Application Note

Guidelines for Termination of Amperium® Wire

Amperium wire contains a yttrium-barium-copper-oxide (YBCO) ceramic thick film deposited on an oxide-buffered Ni-W alloy substrate. The YBCO film is coated with silver and laminated on both sides with a metal strip stabilizer (copper, brass, or stainless steel) utilizing solder that has a 179 °C melting point. Figure 1 illustrates the basic structure. While the stabilizer provides some physical protection for the YBCO ceramic, Amperium wire can still be damaged if improperly handled or subjected to conditions beyond the recommendations provided here.

Amperium Wire Composition

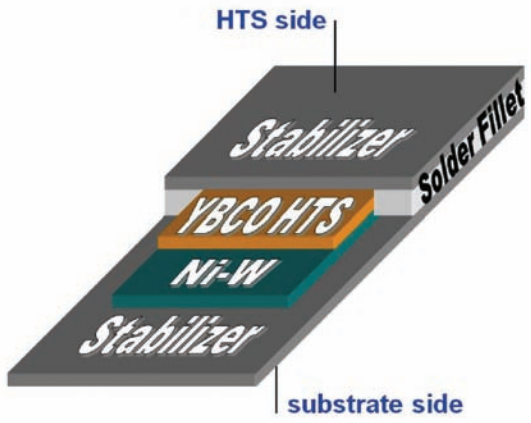

Figure 1. Structure of Amperium Wire

Amperium Wire

Helpful information is easily identified on Amperium wire including incremented markings, lot and part numbers.

Handling Amperium Wire

To avoid damaging the wire

- Do not rest heavy objects on the wire.
- Do not pinch, hammer, puncture, scrape, or abrade the surface.
- Avoid sharp bends – this will permanently damage the wire. Straightening severely bent wire back to its original shape will not undo the damage. The recommended minimum bend diameters for each Amperium® wire type can be found in the wire data sheets.
- Do not immerse the wire in solder flux or other liquids.
- Do not use uncontrolled heat sources such heat guns or open flames and do not use solder guns with a high tip temperature (see temperature guidelines below).
- Soldered connections should be made directly to the laminated metal stabilizer; do not attempt to remove any portion of the metal stabilizer.

Storage:	Store in a dry environment – keep away from humidity and water

Winding Diameter:	Minimum bending diameter is specific to each wire type. Please consult the wire Data Sheets at: http://www.amsc.com/library
Winding Tension:	Maximum winding tension is specific to each wire type. Please consult the wire Data Sheets at: http://www.amsc.com/library

Soldering to Amperium Wire

General Guidelines for Soldering

- The surface to be soldered must be smooth, clean, and free from any contamination.
- A noncorrosive solder flux (see recommendations in Table 1 below) must be applied prior to soldering. Do not immerse the wire in flux – use a brush or pen applicator.
- A low temperature solder with a melting temperature of less than 175 °C should be used. See Table 2 for two recommended solders.
- The HTS wire must be heated to the recommended temperature in a well-controlled manner. To safeguard against possible delamination of the wire structure, Amperium wire should not be exposed to temperatures exceeding the recommendations listed in Table 3. Always use the shortest times and lowest temperatures possible. In no case should the wire be exposed to temperatures exceeding 175 °C (347 °F).
- Gently contact the wire with the soldering iron until solder flows on the wire surface. Do not apply excessive pressure on the wire with the soldering iron tip.
- After assembly, clean the solder joint to remove any excess solder or flux residue.

Flux	Activation	Comments
Alpha 260HF Cookson Electronics www.alphametals.com	Organic acid	Halide-free, water based, water soluble
135 Kester,Inc. www.kester.com	Non-activated rosin	Solvent-based

Table 1. Recommended solder fluxes

Solder/Mfr	Description	Composition	Melt Point	Recommended Tip Temperature
Indalloy 1E Indium Corp. of America www.indium.com	Lower temperature, higher strength	52%In-48%Sn Eutectic	118° C (244° F)	135° C – 140° C (275° F – 284° F)
Indalloy 4 Indium Corp. of America www.indium.com	Higher temperature, lower strength	100% In	157° C (315° F)	170° C – 175° C (338° F – 347° F)

Table 2. Recommended solders for terminating Amperium wire

Temperature Range	Maximum Time
165 °C – 175 °C (329 °F – 347 °F)	3 minutes
155 °C – 165 °C (311 °F – 329 °F)	20 minutes
145 °C – 155 °C (293 °F – 311 °F)	60 minutes

Table 3. Time and temperature guidelines for soldering to Amperium wire

Attaching Current Leads to Amperium Wire

The electrical resistance of solder connections to Amperium wire depends on several factors including solder type, surface cleanliness, contact uniformity, and joint length. But the most important factor affecting joint resistance is the side of the wire used for contact. The construction of Amperium wire is asymmetrical and the side closest to the YBCO layer provides the lowest resistance path to the superconducting layer. Contacts made to the opposite side will have higher resistance due to the nickel-tungsten substrate. The two sides are easily identifiable.

