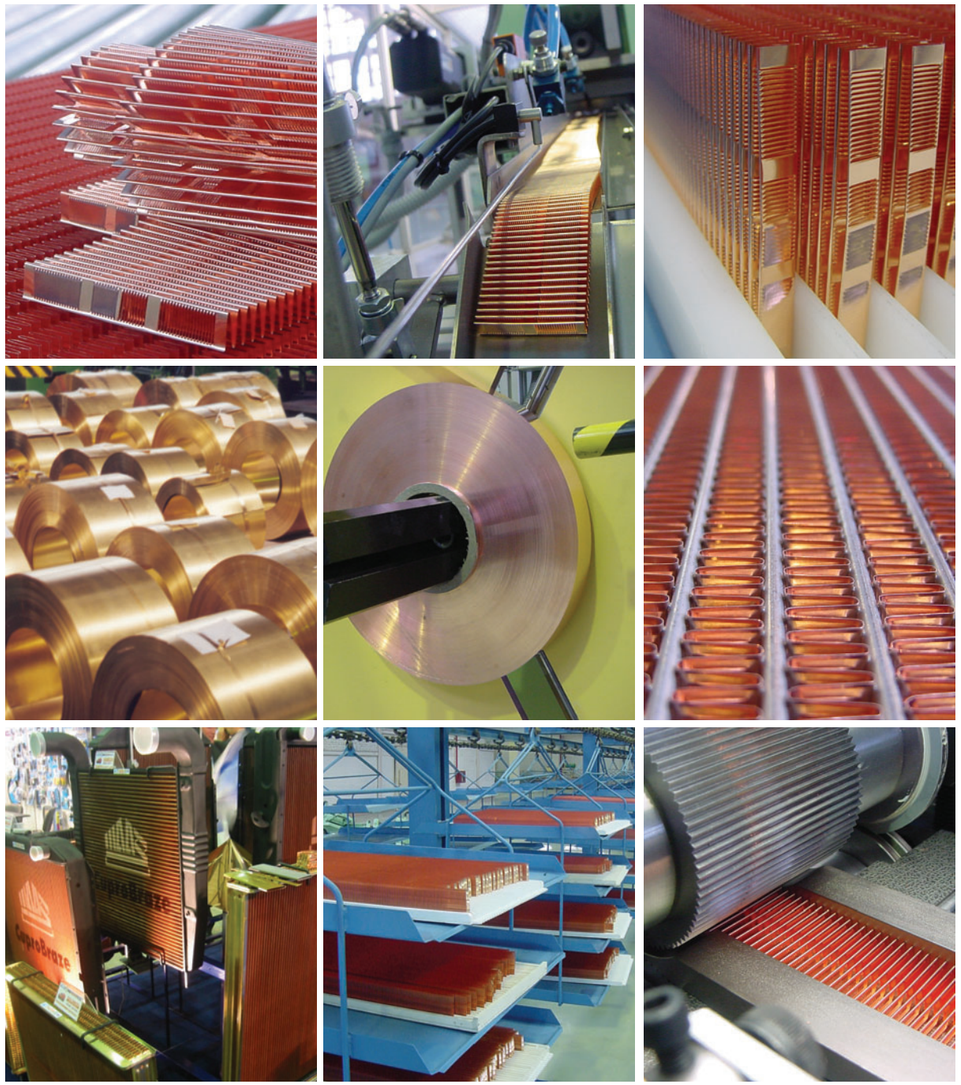
CuProBraze®

Advanced Heat-Exchanger Technology



International Copper Association, Ltd.
260 Madison Avenue, 16th Floor
New York, NY 10016-2401
Tel.: +1 212.251.7240
Fax: +1 212.251.7245

Performance advantages for *Cu*proBraze include size, efficiency and durability.

*Cu*proBraze® technology is well suited for these applications:

- Radiators
- Charge air coolers (CACs),
- Oil coolers,
- Climate control systems,
- And other heat transfer cores

in vehicles and equipment such as

- Heavy-duty (HD) highway trucks,
- Construction & agricultural equipment,
- Stationary power generators,
- Other off-road diesel engines,
- Light trucks & SUVs,
- And passenger cars.

