Russia's Emissions Management

As it moves in line with its Western counterparts, the Russian motor industry is experiencing the contrasting effects of economic deregulation and environmental regulation. Global Emissions Management profiles the region's car market and the impact of emissions legislation.

Car market deregulation

It is not surprising that car ownership in Russia has historically been low. A Soviet car used to cost as much as 70 months average wages with waiting lists of up to three years, whilst only the highest-ranking Government officials could import foreign vehicles. The opening up of the Russian economy has changed all this and cars have become both available and affordable.The changing economy has helped create a growing middle class looking to purchase cars, whether domestically produced or second-hand imports, whilst new foreign cars figure among the status symbols of a rich elite of 'New Russians'.

The huge pent-up demand for cars represents a growth opportunity for both the domestic and the western motor industries. As the Russian economy deregulated, many western motor manufacturers formed joint ventures (JVs) with domestic companies, either in Russia or in the republics of the former Soviet Union, to make and sell new cars. However, few have prospered. One of the reasons for this has been the supply of components. The Russian component sector was set up to supply the domestics, and as such, was not geared up to produce many of the components required by the JVs or, where it could, they often failed to meet the required quality standards. Further, it has lacked access to capital to fund the necessary investments to supply. Consequently the JVs are importing components which are subject to a tariff regime designed to protect domestic manufacturers from second-hand car imports. The outcome has been JV products priced between $10,000 and $15,000 compared with Russian carmakers products selling at one third of the price. So, despite Russia providing a low-cost manufacturing base, the western JVs have been unable to take full advantage.

Given the difficulties that these JVs have experienced, the main beneficiaries of the opening up of the Russian market have been the importers of second-hand cars who compete with the established Russian car makers, such as AvtoVaz (more familiarly known as the manufacturer of Lada cars), UAZ and GAZ.

Despite their old-fashioned design and lack of 'add-on' features in comparison with their foreign counterparts, Russian-made cars still represent an attractive investment for the local population. The severe weather conditions and poor roads in Russia are a hazard for all cars, be they of foreign or of Russian origin. Whilst anecdotal evidence indicates that western-produced cars have fared better in these conditions and have proven more reliable, spare parts for these vehicles are costly and of limited supply. Therefore many Russians see the availability of spare parts and the simple maintenance demands of domestic cars as a plus.

Given these unique market conditions, the domestic producers have been able to continue to compete effectively albeit that they recognise the need to replace their 'classic' models with updated designs. In the years ahead, both domestic and JV producers need

the domestic components sector to develop its capabilities further, either by partnering or collaborating with western companies.

Environmental problems

The number of private cars in Russia is increasing by nearly 10 per cent a year leading to increased pollution and congestion. The effect is most obvious in Moscow, where the number of cars has increased from 600,000 in 1988 to over 2.5 million today. Cars are now reported to account for almost 90 per cent of Moscow's air pollution, which frequently exceeds health guidelines, resulting in the number of respiratory diseases in Moscow reported at twice the Russian average.

Transport industry insiders argue the Russian market is flooded with old second-hand western vehicles, which are in poor condition and are not fitted with catalytic converters and that this is a major source of air pollution in Russia's cities. However, fuel quality is also contributing to these problems, as low-grade gasoline is finding its way into the distribution system.

In an attempt to reduce high pollution levels in Moscow, city authorities have introduced a range of measures including tightening the Inspection and Maintenance regime through obligatory annual inspection for cars older than five years, as well as promoting alternative fuels such as liquefied natural gas. To address the fuel quality issue, oil companies are developing their own network of filling stations and adding coloured dyes to their refinery output of gasoline to deter counterfeiters.

Emissions legislation

While European countries are preparing to introduce Euro 4, Russia is playing catch up. The introduction of Euro 1 standards started to be discussed in 1996 and three years later those limits became compulsory for all new models. With effect from 1 July 2002 Russian carmakers have been required to conform to Euro 2 standards. However, due to the difficult engineering challenges facing the vehicle manufacturers and engine suppliers, the legislation is being phased in over a three-year period. This will require 25% of production to meet the standards in 2002, 50% in 2003 and 75% in 2004 with full compliance by 2005, at which time Euro 3 standards will be implemented.

