MATERION

TECH BRIEFS

# Resistance Welding Copper Beryllium

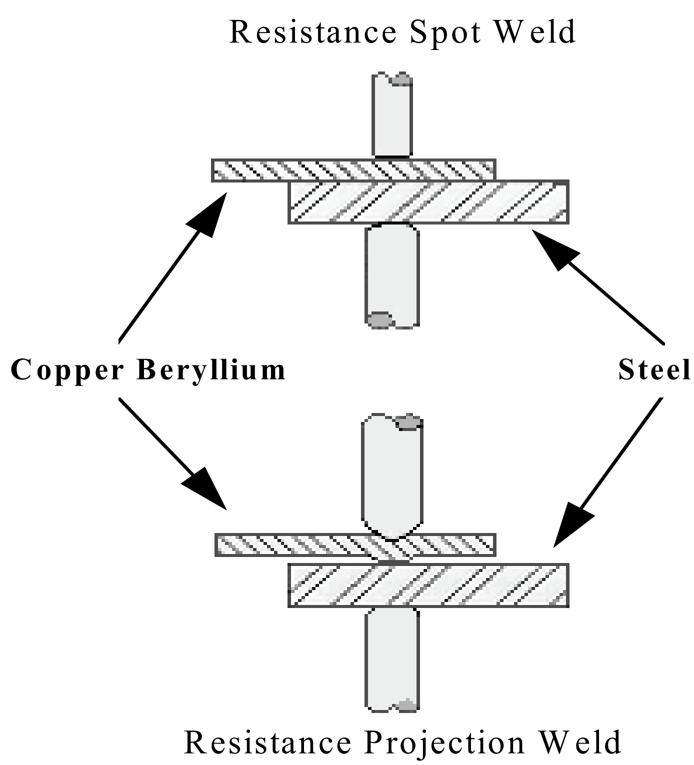
Electric resistance welding (RW) is a reliable, low cost, efficient method of permanently joining two or more thin pieces of metal. Although RW is a true welding process, no filler metal or protective gases are required. There is no excess metal to remove after welding. The process is suited to high volume production. The welds are strong and almost invisible.

Historically, RW has been used effectively in joining high resistivity metals such as steels and nickel alloys. The higher electrical and thermal conductivity's of copper alloys makes their welding more challenging, but conventional welding equipment usually has the capability to provide high integrity welds in these alloys. Copper beryllium can be welded to itself, to other copper alloys, and to steels using appropriate RW techniques. Copper alloys less than 0.04 inch thick are generally easier to weld.

The RW processes that are commonly applied to copper beryllium components are spot and projection welding. The work piece thickness, alloys, available equipment, and desired surface finish determine which process is best suited for each application. Other common RW techniques, such as flash, butt, and seam welding, are not typically used with copper alloys and will not be discussed.

The key variables in the RW process are current, pressure, and time. Electrode design and electrode material choice are also important in assuring weld quality. Since the procedures for RW of steels are well documented, the requirements for welding copper beryllium will use equal thickness as reference. RW is hardly an exact science, and the welding equipment and procedures exert significant influence on the weld quality. Therefore, only guidelines will be presented here. A series of test welds can establish optimum welding conditions for each application.

The work pieces should have nominally clean surfaces because most surface contaminants have high resistivity. Contaminated surfaces increase the electrode operating temperature, decrease the tip life, cause objectionable surface appearance, may lead to metal expulsion from the weld zone, and may cause voids or slag entrainment in the weld. A very thin coating of oil or corrosion inhibitor such as benzotriazole (BTA), will usually not present a problem in RW. Depending on the thickness, plated copper beryllium (silver, gold, copper, nickel, or tin/lead) can be welded with minimal problems.




Copper beryllium with excess oil or stamping lubricant can be solvent cleaned. If the surface is heavily tarnished or oxidized from heat treatment, acid cleaning will remove the oxide. Unlike the highly visible red brown copper oxides, transparent beryllium oxide (from inert or reducing gas heat treatment) on the strip surface is difficult to detect, but it must also be removed before welding. Contact Materion

**Materion Brush Performance Alloys**
6070 Parkland Boulevard
Mayfield Heights, OH 4414 USA
phone: 216.486.4200 fax: 216.383.4005
e: BrushAlloys-Info@Materion.com

**TECHNICAL INQUIRIES**
ph: 800.375.4205

**MATERION CORPORATION**
www.materion.com

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Brush Performance Alloys for a Cleaning Copper beryllium TechBrief.

## COPPER BERYLLIUM ALLOYS

There are two classes of copper beryllium alloys. The high strength copper beryllium alloys (Alloys 165, 25, 190, and 290), which have the highest strength of any copper alloy, are widely used in electronic connectors, switches, and springs. These high strength alloys have electrical and thermal conductivity's that are about 20% of pure copper. The high conductivity copper beryllium alloys (Alloys 3, 10, 174, BrushForm® 47, Brush 60®, 390® and 390E) have about 50% of copper's conductivity at a lower strength level, and are used in power connectors and relays. The high strength copper beryllium alloys are easier to RW because of their lower conductivity (or higher resistivity).