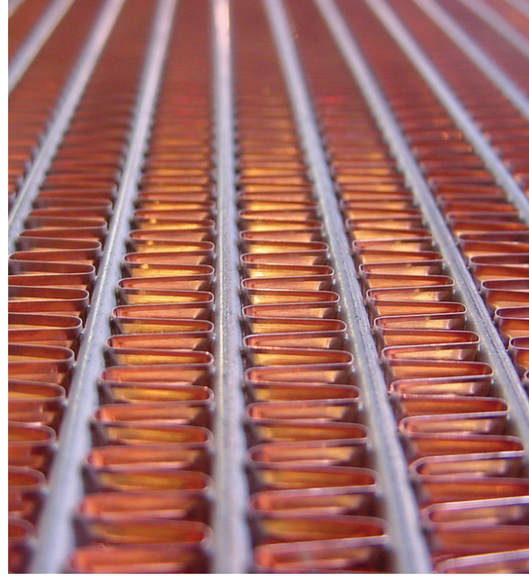
PERFORMANCE

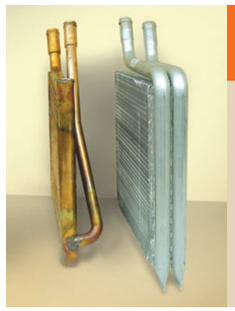
EFFICIENCY

Cores made from copper and brass can reject more heat per unit volume than any other material system. In other words, *Cu*proBraze offers a lot of cooling capacity in a small size. The overall thermal efficiency of a heat exchanger core depends on many factors such as

- Thermal conductivity of fins and tubes,
- Strength and weight of the fins and tubes,
- Spacing, size, thickness and shape of fins,
- Spacing, size, wall thickness and shape of tubes
- Velocity of the air passing through the core,
- And other factors.

Efficiency can be readily calculated and measured. Heat-transfer simulations and wind tunnel testing show that copper/brass cores hold the advantage.

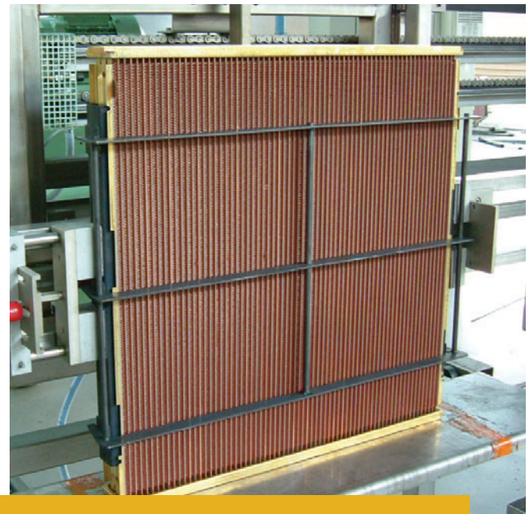




SIZE

The *Cu*proBraze advantage in efficiency is equivalent to a size advantage.

- The same heat rejection can be achieved with a smaller-sized core. A significant reduction in frontal area and volume is typical for *Cu*proBraze designs.
- More airflow can be directed to other heat exchangers in the same vehicle, e.g., for the radiator downstream from the charge air cooler in a heavy-duty truck.



*Cu*proBraze excels with respect to critical performance criteria such as size, efficiency and durability. It is the material of choice in practically every application calling for superior heat transfer in a compact space.

DURABILITY

Brazing of copper and brass in a furnace at temperatures of 650 °C results in the formation of a strong joint. Special anneal-resistant alloys ensure that the radiator cores retain their strength despite exposure to these high brazing temperatures. Compared to other materials, *Cu*proBraze provides stronger, tougher joints, allowing for more durable products.

Thanks to strong brazed joints and the reduction of galvanic corrosion at the joints, heat exchangers made by the *Cu*proBraze process are extremely rugged. Their excellent resistance to fatigue and corrosion adds up to a long service life in many applications.

Ongoing laboratory tests and field experience, over a number of years on variety of product designs, already demonstrate long service lives for *Cu*proBraze heat exchangers in real world applications.

*Cu*proBraze is clearly superior for applications that must withstand elevated temperatures without failure.

ELEVATED TEMPERATURES

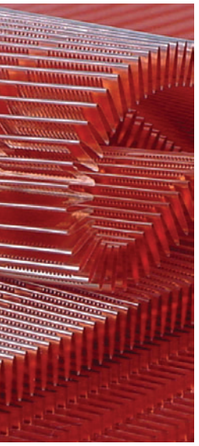
The ability to withstand elevated temperatures is a crucial benefit. *Cu*proBraze – and *Cu*proBraze alone – is qualified for use at high temperatures.