JM in Russia

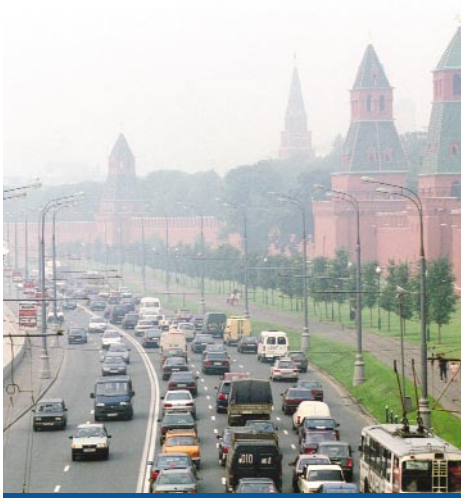
Autocatalyst technology from the domestic components sector is not advanced and given the technical requirements of emissions compliance, autocatalysts are expected to continue to be imported for the foreseeable future.

Johnson Matthey is currently using the latest catalytic technology to help Russian carmakers, such as AvtoVAZ, to meet Euro 1, Euro 2 and now Euro 3 standards. Meeting Euro 3 is a particular advantage as it allows export to western markets which helps gain valuable foreign currency earnings.

Commenting on Russia, Dr Pelham Hawker, Managing Director of Johnson Matthey's Catalytic Systems Division, said "The Russian car market presents a great opportunity for car component suppliers and Johnson Matthey is making sure it is on track for a leading position in this important emerging market. We have established good working relationships with the components sector and car companies and see our supply to domestics as complementing our existing business with the JVs western partners. As the industry develops we will be well placed to supply through whichever distribution channel is preferred."

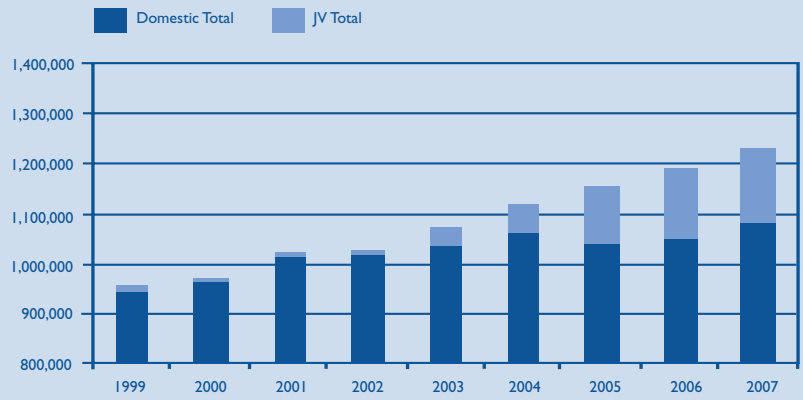
"Johnson Matthey is currently using the latest catalytic technology to help Russian carmakers, such as AvtoVaz, to meet Euro 1, Euro 2 and now Euro 3 Standards. Meeting Euro 3 is a particular advantage as it allows export to western markets which helps gain valuable foreign currency earnings."

