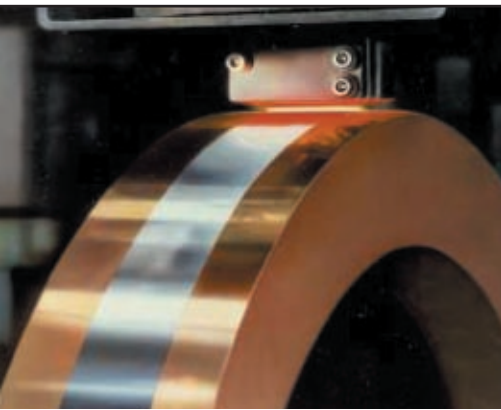


# EXECUTIVE *Report*

The alloy can be processed into a foil, powder, paste or slurry.

## Brazing Filler Materials Available through Global Network of Materials Vendors

Soldering and brazing involve the same bonding mechanism except that soldering is defined as using filler metals that melt below 450 °C (which equals 723 K or 840 °F) and brazing uses filler metals that melt at higher temperatures. The *CuproBraz* process uses anneal-resistant copper and brass materials along with a filler material that melts at about 600 °C.



A rapid solidification process can be used to fabricate CuproBraz filler alloy into thin ductile foils with thicknesses from 20 µm to 40 µm and widths from 20 mm to 100 mm. (Samples available from VAC.)

**T**he filler material is first processed into a powder or a thin foil. The powder can be processed into a variety of forms for efficient application to tubes, fins and header prior to brazing in a furnace. Several materials vendors globally are already making commercially available pastes and slurries specifically for the *CuproBraz* process. In addition, process engineers at the Brazing Center in Västerås, Sweden are continuing to develop and test new forms of filler materials and new methods of application, to make the *CuproBraz* process even more competitive.

This report briefly reviews the differences between soldering with brazing and describes the major types of filler materials presently available to heat exchanger manufacturers. Contact information is given for several major vendors of filler materials at the close of this report.

### Comparison of Brazing with Soldering

For decades, manufacturers avoided annealing effects in copper-brass radiators by using solders that melted well below annealing temperatures. These solders were used to bind copper fins to brass tubes and brass tubes to headers, which were the essential steps in the radiator assembly. A tremendous body of specialized manufacturing expertise and process knowledge, including many specialized machines and furnaces, developed around this industry. The basic process consists of melting, flowing and solidifying the solder at the joint, typically forming a metallic bond with the soldered surfaces (or parent metals).

In both soldering and brazing the bonding mechanism is a reaction between the filler metal and the parent metal or metals. Brazing and soldering generally result in alloying, i.e., a metallic-type bond forms at the interface. Typically, the filler metal flows into the joint gap by capillary force, solidifies and forms a bond.

Several factors affect the mechanical performance of the finished joint. For example, joint clearance, geometry and surface cleanliness are important. The relationship between the joint gap-width and capillary force accounts for filler metal distribution.

### Brazing Filler Metal Alloy

The brazing filler metal that was developed for joining *CuproBraz* fins and tubes belongs to the CuSnNiP-family. Called OKC600, this filler metal is composed of 4.2 weight-percent nickel (Ni), 15.6-wt.% tin (Sn) and 5.3-wt.% phosphorus (P) with the balance copper (approximately 75-wt.% Cu). This alloy has been patented (U.S. Patent Number 5,378,294) but is licensed free of charge to high quality powder manufacturers and the powder made by those manufacturers can be freely used for automotive and heavy-duty industrial heat exchanger applications. The melting temperature is 600 °C with a melting range of 10 °C.

### Powder, Foil or Paste

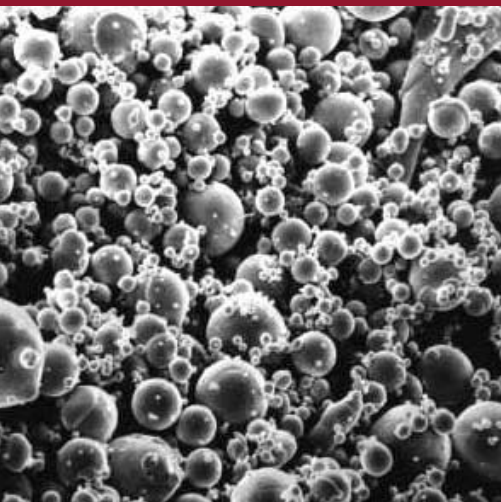
The OKC600 filler metal alloy is available as a powder, foil or paste. Cold forming of the filler metal is virtually impossible.

OKC600 powder is produced by gas atomizing the material into a spherically shaped, fine-grained powder. Atomization is normally performed using a protective gas such as nitrogen as atomizing media. The atomization parameters

## The International Copper Association, Ltd. (ICA)

is the leading organization for the promotion of the use of copper worldwide. The Association's twenty-nine members represent about 80 percent of the world's refined copper output, and its six associate members are among the world's largest copper and copper alloy fabricators. ICA is responsible for guiding policy, strategy and funding of international initiatives and promotional activities. With headquarters in New York City, ICA operates in 28 worldwide locations through a network of regional offices and copper development associations.

