

EXECUTIVE Report

Valtra Tractors Reap the Rewards of Advanced Heat Exchanger Technology

CuproBraze Radiators and Charge Air Coolers Installed in World Class Tractors

Valtra tractors are among the best known and most admired in the world. They are built in the most advanced factories in the industry at Suolahti, Finland and Mogi das Cruzes, Brazil and sold in over 75 countries worldwide. Valtra is a worldwide brand of the AGCO Corporation, which is the third-largest manufacturer of agricultural equipment in the world and is based in Duluth, Georgia, in the USA. AGCO Corporation is a world leader in design, production and distribution of agricultural equipment and related replacement parts [1, 2].

Valtra recently joined the ranks of OEMs that use CuproBraze heat exchangers in cooling systems. Valtra is pioneering the use of CuproBraze heat exchangers in tractors for a wide range of off-road applications, including agricultural and contractor uses such as road maintenance and forestry applications.

A Rich Technological History

Headquartered today in Finland, Valtra Inc. traces its heritage to 1832 when Johan Theofron Munktell established a mechanical workshop in Eskilstuna, Sweden. The company came to be called "Munktells" and developed steam locomotives for Sweden's budding rail industry. Munktells combined an internal combustion engine with a locomotive chassis to produce its first tractor in 1913.

The Munktell 30-40 tractor was a behemoth at a total weight of eight tons. The raw oil engine was a semi-diesel, two-cycle, twin cylinder machine with a displacement of 14 liters. The cooling system contained 380 liters of water. The big Munktell reportedly plowed about one acre per

hour. Altogether 31 units of this model were manufactured, some for export to Denmark, Germany and Russia.

Valtra's history parallels the evolution of the tractor. The companies associated with it originated many breakthroughs essential to modern tractors. Today's Valtra tractors are the offspring of two manufacturing giants: Finland's Valmet and Sweden's Volvo BM, itself an outgrowth of Munktell [3].

Valtra continues to innovate as one of the first tractor makers to use CuproBraze radiators and charge air coolers in its current production models.

A New Technology

CuproBraze is still a new technology for most OEMs. It is a breakthrough technology for brazing copper-fins to brass-tubes as well as brass-to-brass. It was developed in part by the International Copper Association in cooperation with the copper industry in the 1990s.

A brazed joint is much stronger than a soldered joint and is more resistant to fatigue, corrosion and elevated temperatures. The durability of CuproBraze heat exchangers is especially prized in tractor applications, in which the installed heat exchangers may be exposed to severe climates and harsh environmental conditions.

Valtra is known for its tractors' long life in heavy-duty use in extreme conditions. From the cold and darkness of Scandinavian winter road maintenance to the heat and dust of Brazilian sugar cane farms, Valtra tractors prove their reliability every day. Farm contracting, forest use, municipal use, road maintenance, peat harvesting and sugar cane harvesting describe just a few applications of

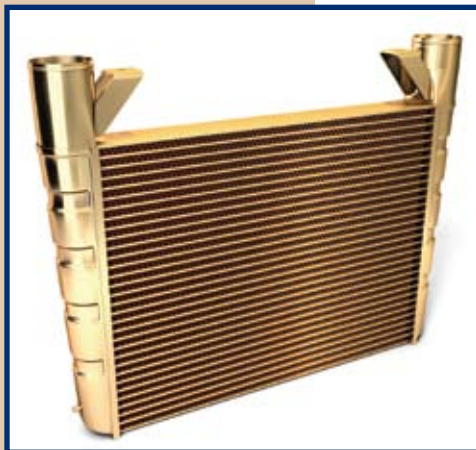
Among the earliest tractors, the Munktell 30-40 was built in 1913 by one of the companies that today make up Valtra's rich heritage.





Cross-sectional drawings of Valtra T Series (top) and N Series (bottom) tractors. These tractors now feature *CuproBraz*e radiators and CACs. Compactness of the heat-exchanger design is an essential design criterion for these tractors.

