EXECUTIVE Report

New Copper-Brass Heat Exchangers Excel in Generator Set, Locomotive, Off-Road and Military Applications

End Users Favor CuproBraze Technology for Cooling Efficiency and Durability

A new wave of interest has materialized for *Cu*proBraze technology, especially for stationary generators, locomotives, off-road equipment and government and military systems. For these large heat exchangers, *Cu*proBraze faces off against at least three competitive core technologies:

- Soldered copper/brass plate fin
- Soldered copper/brass serpentine fin
- Brazed aluminum serpentine fin

Nonetheless, *Cu*proBraze technology is now the first choice for many of these applications. It represents a breakthrough technology that has been anticipated for a long time.

In this report, key design criteria are examined for the heat exchangers that are used in locomotives, stationary generators and off-road applications.

Competitive Advantages

The chief reason for the popularity of *Cu*proBraze technology is that it allows for the use of brazed serpentine-fins (often of the square-wave type) in brazed copper-brass heat exchanger designs. The latter have the following advantages over competitive designs:

- Less expensive to manufacture than soldered plate-fin designs
- More durable than soldered serpentine-fin designs (because of much stronger joints)
- Greater cooling efficiency and more rugged than brazed aluminum serpentine-fin designs (because thinner materials allow for more air to pass through)
- Square-wave type fins are not easily clogged and can be cleaned with pressurized water, allowing the thermal performance to be maintained during operation

Moreover, aluminum has durability issues at the higher temperatures and pressures that are necessary to meet more-stringent emissions requirements around the world.

In selecting heat exchangers for locomotive, generator sets and off-road applications, consideration should be given to cooling efficiency and durability, including corrosion, fatigue and elevated temperatures.

Maximizing Cooling Efficiency

The main performance criterion for heat exchangers is cooling efficiency, which describes the heat dispersion from a given space by a heat exchanger. Greater efficiency means the same heat can be dispersed with a smaller core, so it amounts to a size advantage.

Cooling efficiency is especially important in applications where the diesel engines are stationary, because the flow of cooling air is not provided by the vehicle velocity. Copper-brass cores can disperse more heat per unit volume than any other material system. However, efficiency is determined by not only the materials but also the design. The efficiency of typical large heat exchangers is influenced by the following factors:

- Thermal conductivity of fin materials
- Spacing, size, thickness and shape of fins
- Shape of tubes
- Velocity of the air passing through the core
- Various other design factors

A significant reduction in frontal area and volume is typical for a serpentine-fin design with flat tubes compared to a plate-fin design with round tubes. Experience so far shows that *Cu*proBraze technology with a serpentine-fin design delivers the maximum cooling efficiency in the smallest volume without compromising durability.

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 information about the *Cu*proBraze process or ICA's *Cu*proBraze consulting services, please contact the International Copper Association at: cuprobraze@copper.org.
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The Finnish Radiator Manufacturing Company (Finn Radiator) used Luvata's automotive wind tunnel in Sweden to evaluate the cooling efficiency of *Cu*proBraze heat exchanger designs. Its customers have certified these first-generation *Cu*proBraze radiators and charge air coolers for use in a wide range of off-road applications, including tractors, terminal tractors, piling rigs and special purpose machinery [1].

Similarly, Young Touchstone, a Wabtec Company (Jackson, Tennessee) has certified radiators for use in locomotives and power generation equipment. It supplies Kohler Power with *Cu*proBraze heat exchangers for power generators and supplies its sister company MotivePower, a Wabtec Company (Boise, Idaho) as well as other OEMs in the rail industry with *Cu*proBraze radiators for locomotives [1]. Siemens AG Transportation Systems (Erlangen, Germany) is also using *Cu*proBraze radiators for locomotive applications [1].

Quality of Endurance

A common denominator of locomotive and off-road applications is the harsh environments in which such heat exchangers must operate. Compared to other materials, brazed copper-brass provides stronger, tougher joints, allowing for more durable products.

Strong brazed joints and the reduction of galvanic corrosion at the joints makes *Cu*proBraze heat exchangers extremely rugged. Their excellent resistance to corrosion and fatigue adds up to a long service life in many applications.

Bombardier achieved superior performance at a lower initial cost using *Cu*proBraze for transformer oil coolers in electric locomotives. Designs based on round copper-alloy tubes with aluminum fins frequently had to be overhauled due to overheating, taking the locomotives out of service. The new *Cu*proBraze heat exchangers provide superior performance at a lower cost and are rugged enough for the harsh operating environments [2].

Another success involves the renowned Tunner aircraft loading system, which is now made by DRS Sustainment Systems (St. Louis, Missouri) for the USAF. The soldered radiators caused specific and recurring problems, which vanished once the system was replaced with a *Cu*proBraze design. The superior performance of *Cu*proBraze radiators in the harsh operating climates of this vital transport system operated by the government and military was the subject of an earlier report [3].

Fully assembled heat exchangers made from *Cu*proBraze alloys, soldered copper-brass and brazed aluminum heat exchangers were subjected to at least four different corrosion tests [4]:

- Road environment pollutant
- Salt spray
- Sea water acetic acid
- Marine air corrosion

Test results confirm that *Cu*proBraze resists corrosion much better than soldered copper-brass and is very competitive with brazed aluminum. Papers on the corrosion resistance of *Cu*proBraze are available from the SAE [4-6] and additional information can be found in the "*Cu*proBraze Brazing Handbook" [7].

Extensive laboratory testing also quantifies the superb resistance of *Cu*proBraze heat exchanger cores to fatigue cracking from room temperature up to 300 ºC [8-11].

The ability to withstand elevated temperatures is another crucial benefit. *Cu*proBraze – and *Cu*proBraze alone – is qualified for use at high temperatures. Aluminum heat exchangers simply cannot withstand high temperatures without a total breakdown in their mechanical properties. Aluminum alloys are "temperature challenged" above 200 ºC.

The Second Wave

Copper holds the advantage over aluminum in terms of heat dispersion per unit volume.

In terms of durability, *Cu*proBraze has proven itself in applications such as locomotives, generator sets and off-road equipment as well as in military environments.

Heat exchanger manufacturers are bracing themselves for a second wave of demand for *Cu*proBraze products. This new wave of popularity is due to superior durability and cooling efficiency in harsh environments. ■

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