**For additional information about the CuproBraz process or ICA's CuproBraz consulting services, please contact the International Copper Association at [Alea@copper.org](mailto:Alea@copper.org).**



The OKC600 alloy can be atomized into a spherical powder, which has an average particle size from 15  $\mu\text{m}$  to 30  $\mu\text{m}$  and a melting temperature of 600 °C.

are set for a maximal particle size of about 90  $\mu\text{m}$  (i.e., 0.0035 inches or 3.5 mils).

Depending on the powder manufacturer, the average particle size is normally 15- to 30- $\mu\text{m}$  (i.e., 0.6 to 1.2 mils). In practice, each atomized lot is passed through a sieve to exclude particle sizes exceeding 90 microns. Some powder manufacturers reduce the powder to remove surface oxidation, and some manufacturers use other methods to stabilize the powder against oxidation. The powder must be protected against oxidation during manufacturing, transportation and storing. The product data sheets and storing instructions should be carefully followed. In case the powder oxidizes during transport or storage, reconditioning by reduction treatment might be possible by powder manufacturers. (Reduction is a reverse chemical reaction to oxidation.)

Thin brazing metal foil with thickness down to 20  $\mu\text{m}$  and composition close to OKC600 is also available for the CuproBraz process. In some cases, foil can be more practical than paste and should be considered complementary to the paste, depending on the process requirements.

Paste is a mixture of brazing powder and binder. The purpose of formulating a paste is to facilitate application of the powder to the parts to be brazed. Application can then be done by means of conventional commercial application methods. Binders can be water-based, solvent-based or thermoplastic.

### Economies of Scale

The cost of filler materials is an important consideration for manufacturers of heat exchangers. Eighty to 90 percent (weight percent) of the composition of paste consists of powder. The volume percentages are considerably smaller because of the higher density of the powder compared to the binder. In any case, because pastes have such a high powder content, prices for pastes should follow the powder prices. It

works out that the price per kilogram is roughly at the same level or slightly higher for paste compared to powder.

The economies of volume production have driven the price of powder down considerably since the CuproBraz process was first introduced several years ago. The price started at a level of about 40 U.S. dollars (USD) per kilogram for pilot scale production and dropped about 75 percent to its current level for limited mass production. Powder prices could drop another 50 percent as mass production volumes increase. Some companies already are offering powder at lower price levels for large volumes but have not yet produced the powder in large quantities.

### Conclusion

More than ten years ago the International Copper Association responded to the industry need for stronger radiator materials by initiating research that culminated in the discovery of CuproBraz technology, which is now being applied globally in the manufacture of advanced heat exchangers.

The Brazing Center in Västerås, Sweden was established to serve customers by demonstrating the process and by assisting in evaluating the technology through building prototypes and training heat-exchanger manufacturers. Metallurgists and process engineers can provide expert advice on the selection of brazing pastes and slurries for various applications.

The "CuproBraz Technical Manual" is an excellent resource for information on filler materials and their method of application. Also, many brazing material vendors have in-house experts on CuproBraz filler materials and they can offer valuable technical guidance on implementing a brazing process.

In summary, a global network of materials vendors is ready to deliver filler materials in volume for use in the production of CuproBraz heat exchangers. ■

### Filler Material Suppliers

See [www.cuprobraz.com](http://www.cuprobraz.com) for additional suppliers.

**OMG BrazeTec** ([www.brazetec.com](http://www.brazetec.com)); and

**OMG Americas** ([www.omgi.com](http://www.omgi.com))

OMG acquired BrazeTec and both now sell pastes, powders, slurries under the Cobrabond™ brand that previously was used by OMG. Contacts include Anil V. Nadkarni ([anil.nadkarni@omgi.com](mailto:anil.nadkarni@omgi.com)) +1 919 544 8090 Ext. 281 and Dr.-Ing. Hartmut Schmoor ([hartmut.schmoor@brazetec.de](mailto:hartmut.schmoor@brazetec.de)) + 49 6181 59-4503.

**Lucas-Milhaupt** ([www.lucas-milhaupt.com](http://www.lucas-milhaupt.com))

Lucas-Milhaupt is a member of the Handy & Harman Precious Metals Fabrication Group. Pastes and thin paints are sold under the Cupro-Flo™ brand. Contacts include Keith Perrin ([kperrin@handyharmanpmtfg.com](mailto:kperrin@handyharmanpmtfg.com)) +1 414 769 6000 Toll Free +1 800 558 3856

**VAC Vacuumschmelze** ([www.vacuumschmelze.com](http://www.vacuumschmelze.com))

VAC fabricates the OKC600 alloy into thin foils, which is a promising technology. Contacts include Dieter Nuetzel ([dieter.nuetzel@vacuumschmelze.com](mailto:dieter.nuetzel@vacuumschmelze.com)) +49 6181 38-3041

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