For the lowest resistance terminations, it is recommended that all electrical connections be made to the HTS side of the tape. If joint resistance is not critical, electrical connections can be made to either side.

The recommended configuration for attaching current leads to Amperium wire is shown in Figure 3. For illustrative purposes it is assumed that the current lead is a metal strip of approximately the same thickness and width as the HTS wire. However, the methods described in this Service Note are also applicable to other current lead geometries.

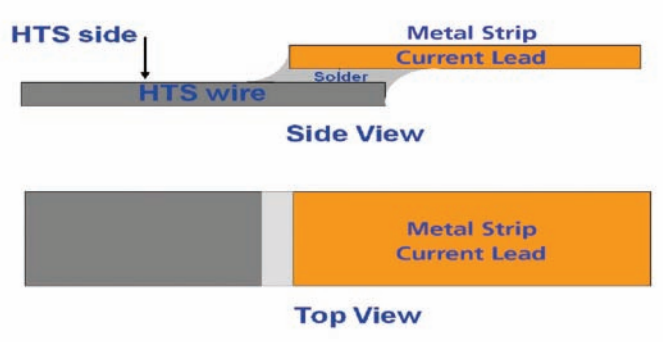

Figure 3. HTS wire – metal strip current lead connection

Detailed Instructions for Soldering Leads to Amperium Wire

Tools/Materials Required

- Suitable solvent for cleaning (methanol, ethanol, etc.)
- Lint-free cloth or tissue wipes
- Noncorrosive flux (Table 1)
- Low temperature solder (Table 2)
- Diagonal wire cutters (e.g., Knipex, Model 7491250 or Excelta, Model 7142E)
- Temperature-controlled soldering iron with chisel tip (e.g., Weller, Model WD1M / WP80)
- Solder tip thermometer (e.g., American Hakko Products, Model FG-100)
- A small wooden dowel or "orange stick" to apply pressure on the joint during assembly
- A heat tolerant (low thermal conductance) work surface, such as a G-10 phenolic sheet
- A straight edge, such as a 30 cm long steel rule, to assist with alignment

Step-by-Step Instructions for Current Lead Attachment

1. Wire Cutting

a. Cut clean, straight ends on the HTS wire and the current lead material using a recommended tool. All edges should be free from burrs or sharp protrusions. Figure 4 shows an example of how the cuts should look.

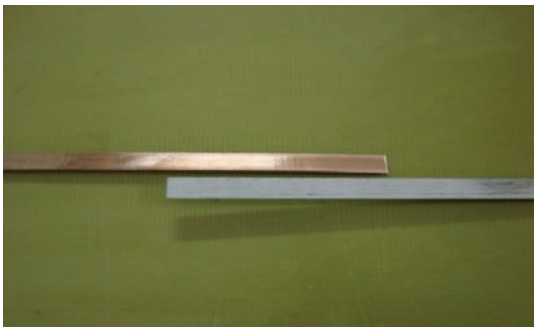

Figure 4. Cut HTS wire and copper lead ready for soldering

2. Wire/Lead Preparation

a. Turn on the soldering station and set the iron to the appropriate temperature. Once the iron is fully warmed up, check the tip temperature using an external tip thermometer. Confirm that the tip temperature does not exceed 175 °C.

b. Wipe all surfaces to be soldered with solvent

c. Apply flux to the side of the wire to be soldered

d. Tin the fluxed portion of the wire with a thin coating of solder covering 3-4 cm near the end of the wire, moving the solder tip from the inside towards the end of the wire as shown in Figure 5. Holding the wire in free air while applying heat with the soldering iron will minimize heat transfer to external surfaces and help the solder to flow more easily.

(a)

(b)

Figure 5. Tinning the wire end. Start with the iron away from the wire end (a) and work the solder layer towards the end (b) to produce a smooth, even coating.

e. After the wire has cooled, use the wire cutters to cut about 1cm off the tinned wire. This will eliminate any excess solder bump that might be near the end.