Severe weather and poor roads make repair costs an issue

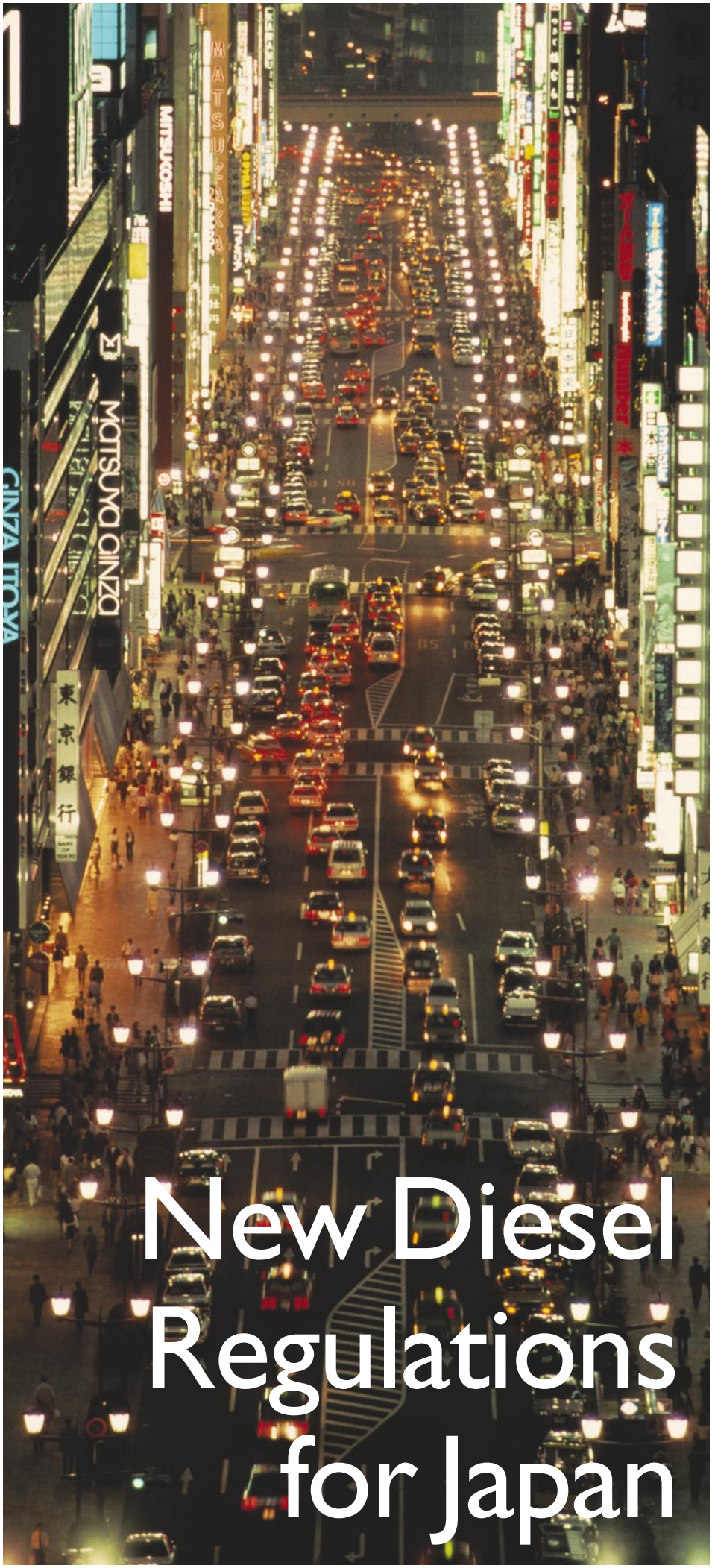


Moscow is becoming a very congested and polluted city

Russian Car Production Forecast



Source: JD Power



New Diesel Regulations for Japan

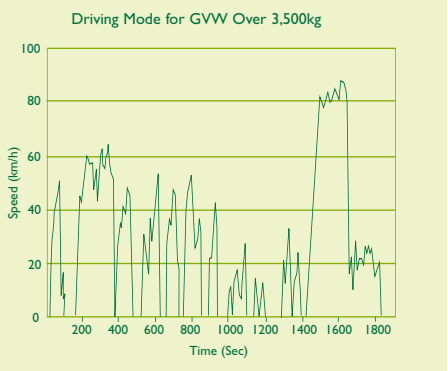
A new set of diesel emissions legisation has been announced for Japan. The regulations, which call for sizeable reductions in PM and NO_X emissions, have been shaped both by regulatory developments elsewhere in the world and by the politics of Tokyo.

New emissions limits

The Japanese government has announced new 'long-term' regulations on tailpipe emissions for all diesel-powered motor vehicles. The new regulations, which will come into effect from October 2005 for Heavy Duty Diesel (HDD) vehicles, include new limit values and a change in the test cycle. They target the reduction of PM emissions from trucks and buses by up to 85 percent and NO_X emissions by 50 percent compared with the 'short-term' diesel regulations that came into force in April 2003 (Figure 1).

Figure 1: HDD emissions limits – Japan

Figure 2: New testing mode for HDD



The Governor of Tokyo, Shintaro Ishihura

Trucks in Japan are typically smaller than those used in other regions

New test cycle

In order to accurately assess emissions management, the test mode will be changed from a steady state to a transient cycle (Figure 2). The new test mode will be phased in between 2005 and 2011, defining HDD vehicle limits from 2005 and passenger cars limits from 2008.

Background to the new regulations

The new regulations are the result of a period of consultation and review. This process was informed by a variety of sources, notably by research undertaken within the Japanese Clean Air Program (JCAP) in which the latest emissions control technologies were investigated, along with related factors including fuel quality.

Among the interested parties, the Central Environment Council advised Japan's Ministry of the Environment to tighten HDD regulations. Their interest reflects a "Tokyo Effect" that has been extremely influential in defining the context for the tightening regulations.

'The Tokyo Effect'

Tokyo continues to suffer from serious air pollution. Levels of nitrogen oxides (NO_X) and particulate matter (PM) have remained stubbornly high and static over the past ten years. Almost 70% of NO_X emissions in the Tokyo Metropolis come from mobile sources and, of these, 70% come from trucks, while 36% of particulate matter (PM) is emitted by vehicles, almost all of which is from diesels.

