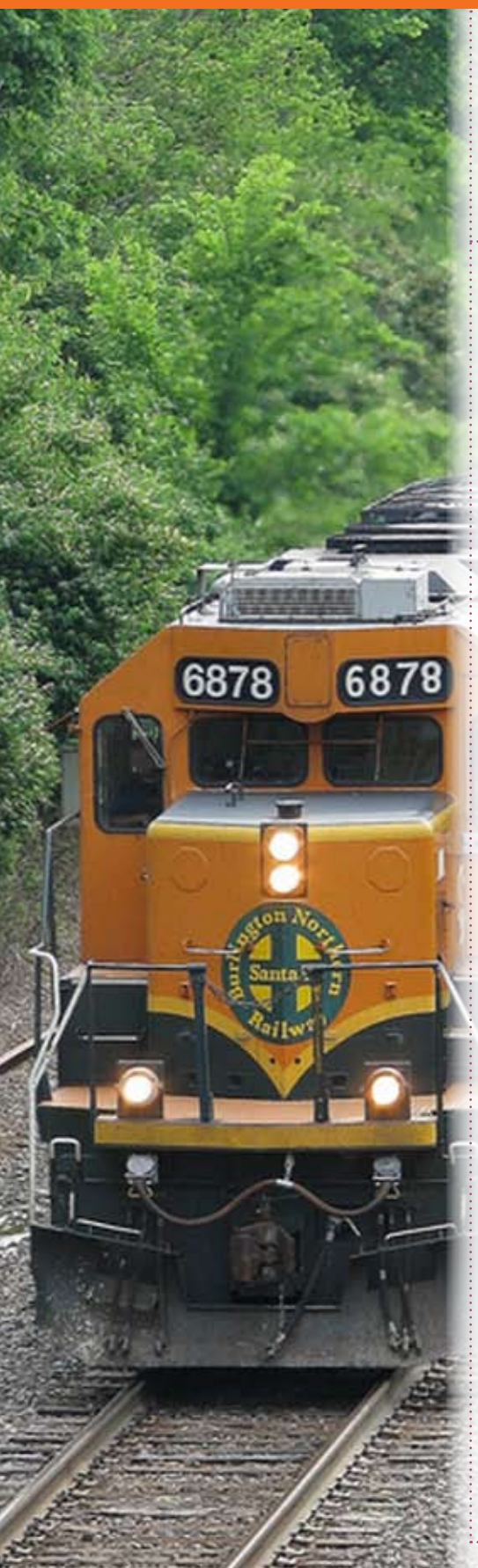
# EXECUTIVE Report




## CuproBraze Meets Success in Locomotives

***Serpentine Copper-Fins Brazed to Brass-Tubes Offer Superior Combination of Efficiency and Durability***

Railways enjoy a rich history and remain a major mode of transportation despite being overshadowed in the last century by trucking and airlines. Trains offer major advantages in energy efficiency for the transportation of passengers as well as freight.

*Cu*proBraze technology is uniquely suited for cooling systems in locomotives and has already demonstrated its success in diesel-engine and all-electric locomotive applications, both of which require large on-board cooling systems.

### Railways and the Environment

Recently, the International Union of Railways (UIC) and the Community of European Railway and Infrastructure Companies (CER) jointly published a 40-page brochure titled "Railways and the Environment: Building on the Railways' Environmental Strengths" [1]. In this 2009 report, railways are compared to other modes of transportation such as road, air and waterways. By all measures, rail is shown to be the most energy-efficient of these modes.

### Harsh Environment, Limited Space

*Cu*proBraze technology is already making a significant impact on railway operations around the world because heat exchangers built with this process provide excellent cooling efficiency and durability.

Locomotives historically have relied on heat exchangers made with copper plates and round brass tubes. Such plate-fin systems are extremely rugged and easy to clean. Yet serpentine fins, also known as corrugated fins, are much more efficient than plate fins for heat removal. There are other advantages to using corrugated fins rather than plate fins. It is less labor intensive to build a heat exchanger with corrugated fins instead of plate fins. Plate-fin heat exchangers are not designed for manufacturability. Inserting tubes through holes in plates is difficult and, ultimately, the finished product lacks the cooling efficiency of a corrugated-fin design. The use of corrugated fins also allows for the possibility of down-gauging the thickness of the fins. In other words, corrugated-fins can be thinner than plate-fins.

