

LATEST TECHNOLOGY SERIES / 2002-2003

Heat Exchangers

Part 1 - EMISSION STANDARDS



CuproBraze®



NO_x EMISSION

Europe, USA, Japan and China are some of the leading economies striving to reduce nitrogen oxide (NO_x) emission levels in the environment. NO_x is one of the harmful pollutants emitted by automobile engines.

NO_x emission from engines has been under the spotlight of various environmental protection agencies all over the world. For instance, regulators in Europe, USA and Japan have set up stringent limits for both NO_x and particulate emission from heavy-duty diesel vehicles (Fig 1).

Fig 1: International emission legislation for heavy-duty diesel vehicles

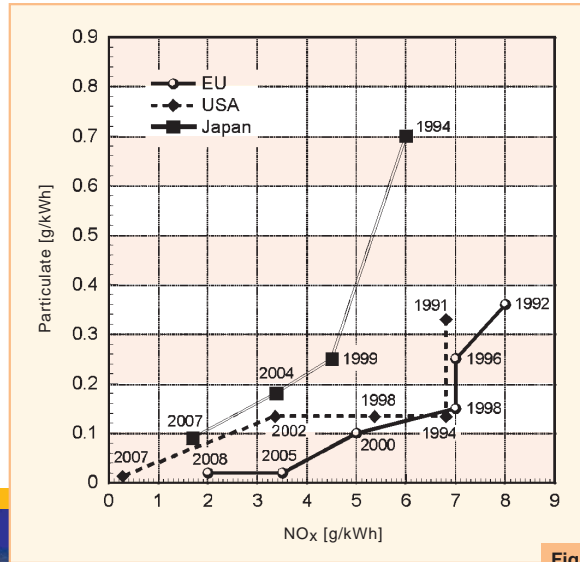


Fig 1



The Euro IV Emission Legislation in 2005 will require NO_x

emission from heavy-duty diesel vehicles to drop from the current level of 5 g/kWh to 3.5 g/kWh, a reduction of 30%]

The Euro IV Emission Legislation in 2005 will require NO_x emission from heavy-duty diesel vehicles to drop from the current level of 5 g/kWh to 3.5 g/kWh, a reduction of 30%. Also, the US EPA standard is targeting a steep reduction from the current level of 3.35 g/kWh to 0.27 g/kWh, a 95% reduction by 2007. Similar trends can be seen for the other applications of diesel engines, such as cars, light commercial vehicles, etc.

Fig 2: Huge reductions in NO_x emission levels from heavy-duty diesel vehicles in the future

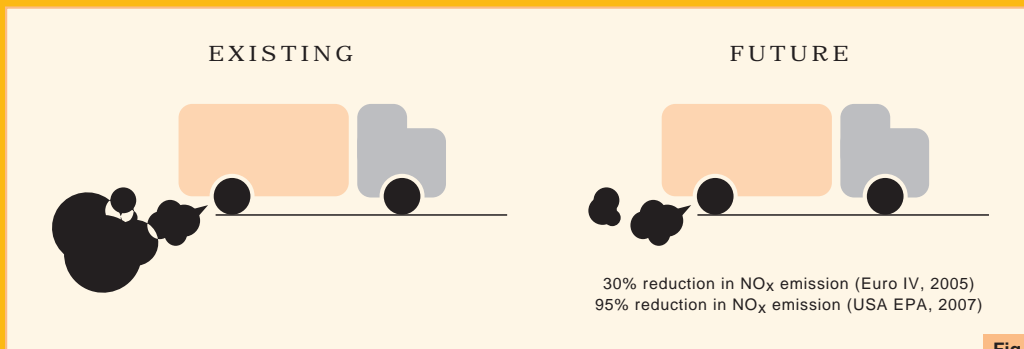


Fig 2

Most diesel vehicle manufacturers acknowledge that existing technologies and designs may need to change to meet the more stringent emission standards. The question is: Are organisations geared up to meet the challenges of reduced emission levels?



NO_x EMISSION LEVELS: SOLUTIONS

EGR TECHNOLOGY

Apart from oxygen which is essential for fuel combustion, ambient air contains nitrogen. The high temperatures found within engines cause nitrogen to react with oxygen to form nitrogen oxide.

One of the most effective means of tackling nitrogen oxide is through the Exhaust Gas Recirculation (EGR) technology. EGR directs some of the exhaust gases back into the intake of the engine (Fig 3). By mixing the exhaust gases with fresh air, the amount of oxygen entering the engine is reduced. Since there is less oxygen, temperatures are reduced and less nitrogen oxide is formed. This can greatly reduce the amount of nitrogen oxide that a vehicle releases into the atmosphere.