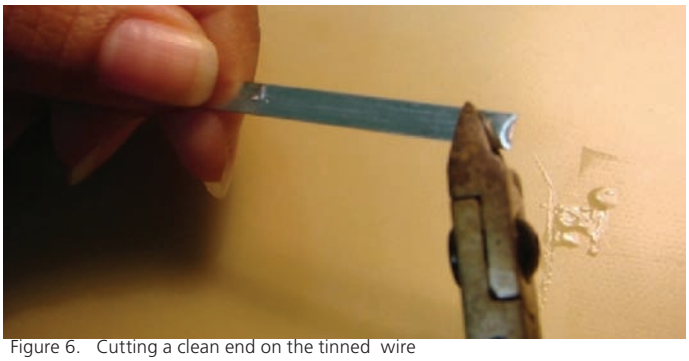

Figure 6. Cutting a clean end on the tinned wire

f. Repeat steps b) through e) for the metal current lead

3. Soldered Joint Assembly

a. Once both surfaces are tinned, cleaned, and ready for assembly (see Figure 7), apply flux to each of the surfaces to be joined

Figure 7. Tinned and cleaned HTS wire and metal current lead

b. Position the HTS wire and metal lead together with the desired overlap and tinned surfaces facing each other. Apply a thin coating of flux on the outer surface of the metal lead as shown in Figure 8. This will improve heat transfer from the soldering iron tip.

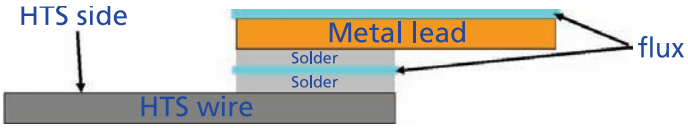

Figure 8. Positioning of HTS wire and current lead for assembly

c. Ensure good axial alignment of the metal lead and Amperium wire by positioning the two pieces parallel to a straight edge (see Figure 9).

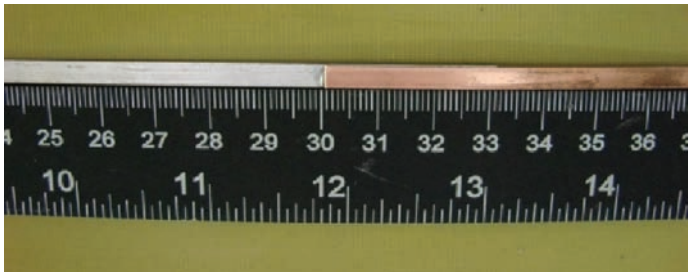

Figure 9. Aligned wire and metal lead prior to solder assembly

d. Apply a small amount of solder to the tip of the soldering iron. Then use the soldering iron to apply heat to the outer surface of the metal current lead until solder reflow occurs at the joint (Figure 10). Slowly move the solder iron over the joint to ensure good flow over its entire length. As the solder iron passes over the joint, maintain slight pressure on the joined wires with the wooden dowel.

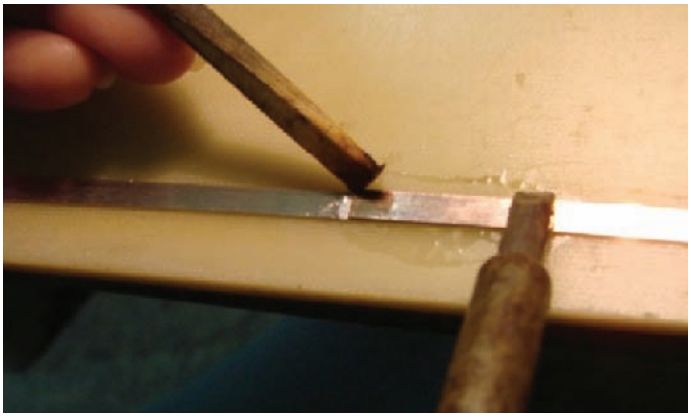

Figure 10. Soldering the wire and metal lead together

e. Remove the soldering iron and continue to apply slight pressure on the joint with the wooden dowel. Maintain pressure until the solder has solidified (Figure 11).

Figure 11. Maintaining pressure on joint as it cools.

f. If needed, the solder at the edges of the wire and the metal strip can be touched up with the soldering iron to fill in any small gaps or remove any bumps. Apply flux over the area to be touched up prior to applying heat.

4. Finishing/Rework

a. Remove any excess flux with solvent.

b. If excess solder must be removed gently, use an Xacto® knife or similar sharp instrument to gently trim the solder from the faces and/or edges. See Figure 12.

Figure 12. Gently removing excess solder with an Xacto knife

An example of a finished metal-HTS joint is shown in Figure 13. The joint should have a uniform solder layer over its entire length and be free from any sharp protrusions. A good joint will also have small solder fillets at the wire and metal strip ends. These fillets can significantly improve the mechanical performance of the joints.

Figure 13. Finished joint

Wire Splicing

Additional factors must be addressed when splicing two Amperium wires together. For detailed information on splicing wires, please refer to Application Note Guidelines for Hand-Assembled Splicing of Amperium® at www.amsc.com/library

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