Corrugated fins are replacing conventional plate fins in locomotive applications. The rectangular or square wave fins (left) are preferred over the triangular fins (right) for use in harsh environments because they are easier to clean.

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

The International Copper Association, Ltd. (ICA) is the leading organization for promoting the use of copper worldwide. The Association's 38 member companies represent about 80 percent of the world's refined copper output. ICA's mission is to promote the use of copper by communicating the unique attributes that make this sustainable element an essential contributor to the formation of life, to advances in science and technology, and to a higher standard of living worldwide.

For information about the *Cu*proBraze process or ICA's *Cu*proBraze consulting services, please contact the International Copper Association at:
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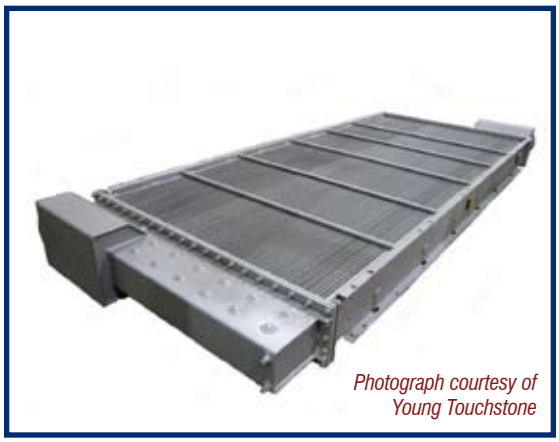
For European inquiries contact:
ndc@eurocopper.org.

## References


1. A 2009 report from the International Union of Railways (UIC) and the Community of European Railway and Infrastructure Companies (CER) www.uic.org/homepage/railways_and_the_environment09.pdf


*Cu*proBraze is ideally suited for diesel and electric locomotive applications. Bombardier overhauled 45 Class E Locomotives for South African Railways, installing *Cu*proBraze heat exchangers for cooling the transformer oil.



*Photograph courtesy of Young Touchstone*

*Cu*proBraze technology is rapidly being adopted for many types of locomotive heat-exchanger designs such as this charge-air cooler. The brass tubes and copper fins were brazed using CuproBraze technology and then painted gray.

When corrugated fins are used in locomotive radiators, rectangular (i.e., square wave) fins are recommended over ordinary triangular fins, because the latter are prone to clogging, which tends to limit fin density, also thereby limiting the thermal performance triangular fins. On the other hand, when square-wave fins are used, the spaces between the fins are large enough for easy maintenance. Rectangular (square-wave) corrugated fins are much easier to clean and so are an excellent choice for locomotive radiators. See figure for a comparison of these two types of corrugated fins.

Copper fins are recommended over aluminum fins because the copper fins are much harder and consequently are more resistant to sand erosion and impingement by stones. The stiffness and durability of the copper fins facilitates washing by pressurized water. *Cu*proBraze heat exchangers maintain their performance for especially long periods of time because the brazed joints between the copper fins and brass tubes are extremely strong.

In summary, *Cu*proBraze technology is a breakthrough for locomotive radiators because it provides the best combination of durability and performance that is available today. *Cu*proBraze radiators with rectangular corrugated fins deliver the level of reliability, cleanability and long service life that is essential in locomotive applications.

## Destiny of Railways

There are more than 1,370,000 kilometers of railways in the world. As national leaders recognize the importance of railways as an energy-efficient mode of transportation, investment in railway infrastructure will increase and railways will play an ever larger role in transportation.

Looking ahead at the not-too-distant future of transport, railroads will continue to play a vital role in transporting people and products in a sustainable manner. These future railroads may be powered by biodiesel from farms; clean electricity from wind, solar or geothermal; or another as yet undefined energy source.

Whether powered by biodiesel, the sun or the atom, *Cu*proBraze will be the technology of choice for the locomotive cooling systems. ■

| Country | Railways(km) |
|---|---|
| World | 1,370,782 |
| European Union | 236,436 |
| United States | 226,612 |
| Russia | 87,157 |
| China | 75,438 |
| India | 63,221 |
| Germany | 48,215 |
| Canada | 48,068 |
| Australia | 38,550 |
| Argentina | 31,902 |
| France | 29,370 |
| Brazil | 29,295 |
| Japan | 23,474 |
| Poland | 23,072 |
| Ukraine | 21,852 |
| South Africa | 20,872 |
| Italy | 19,460 |
| Mexico | 17,665 |
| United Kingdom | 16,567 |
| Spain | 14,974 |

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