The Governor of Tokyo, Shintaro Ishihura, has turned the impacts of diesel exhaust health into a prominent political issue. Commencing in August 1999, Ishihura and his Tokyo Metropolitan Government (TMG) ran a "Say No to Diesel Vehicles!" campaign. The campaign called for diesels to be replaced by gasoline or alternatively fuelled vehicles but also allowed for trucks and buses to be retrofitted with diesel particulate filters (DPFs). Based on the idea of imposing stricter standards for Tokyo compared with the rest of Japan, the policy has developed further with plans for all diesel vehicles registered in or entering the Tokyo Metropolis to be fitted with DPFs. The regulations, which will come into effect from October 2003, are complemented by a programme of financial incentives for retrofit and low-interest financing for the purchasing of low-emission vehicles.

The regulations potentially apply to 430,000 vehicles in Tokyo and an extra 180,000 that travel through the city. In recognition of the need for low sulphur fuel for DPF systems and NO_X traps, the whole of Japan is expected to switch from the current limit of 500 ppm to less than 50 ppm by the end of 2004 but with metropolitan areas like Tokyo switching grades sooner.

CRT® under test at JCAP

The emissions management sector responds

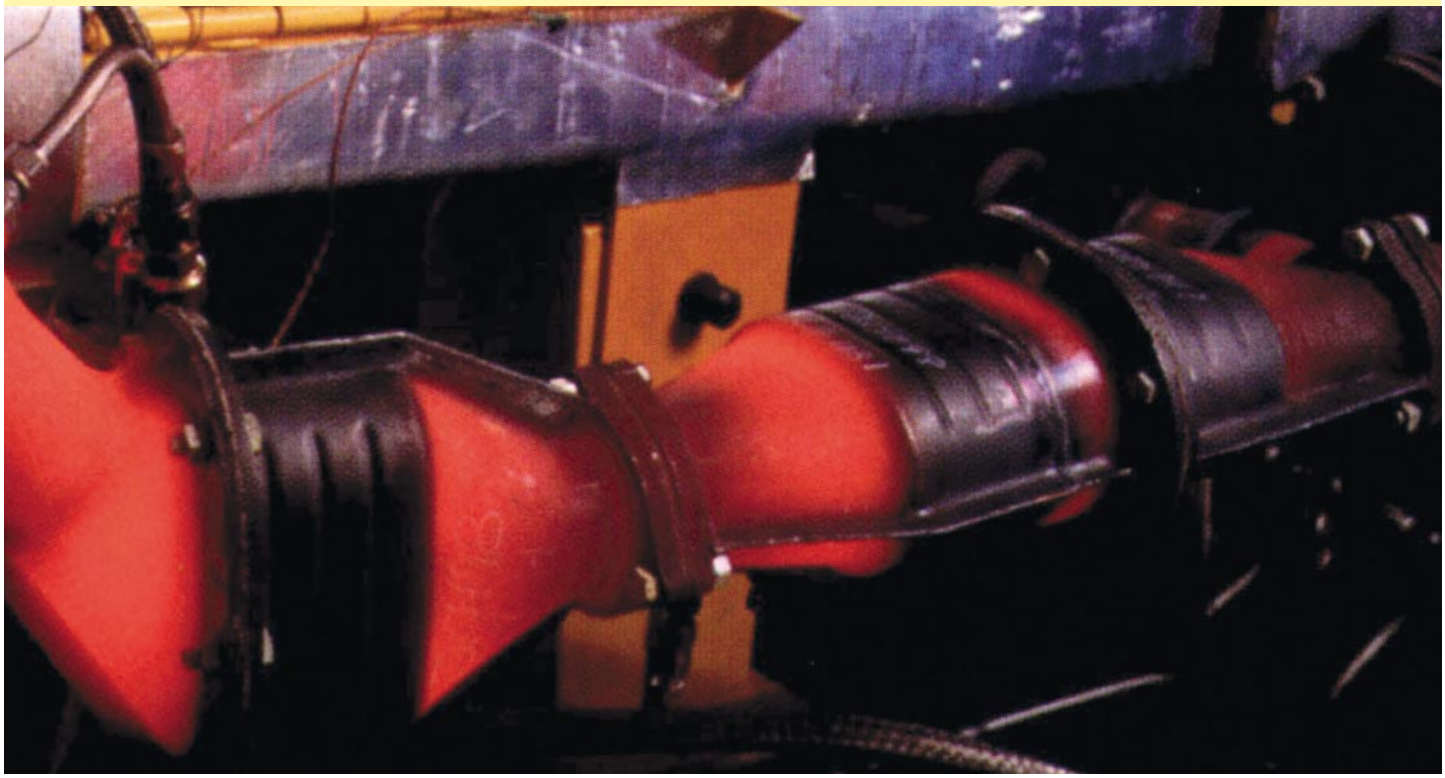
The HDD regulations proposed for 2005 bring Japan in line with European and US regulations targeting sharp reductions in both PM and NO_X. This commonality of targets aids a co-ordinated response from industry. With emissions control likely to become a necessity to meet the long-term regulations for HDD, the new test cycle has attracted particular attention because it is transient rather than steady-state and designed to reflect Japan's slow speed urban driving patterns. The test cycle is thought likely to result in low loads on the engine and therefore low average exhaust gas temperatures, impacting on the application of catalytic emissions control.