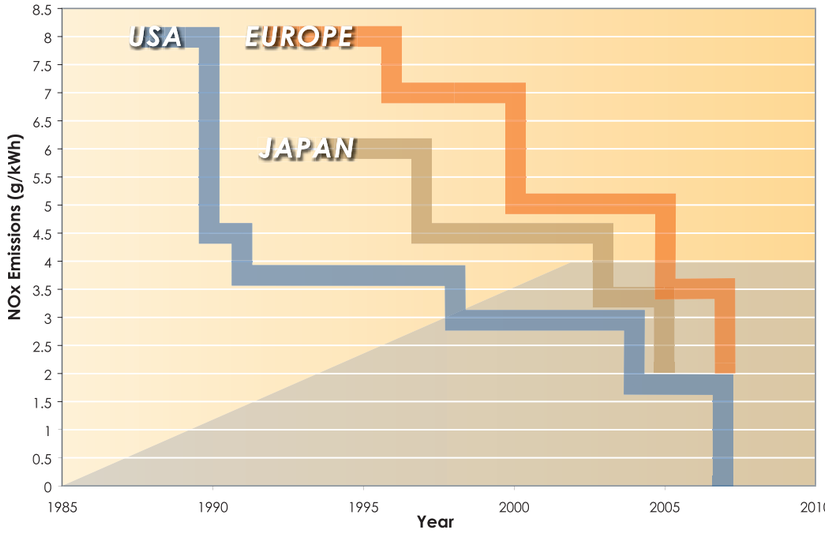
Aluminum heat exchangers simply cannot withstand high temperatures without a total breakdown in their mechanical properties. Aluminum alloys are "temperature challenged" above 200 °C. This inherent property of aluminum is a consequence of its low melting point.

The yield strength of aluminum is severely compromised above 200 °C, and it is meaningless to talk of the strength of aluminum above 250 °C. Problems with fatigue cracking are greatly exacerbated in aluminum at elevated temperatures.

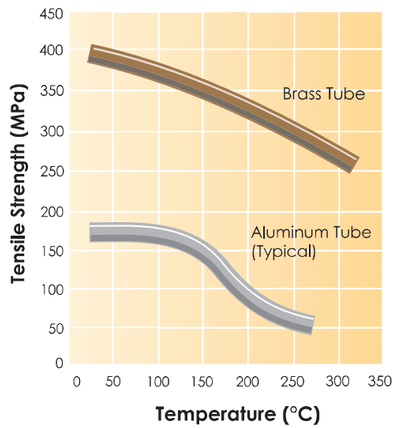
On the other hand, copper and brass heat exchangers can operate at temperatures well above 250 °C. Some cores can withstand temperatures of 290 °C and above, which are still well below the melting point of copper and brass.

SUPERIOR





Note: The heavy-duty truck emission levels represented here are only examples. Additional rules apply, including standards for particulate matter (PM), non-methane hydrocarbon (NMHC) and carbon monoxide (CO) emission levels. Refer to the original rules for details. More information can also be found at www.dieselnet.com/standards.html



CLEAN DIESEL ENGINES

New legislation in Europe, Japan and the United States aims at reducing emissions from diesel engines. (See Chart.) These new laws call for a dramatic reduction in the oxides of nitrogen released from heavy-duty (HD) over-the-highway truck engines as well as off-road diesel engines.

Diesel engine manufacturers must develop engine technologies such as exhaust-gas recirculation (EGR) to reduce the oxides of nitrogen (NOx) released from diesel engines. These solutions invariably result in significantly higher operating temperatures, since engine designs must cope with additional heat rejection from exhaust gas coolers, radiators and charge air coolers (CACs).

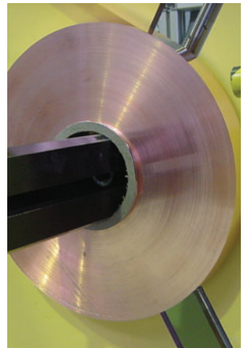
CACs must be highly efficient and durable in order to meet the stringent emissions regulations. Previously, most CACs were made of aluminum, but the tensile strength of aluminum declines rapidly at 150 °C and repetitive thermal cycling between 150 and 200 °C substantially weakens the product.

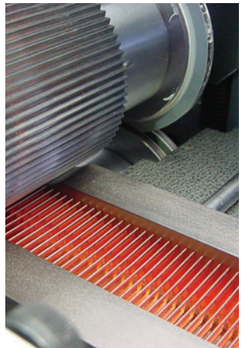
The average inlet temperature in current charge air coolers is 190 °C. To comply with the reduced emission standards, the industry expects the average inlet temperature to reach temperatures exceeding 240 °C. *Cu*proBraze CACs can handle these elevated operating temperatures.