Fig 3: Exhaust Gas Recirculation (EGR) Process

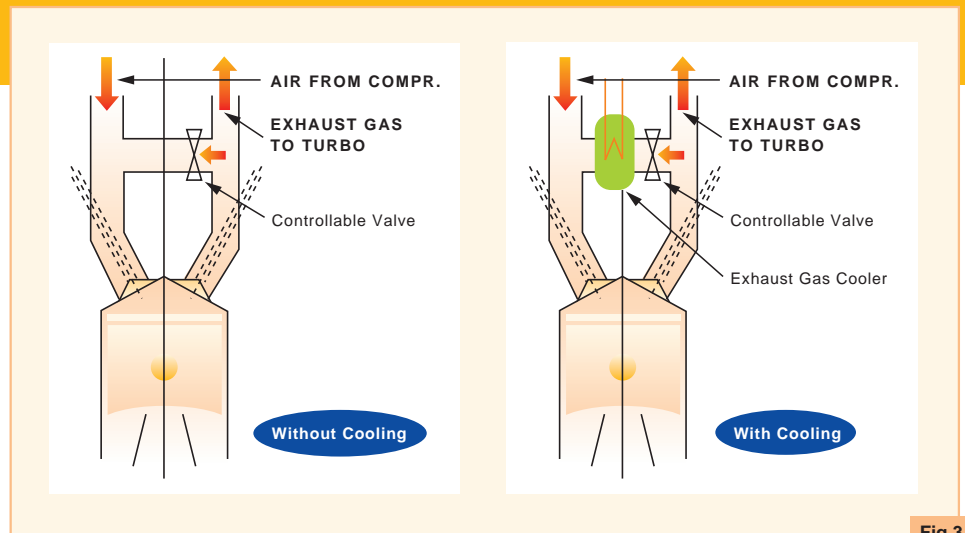


Fig 3

BENEFITS OF EGR

Figure 4 shows how EGR can lead the way for diesel engines to comply with the EURO V - the European emission standards. With EGR technology, NO_x values as low as 2g/kWh are possible with particulate emissions ranging between 0.05g/kWh and 0.1g/kWh. To achieve NO_x values even lower than 2g/kWh, manufacturers can use a particulate trap.