This *CuproBraz*e charge-air cooler (unpainted) was made by “one-shot” brazing.



Valtra tractors where durability is essential.

Before Valtra could qualify *CuproBraz*e heat exchangers for use in its tractor engine cooling systems, it was necessary for this new materials system to prove itself under harsh conditions.

Corrosion Resistance

Extensive corrosion tests were necessary to show that *CuproBraz*e heat exchangers could withstand the harsh conditions that Valtra tractors must endure. Research conducted in cooperation with the Helsinki University of Technology (TKK) revealed that the galvanic potential of the brazing alloy is about the same as that of copper and brass, predicting that brazed copper-brass heat exchangers

would exhibit superior corrosion resistance in the field [4].

Extensive laboratory testing, including fatigue testing at various temperatures, was conducted over several years at various locations, including at the Luvata Brazing Center [5-7]. All laboratory and field tests indicated that *CuproBraz*e components were more corrosion resistant than soldered components and very competitive with aluminum.

A major advantage of *CuproBraz*e compared to aluminum is that copper-based components can be easily repaired in the field, unlike aluminum, which is difficult or impossible to weld or solder outside a properly equipped facility. In remote areas where spare parts are not readily available, a leak in an aluminum radiator can be catastrophic, shutting down production for days. That’s not the case with a copper-brass radiator because it is readily repairable on the spot.

Compact Design

Besides durability and repairability, compactness was an important criterion for Valtra’s tractor design team.

Mr. Ilpo Ahola, Manager of Front-end Installations at Valtra Inc., is responsible for evaluating *CuproBraz*e technology for the company’s machines. According to Mr. Ahola, component size and design limitations are critical on

Valtra agriculture tractors. “That is why any performance increase relating to cooling design is very welcome,” he says. Mr. Ahola first learned about *CuproBraz*e technology from his contacts at the Suomen Jäähdytintehdas Oy (SJT), also known as the Finnish Radiator Manufacturing Company. Additionally, he researched the available literature about *CuproBraz*e, including technical articles, newsletters and Executive Reports as well as the “*CuproBraz*e Brazing Manual” and “other materials available on” the *CuproBraz*e Alliance Web site.

The space available for cooling systems underneath the hood of various models of Valtra tractors, including Model-N, Model-T and Model-A Series tractors, was limited (See illustrations on this page.). “If the heat exchangers were too tall, they would cut the visibility of the driver,” Mr. Ahola explained. “These tractors are used in many applications where visibility is very important – for example, in forestry applications – and so the size factor was a major concern.”

Mr. Ahola approached SJT with his design criteria and prototypes were developed. “The first prototype was a radiator for the Model-N Series tractors,” he said. “We were quite pleased with the performance of the prototypes. Because of the need for a compact size, aluminum was never an option.”

Before gearing up for production, SJT produced and tested approximately 30 prototype units of heat exchangers. Valtra also tested the thermal performance of the units for each of three models (including one model in the N-series and two models in the T-series).

Meanwhile, SJT was already moving ahead with the establishment of a *CuproBraz*e production line and preparing to deliver *CuproBraz*e radiators in volume as described previously [8-9].

Customized Production

Soon Valtra was upgrading to brazed copper-brass radiators and charge-air coolers in production models.

In 2006, the company purchased 1,600 SJTmanufactured *CuproBraz*e radiators for its N Series tractors, which are the most versatile 4-cylinder tractors in their class, ranging from 88 to 152 horsepower. Their compact wheel-base makes them particularly stable and ideal for front loader operation. Toward the end of 2006, SJT also provided 460 *CuproBraz*e radiators for Valtra’s T series tractors, which utilize the very latest technology and range from 139 to 211 horsepower.