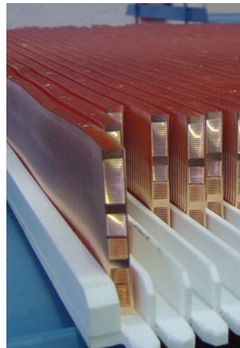
New *Cu*proBraze charge air coolers cope easily with higher temperatures and the greater strength of brass can withstand high pressure. Already many companies have switched to *Cu*proBraze charge air coolers, and high volume production of *Cu*proBraze CACs has begun.

Higher operating temperatures also place greater cooling requirements on the radiators of both on-road and off-road heavy-duty trucks. Many truck makers are switching to *Cu*proBraze from soldered copper-brass for this application.

New designs of diesel engines for SUV applications are increasing demand for compact, high-efficiency heat exchangers that can withstand high temperatures.







*Cu*proBraze is attractive in terms of total cost.

EIGHT WAYS TO SAVE WITH *CU*PROBRAZE

*Cu*proBraze technology has many advantages that impact the bottom line.

1. *Cu*proBraze can be automated. The use of semi-automated or automated assembly equipment can greatly reduce manufacturing costs compared to other labor-intensive manufacturing methods.

2. *Cu*proBraze is simple. Compact and able to withstand elevated temperatures and vibrations, a *Cu*proBraze core may allow for lighter mounting hardware and space-saving design layouts.

3. *Cu*proBraze is forgiving. Brazing temperatures can be ramped up faster. Because it takes less energy to heat copper than it does to heat aluminum, it takes less energy to braze each unit.

4. *Cu*proBraze allows for efficient economies of scale. Since the furnace and production line don't need to be dedicated to just one product, manufacturers can cater to the needs of the profitable niche and special orders markets.

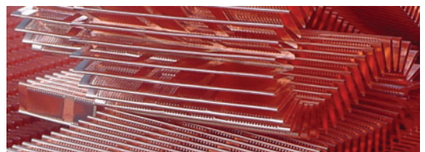
5. *Cu*proBraze is flexible. The continuous belt furnace allows for quick product changeovers — even at high throughput rates.

COST

6. *Cu*proBraze brazing is a fluxless process, eliminating the need for a separate rinse step to remove the flux from the brazed product. No rinsing operation means no expensive treatment of discharge water. Moreover, *Cu*proBraze does not use lead and other toxic chemicals in the manufacturing process.

7. *Cu*proBraze allows for one-shot brazing. The *Cu*proBraze process can make a complete heat exchanger in the brazing furnace, thus eliminating separate operations for attaching components such as inlet and outlet fittings.

8. *Cu*proBraze heat exchangers are repairable with lead-free solder in the plant or in the field. Less scrap, fewer returns and more uptime in the field add up to savings for the maufacturer and the end user.



SUSTAINABLE DEVELOPMENT

In today's world of regulations, forward-thinking manufacturers are taking the environment into account when they analyze costs.

The production of millions of heat exchangers per year significantly affects the allocation of natural resources on a global scale, yet the quality of life worldwide has been greatly improved by the use of off-road diesel engines, heavy-duty trucks and passenger cars.

Today, the concept of sustainable growth – that is, the improvement of conditions through the judicious use of natural resources – guides conservationists. Environmentally, the *Cu*proBraze process has important advantages over other technologies. No fluxing stage is needed for brazing, and the process is free of lead and other toxic chemicals. Also, *Cu*proBraze heat exchangers are repairable, which means less waste. Furthermore, copper and brass are virtually 100 percent recyclable.

Aluminum production uses more than twice as much electrical energy compared to copper production (i.e., 75 MWh per ton of aluminum versus 30 MWh per ton of copper). Carbon dioxide entering the atmosphere each year could be reduced by about one million tons by making heat exchangers from copper and brass instead of aluminum.

If all other criteria are equal then *Cu*proBraze should be chosen for the sake of the environment!

More about copper and the environment can be found at www.copperinfo.com.

IT'S COME A LONG WAY

*Cu*proBraze is already proven to be a cost-effective manufacturing technology. It has been successfully transferred to the factory floor for small volume, midsize and high-volume production.

A worldwide network of materials suppliers and equipment makers stands ready to guide you, whether you plan to build a high-volume *Cu*proBraze production facility or purchase *Cu*proBraze heat exchangers from another source. Participating companies are listed at www.cuprobraze.com.

The International Copper Association licenses *Cu*proBraze technology free of charge to manufacturers. Technical experts will transfer the technology to your production line anywhere in the world. Indeed, there are already many champions of the *Cu*proBraze process in the automotive industry, and the number continues to grow. You can tap into the experiences of manufacturers who have established *Cu*proBraze production facilities of various sizes. Many are willing to share their cost and operation experiences.