Fig 4: How EGR can meet future emission standards

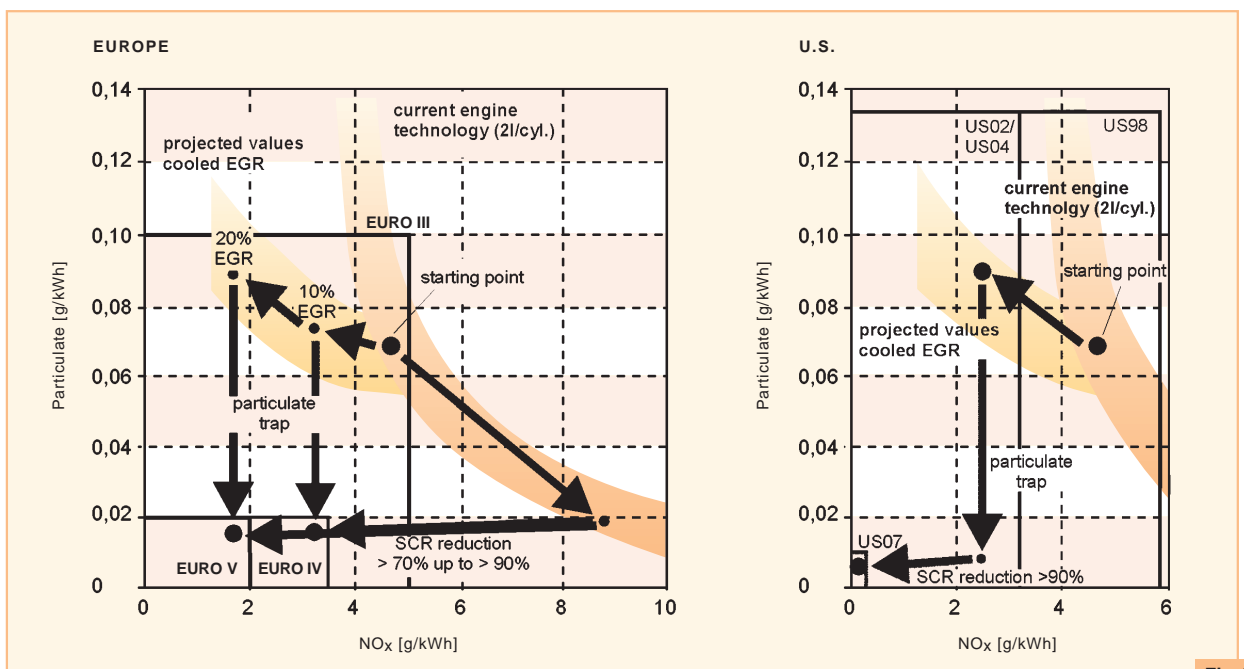


Fig 4



NO_x EMISSION LEVELS: SOLUTIONS - cont'd

IMPLICATIONS OF EGR

The use of an EGR system in an engine, however, leads to certain changes for the total cooling system. In the EGR cooler, heat is transferred from the exhaust gas to the coolant, which places an extra burden on the cooling system.

Also in EGR, mixing exhaust gas with the charge air leads to a reduced air ratio in the combustion process. This is not acceptable because of the particulate emission factor. Boost pressure must be increased to achieve the same value of air ratio as before EGR was applied. Higher boost pressure leads to higher charge air cooler (CAC) temperatures after the compressor.

Therefore, with EGR, the CAC requires a higher cooling performance and also the strength to withstand higher thermal and mechanical loads.

IMPROVED CAC

How can the CAC meet EGR's requirement for enhanced performance? The new challenges for the cooling system can only be met by:

- using more efficient heat exchangers, preferably with no change in size
- enabling these heat exchangers to withstand higher temperature conditions

In short, as shown in Fig 5, compliance to future emission standards would require enhanced thermal performance and strength from heat exchangers.

Fig 5: Lower NO_x emissions require improved CAC performance

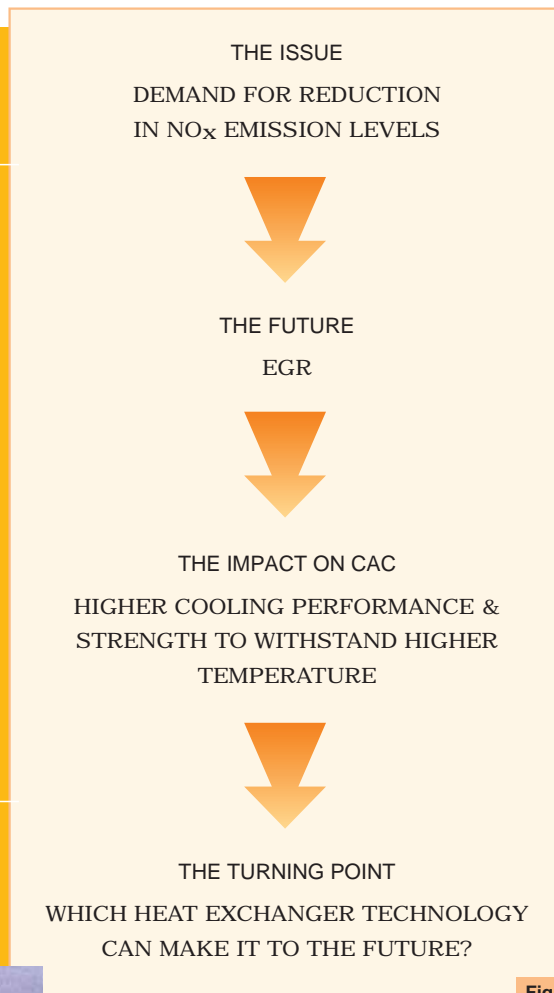


Fig 5



[A significant advantage of CuproBraze is that it allows the use of thinner fin and tube material. This in turn affects thermal performance. Wind tunnel tests confirm that this feature leads to lower airside pressure drops]



HEAT EXCHANGER TECHNOLOGIES

1 ► ALUMINIUM

Are the existing aluminium heat exchangers able to deliver the higher thermal performance and strength that EGR technology requires?

Aluminium loses strength over 150°C, making aluminium type CACs susceptible to strength problems. Serious problems occur at temperatures above 200°C at which the strength of aluminium drops 40% to 60% compared to its strength at 150°C. These limitations indicate that aluminium CACs might fail prematurely when subject to high temperatures. Tube cracking and tube-to-header joint failure are common problems for aluminium CACs.

The current generation of aluminium CACs has serious limitations at the high temperatures and pressures of EGR technology .