By 2007, production at SJT was ramping up and approximately 8,300 radiators were delivered to Valtra for use in Model N and next generation Model T tractors, as well as for its nimble Model A Series (74 to 98 horsepower). All told, more than 80 percent of the 10,300 tractors produced by Valtra Suolahti in 2007 included *CuproBraz*e radiators.

In 2008, Valtra Suolahti is building about 11,000 tractors and all of them will include *CuproBraz*e radiators. SJT is supplying four different types of radiators for these machines, and producing two different types of chargeair coolers for the manufacturer. Although the relatively small A-Series tractors will use aluminum-CACs, all N-Series and T-Series tractors made in the 2008 Model Year will include *CuproBraz*e CACs.

It is noteworthy that Valtra tractors are individually custom built to meet the requirements of the customer. The selection system includes several options for power transmission and hydraulics, plus many equipment combinations.

When asked about customer response to the *CuproBraz*e radiators, Mr. Ahola is cautiously enthusiastic. "I believe our customers are getting a better radiator and that the *CuproBraz*e radiator adds to the value of a Valtra tractor," he says. "So far we have had no customer complaints. In our business, silence is good."

Emissions Reduction

Valtra tractors use SisuDiesel engines. Formerly an affiliate of Valtra and now another AGCO Corporation brand, the company was founded in 1942 and began diesel engine manufacture in 1947. Since then the brand name has become synonymous with robustness and extreme durability. Its engines are used in a wide range of products includ-

ing agricultural machines, industrial machines and marine applications. SisuDiesel engines are manufactured at Nokia, Finland, and also assembled in Mogi das Cruzes, Brazil.

All diesel engine and equipment makers are facing increasingly stringent emissions standards. For off-road equipment such as Valtra tractors, more demanding US EPA Tier 3 and Tier 4 requirements are looming. Starting in 2008 and continuing through 2015, EPA Tier 4 emissions standards will be phased in by off-road diesel engine manufacturers. Tier 3 and Tier 4 standards together require that emissions of particulate matter (PM) and nitrogen oxides (NOx) should be further reduced by ~ 90 percent. The European Stage III and Stage IV standards are harmonized with US Tier 3 and 4. Hence, the Euro Stage IV standards for the larger off-road engines call for 0.4 g/kWh NOx (i.e., the same as US EPA limits) by 2014. This is a dramatic reduction from previous levels [10].

According to Mr. Ahola, the design of a new heat exchanger plus prototyping, testing and tooling for production can take about 12 months. In fact, more than 1,600 *CuproBraz*e charge air coolers were installed in the 2007 Model Year Valtra tractors. "We already are using *CuproBraz*e CACs in our N and T Series tractors," explains Ahola. "We have been working with SJT to continually improve our CAC designs. We want to be prepared for whatever heat exchangers are necessary for the new diesel engines. The *CuproBraz*e air-to-air designs are performing beyond expectations, and these CACs will be able to withstand the higher pressures and temperatures that we are anticipating from future diesel engines and turbochargers.

"In agricultural and contractor applications, vibration and shock can place fatigue stresses on the CAC joints," Mr. Ahola adds. "The combination of heat and fatigue and increased internal tube pressures does not bode well for aluminum."

This Valtra T series TwinTrac tractor is being used here in a mowing application. It now features a *CuproBraz*e radiator and CAC.



This Valtra N Series N 141 HiTech is being used as backhoe loader. It now features a *CuproBraz*e radiator and CAC.



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 *CuproBraz*e process or ICA's *CuproBraz*e consulting services, please contact the International Copper Association at: cuprobraz@copper.org. For European inquiries contact: ndc@eurocopper.org.