Copper beryllium alloys are heat treated to achieve their high strength. Both classes of copper beryllium alloys are available in tempers that are either pre heat treated (mill hardened) or require heat treatment by the customer after forming the part.

Resistance welding should be performed after heat treatment. In RW of copper beryllium, the heat affected zone is usually small, and a post weld thermal cycle is not required on welded copper beryllium parts. Alloy M25 (C17300), a free machining copper beryllium rod product, is not suited for RW because of the alloy's lead content.

## RESISTANCE SPOT WELDING

Copper beryllium has lower resistivity, higher thermal conductivity and higher thermal expansion compared to steel. It generally has equivalent or higher strength than steel. In resistance spot welding (RSW) copper beryllium to itself or other alloys, a higher welding current (150%), less pressure (75%), and shorter weld time (50%) are used (the values in parentheses are starting approximations compared to welding the same thickness of steel strip). Copper beryllium can tolerate higher welding pressures than other copper alloys, but problems can result from too low pressure.

To achieve consistent results in copper alloys, welding equipment must have precise time and current controls. AC welding equipment is preferred because of lower electrode temperature and cost. A weld time of 4 8 cycles provides good results. Upslope and post weld current will control the metal's expansion to limit the potential for weld cracking when welding dissimilar expansion coefficient metals. For welding copper beryllium to other copper alloys, upslope and post weld current are not necessary. If used, the upslope and post weld times depend on the work piece thickness.

In RSW copper beryllium to steel or other alloys of higher resistivity, a better thermal balance can be obtained by using an electrode with smaller contact area on the copper beryllium side. The electrode material against the copper beryllium should have greater conductivity than the work piece; an RWMA class 2 electrode is effective. Since refractory metal electrodes (tungsten and molybdenum) have much higher melting points and tend not to adhere to copper beryllium, class 13 and 14 electrodes are also used. The advantage of the refractory metal electrodes is longer service life. However, they may mar the surface because of their hardness. Water cooling the electrode will aid in control of the tip temperature and prolong electrode life. However, when welding very thin sections of copper beryllium, a water-cooled electrode may lead to chilling the metal.

If the thickness difference between copper beryllium and a higher resistivity alloy is greater than about five, projection welding should be used because of difficulties in obtaining a workable heat balance.

## RESISTANCE PROJECTION WELDING

Many of the problems in RSW copper beryllium can be reduced by utilizing resistance projection welding (RPW). A projection is useful if one of the parts is either much more conductive than the other (projection on the more conductive part) or if one of the materials is thicker than the other. Multiple welds are possible with smaller heat affected zones. In RPW, there is a wider selection of electrodes and electrode shapes available to reduce distortion and stacking. Electrode conductivity is less of an issue than in RSW. Class 2, 3, or 4 electrodes are typically used; harder electrodes lengthening life. The electrode diameter on the projection side should be at least three times the size of the projection diameter.

While softer copper alloys are not processed by RPW, copper beryllium has sufficient strength to prevent premature projection collapse and provide a high integrity weld. Copper beryllium can be projection welded in thicknesses as low as 0.010 inch. As with RSW, AC equipment is commonly used.

In welding dissimilar metals, the projections are located in the higher conductivity alloy. Copper beryllium has sufficient ductility to allow coining or embossing of almost any shape, including very sharp projections. Forming the projections in copper beryllium should be done before the parts are heat treated to prevent cracking of the projection.

As with RSW, the RPW process for copper beryllium typically requires higher current levels. The current must be applied at a rate sufficient to cause rapid heating at the projection tip. However, it is important to ensure that the weld head is able to follow-through with the projection collapse, i.e., the electrodes should be able to maintain the welding force throughout the weld cycle. Inability to do so may cause arcing at the weld interface. The welding pressure and time are adjusted to control collapse of the projection, and are thus dependent upon the projection geometry. Pressure ramping before and after the weld cycle reduces weld defects.

## SAFE HANDLING OF COPPER BERYLLIUM

Copper beryllium resistance welding operations, when properly controlled, present no special hazard because the weld pool is relatively small, and is not exposed. Mechanical cleaning operations, if required after welding, must be done in a manner to prevent worker exposure to fine particles. Please refer to the Materion Corporation publications "Safety Facts 1 - Safety Practices for Welding Copper Beryllium", and "Safety Facts 105 - Processing Copper Beryllium Alloys."

Handling copper beryllium in solid form poses no special health risk. Like many industrial materials, beryllium-containing materials may pose a health risk if recommended safe handling practices are not followed. Inhalation of airborne beryllium may cause a serious lung disorder in susceptible individuals. The Occupational Safety and Health Administration (OSHA) has set mandatory limits on occupational respiratory exposures. Read and follow the guidance in the Material Safety Data Sheet (MSDS) before working with this material. For additional information on safe handling practices or technical data on copper beryllium, contact Materion Brush Performance Alloys, Technical Service Department at 1-800-375-4205.

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**Materion Brush Performance Alloys**
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Mayfield Heights, OH 4414 USA
phone: 216.486.4200 fax: 216.383.4005
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