2 ► CUPROBRAZE

There is one alternative to aluminium heat exchangers - using copper and brass. *CuproBraze* is a technology that uses both brass tubes and copper fins, involving a special brazing alloy for copper/brass joints.

Used for manufacturing a new generation of high-performance heat exchangers, *CuproBraze* provides heat exchanger and auto manufacturers with a way to produce brazed copper-brass heat exchangers of high strength and reliability.

General Benefits of *CuproBraze*

- The brazing alloy, based on CuNiSnP, is non-toxic.
- Copper and brass have advantages of lower specific heats, lower coefficients of thermal expansion and better corrosion resistance compared to aluminium.
- Employing the latest, no flux, lead-free brazing alloy and anneal-resistant materials, the brazed copper/brass heat exchanger has better performance than thick-walled aluminium heat exchangers.
- The manufacturing processes have overall lower energy consumption, thus saving cost; less scrap; and higher throughput rates.
- Copper has higher conductivity.
- Copper is virtually 100 percent recyclable.

Higher thermal & strength performance

In contrast to aluminium's limitations at high temperatures, tensile strength for tube brass is more than 300 MPa at 200°C and is still well above 250 MPa even at 300°C. Fig 6 shows the difference between the tensile strengths of the two materials. A *CuproBraze* CAC can withstand very high inlet temperatures of up to 300°C, retaining much of its strength and avoiding metal fatigue.

Fig 6: Effects of higher temperatures on strength of aluminium and brass tubes

A significant advantage of *CuproBraze* is that it allows the use of thinner fin and tube material. This in turn affects thermal performance. Wind tunnel tests confirm that this feature leads to lower air pressure drops. It is estimated that a copper-brass heat exchanger will have a 20% to 30% lower air pressure drop for the same heat transfer, compared to aluminium. This advantage, along with the potential to use innovative fin and tube designs, translates to more efficient heat exchangers.

Therefore, from an EGR standpoint, the two key benefits of *CuproBraze* are:

- **Capability to withstand high temperatures**
- **Superior thermal performance**

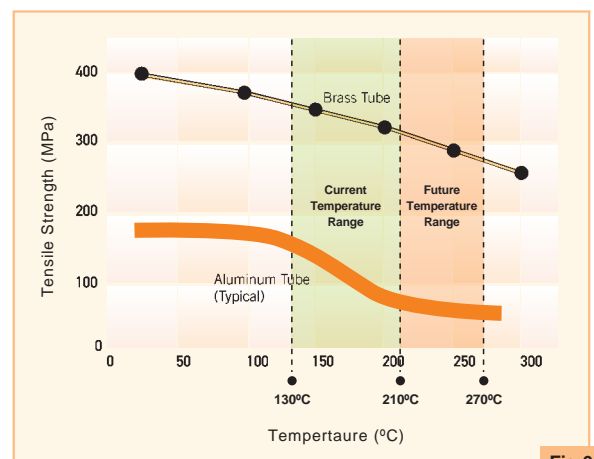


Fig 6



CuproBraze[®] a new, better process to make heat exchangers



CONCLUSION

It is clear that future emission standards for diesel engines require sharp reductions in the NO_x emissions. EGR is one of the most effective means to bring about reduction in NO_x emission levels. EGR would however require higher performance from the CAC in terms of the ability to withstand high temperatures and superior thermal performance.

Contemporary aluminium heat exchangers have the inherent limitation to withstand elevated temperatures. CuproBraze, the latest heat exchanger technology, can overcome the limitations imposed by aluminium heat exchangers and meet the twin requirements of EGR: The ability to withstand high temperatures and superior thermal performance.



Useful References:

www.dieselnet.com

An online information service on diesel emissions, emission control, diesel engines, fuels, and more...

www.sae.org

Website of The Engineering Society for Advanced Mobility in Land, Sea, Air and Space.

www.behrgroup.com

Website of Behr GmbH & Co, a specialist in environmentally compatible vehicle air-conditioning and engine cooling. Behr is one of the leading original equipment manufacturers for passenger cars, commercial vehicles.

www.narsa.com/acj/

Automotive Cooling Journal of the U.S. National Automotive Radiator Service Association

www.copper.org

A service of the U.S. Copper Development Association

Resources:

For more information about CuproBraze, free literature and technical tips, you can look up the website of the CuproBraze Alliance at:

www.CuproBraze.com

If you have any questions or requests for information, you can email to: Info.cuprobrazec@cuprobrazec.com

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