References

1. For more about Valtra, visit www.valtra.com.
2. For more about AGCO, visit www.agcocorp.com.
3. For more about Valtra's rich history, visit at www.valtra.com/company/54.asp
4. Markku S. Ainali, Tapio O. Korpinen and Olof Forsén, "External Corrosion Resistance of *CuproBraz*e® Radiators," Society of Automotive Engineers, SAE Technical Paper Series 2001-01-1718, Order from www.sae.org.
5. Anders Falkenö, "Experimentally Driven Development of New Heat Exchanger Materials," Society of Automotive Engineers, SAE Technical Paper Series 2006-01-0727. Order from www.sae.org.
6. "The *CuproBraz*e Brazing Handbook," Seventh Edition, Edited by Leif Tapper with co-editors Markku Ainali, Anders Falkenö and Robbie Robinson. Produced and published by Luvata. Available from Luvata or download from www.cuprobraz.com.
7. *ICA CuproBraz*e Executive Report Number 41, "Experiments Demonstrate Durability of Brazed Brass Joints Fatigue Testing at Various Temperatures Proves Superiority of Copper-Brass for Heat Exchanger Applications."
8. Bo Svensson, "Cool Technology to Help Meet Emissions Targets" *Diesel Progress International* magazine, July-August 2006.
9. *ICA CuproBraz*e Executive Report Number 44, "SJT Looks Ahead While It Reflects on Past."
10. For more about diesel emissions standards, see www.dieselnet.com/standards.
11. *ICA CuproBraz*e Executive Report Number 26, "New Concepts for Charge Air Cooler Designs."

"One Shot" Brazing of CACs

Mr. Ahola is relieved about the early decision by Valtra to adopt *CuproBraz*e technology for its charge air coolers. "We are much further along than we would be if we had waited for other companies to make the first move," he says. "This has allowed us to refine our charge air cooler designs and tailor them to our tractors. In the case of the radiators, the change was not so drastic since we were already using soldered copper-brass radiators. On the other hand, our charge air coolers were previously made from aluminum. Changing over to a completely new materials system requires more engineering research and product development. SJT has been very cooperative, and as a result we have already overcome many of the initial hurdles."

A great deal of manufacturing research has been focused on developing a production process that could successfully braze fins-to-tubes and tubes-to-headers as well as brazing brass tanks onto the headers. This production goal is known as "one shot brazing." While still in the concept stage, it was the subject of an earlier *ICA CuproBraz*e Executive Report [11]. This goal now has been attained in designs of CACs used in Valtra tractors.

Years of collaboration between Luvata, Umicore BrazeTec, SJT and Valtra has resulted in Valtra tractors being among the first to use a "one shot" brazing process for CACs. "We've been perfecting one shot brazing for many years," says



Aerial photograph of the Valtra Suolahti plant.

Hannu Vetikko, Managing Director of SJT. "We have had successes in the past for small volumes; however, the Valtra CAC is the first to go into full production and represents the culmination of at least five years of process development."

Steady Advances

Valtra has a rich heritage of originality in tractor design, including many great innovations that are an integral part of modern tractors. Compared to Munktell's 1913 behemoth, today's tractors are marvels of ergonomics, efficiency and versatility. In the years ahead, emissions such as nitrogen oxides and soot will be reduced to negligible amounts.

With undeveloped countries rapidly advancing, future prospects are unlimited. "The future looks good now because farmers are able to invest in new tractors," says Mr. Ahola. "Our strength is tailor-made tractors and the demand for customization of tractors is strong."

Valtra will be exhibiting its tractors with *CuproBraz*e heat exchangers at major international fairs such as the Sima Exhibition in Paris and Agritechnica Exhibition in Hannover on 2009.

"The success of pioneering companies such as Valtra in adopting *CuproBraz*e is a fulfillment of many of the promises that have been made by the proponents of *CuproBraz*e technology and the members of the *CuproBraz*e Alliance," says Nigel Cotton, Automotive Manager for the International Copper Association.

"*CuproBraz*e is a revolutionary technology, but big breakthroughs are often followed by periods of market adjustments, continual improvements and steady advances by many players working in cooperation. We look forward to the continued advancement of tractor technology as well as *CuproBraz*e technology." ■