developed in the electrodes, the components being joined, or both — Fig. 1.

The biggest difference from welding is that the ultimate temperature attained is less for a brazed joint. There is no melting involved, no weld nugget being formed. The electrical current and clamping pressure are usually lower than for resistance welding, and the cycle time is usually longer. While still a localized form of heating, a more general heating is used rather than the intense, higher power needed for a weld. These are adjustments in process parameters from what your welding operators are used to.

In selecting electrodes to use in the application you are considering, the primary criteria is the electrical conductivity of the materials you are joining. There are other factors such as the post-brazing surface condition of the contacts, as I am sure surface condition is important in this application, but conductivity is key. When brazing high-conductivity materials such as the ones discussed here, the electrodes will need to be of a low conductivity. The majority of the heat for brazing will be generated in these electrodes, due to their high resistance, and the heat will be transferred to the joint via conduction. This is important in understanding the heat quantity and distribution necessary to make a proper selection of braze filler metal.

There will be a temperature gradient across the electrodes and components being brazed. Under the premise that you will use a high-resistance electrode, where the heat is generated in the electrode, the electrode base metal interface will be at a higher temperature than the filler metal located in the center of the braze joint. This difference may be mitigated by slowing the heating time. The difficulty is that you use resistance brazing because it is fast and localized. Slower heating rates reduce productivity and allow conduction and convection to draw heat from the joint. This definitely works against you. If you keep the heating rate more rapid, it facilitates the brazing but will cause the outside of the joint to be hotter than the interior. The extent of this will depend on factors such as the thickness of components, but be aware there will be a gradient.

When selecting a brazing filler metal, you start with its compatibility with the base metal materials and its suitability for the service conditions.

### Table 1 — Composition and Thermal Properties of Brazing Filler Metals Suitable for Resistance Brazing

<table>
<thead>
<tr>
<th>AWS Classification</th>
<th>Chemical Composition (wt-%)</th>
<th>Liquidus</th>
<th>Solidus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ag</td>
<td>Cu</td>
<td>Zn</td>
</tr>
<tr>
<td>BAg-7</td>
<td>56</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td>BAg-8</td>
<td>72</td>
<td>28</td>
<td>—</td>
</tr>
<tr>
<td>BAg-18</td>
<td>60</td>
<td>30</td>
<td>28</td>
</tr>
<tr>
<td>BAg-24</td>
<td>50</td>
<td>20</td>
<td>28</td>
</tr>
<tr>
<td>BAg-28</td>
<td>40</td>
<td>30</td>
<td>28</td>
</tr>
<tr>
<td>BAg-34</td>
<td>38</td>
<td>32</td>
<td>28</td>
</tr>
<tr>
<td>BCuP-1</td>
<td>—</td>
<td>95</td>
<td>—</td>
</tr>
<tr>
<td>BCuP-2</td>
<td>—</td>
<td>92.75</td>
<td>—</td>
</tr>
<tr>
<td>BCuP-5</td>
<td>15</td>
<td>80</td>
<td>—</td>
</tr>
</tbody>
</table>

minimize heat effects and oxidation, as well as use as little power as necessary, you try to select a brazing filler metal with as low a melting temperature as possible. You mentioned wanting to use as high a brazing filler metal melting point as possible. You need enough heat to melt the brazing filler metal but not cause any melting of the base metals. In this case, the copper- and silver-based contact alloy are relatively low-melting point materials so, because of the temperature gradient across the joint, you necessarily will need to use a low-melting brazing filler metal.

Table 1 shows a chart with common brazing filler metals used in resistance brazing.

Another consideration is that the brazing filler metal needs to be placed in the joint during assembly of the components and be in place when electrode pressure is applied. It becomes part of the electrical circuit that generates the heat for brazing. This necessitates that the brazing filler metal selected be available in a form that can be preplaced. These are called preforms.

You will notice the chart does not include any brazing filler metals containing cadmium. These were once the mainstay of low-temperature silver brazing. While some are still available, cadmium is now considered a hazardous material and finding them in forms usable in resistance brazing is hit or miss. They are not included here because they are considered hazardous. On a practical level, they are more difficult to source, they carry a cost premium for a variety of reasons, you need to take special safety precautions when using them, and the liability is not worth it should someone develop health issues.

Therefore, you are most likely constrained to using one of the brazing filler metals listed in this chart. It is not all inclusive of every conceivable choice, but represents the most commonly used brazing filler metals and the most available. If you want to use a foil preform, common in resistance brazed lap joints, you will want to stay with one of these. Not all brazing filler metals are readily available in a foil form. Please note the inclusion of BCuP designations. These are used on copper to copper joints without flux. The BAg series brazing filler metals shown will all require the use of flux.

There are a couple of take aways from the discussion. While resistance brazing can use the welding equipment you currently employ, adjustments will be needed from the process for making a weld. Additionally, you will want to use the lowest temperature brazing filler metal that will satisfy your application requirement.

This column is written sequentially by TIM P. HIRTHE, ALEXANDER E. SHAPIRO, and DAN KAY. Hirthe and Shapiro are members of and Kay is an advisor to the C3 Committee on Brazing and Soldering. All three have contributed to the 5th edition of AWS Brazing Handbook.

Hirthe (timhirthe@aol.com) currently serves as a BSMC vice chair and owns his own consulting business.

Shapiro (ashapiro@titanium-brazing.com) is brazing products manager at Titanium Brazin Inc., Columbus, Ohio.

Kay (dan.kay@kaybrazing.com), with 45 years of experience in the industry, operates his own brazing training and consulting business.

Readers are requested to post their questions for use in this column on the Brazing Forum section of the BSMC website, brazingandsoldering.com.

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