From its KITEC technical centre near Tokyo, Johnson Matthey is working closely with Japan's main engine manufacturers to develop effective emissions management using either DPFs or catalytic approaches to NO_X control. Commenting on the new regulations, Dr Barry Cooper of Johnson Matthey said "These are challenging regulations to meet but we have the technology options. We look forward to continuing our development, along with our engine manufacturer customers, to help meet these tighter limits."

Johnson Matthey's Continuously Regenerating Trap (CRT®) joins a number of other DPF and catalyst systems that have official Government approval for use in Tokyo.

Some Like It Hot!

Johnson Matthey's latest TWC developments



Three-way catalyst (TWC) development today focuses on optimising catalyst performance features that offer benefits for the customer. Johnson Matthey's latest catalyst formulations offer exceptionally high activity and thermal durability. This article and enclosed technical paper, describe how these attributes can provide customer benefits including low Platinum Group Metal (PGM) loadings and the potential to enable improved fuel economy.

The subject of low PGM loaded autocatalyst technology is very topical. The ability to deliver effective and sustained performance with low PGM loadings is dependent both on advanced catalyst design and optimised emissions control systems. For Johnson Matthey, the key to achieving low loadings has been to combine high activity with exceptional thermal durability, allowing close coupled catalysts to take the burden of emissions control within both single and multiple catalyst systems. Whilst the following article focuses on showing how the latest catalysts can achieve emissions limits with exceptionally low PGM loadings, it should not be forgotten that there are other ways by which these new formulations can benefit customers. For this reason and because it underpins the development of low loaded catalysts, a technical paper is enclosed, first presented at the Society of Automotive Engineers' (SAE) conference in Detroit in March 2002. This paper demonstrates how the improved thermal durability of Johnson Matthey's latest generation of TWCs was proven. The research presented shows that new advanced platinum- and palladium-based TWC technologies can be exposed to temperatures as high as 1050°C whilst still achieving European Stage 4 emissions limits. Using these catalysts it is also anticipated that with appropriate engine management control systems can be calibrated to improve real-world fuel economy.

Automotive journalists are increasingly highlighting the real-world fuel economy of new models

Figure 1: Trends in TWC operating temperatures

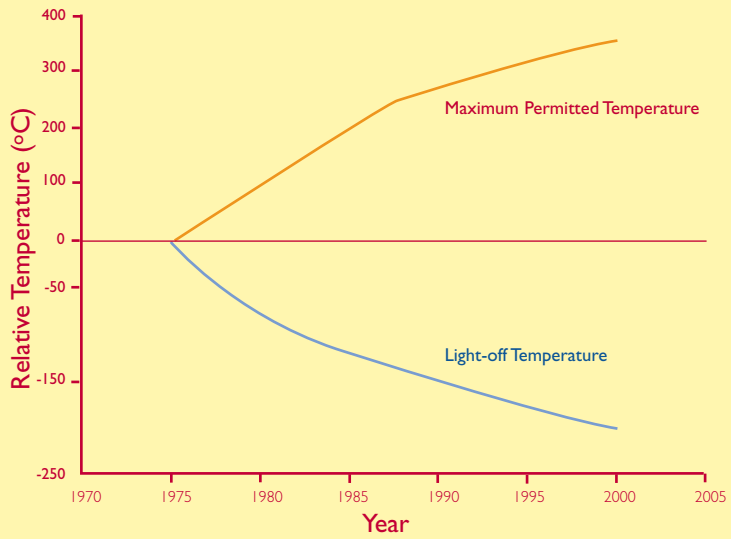
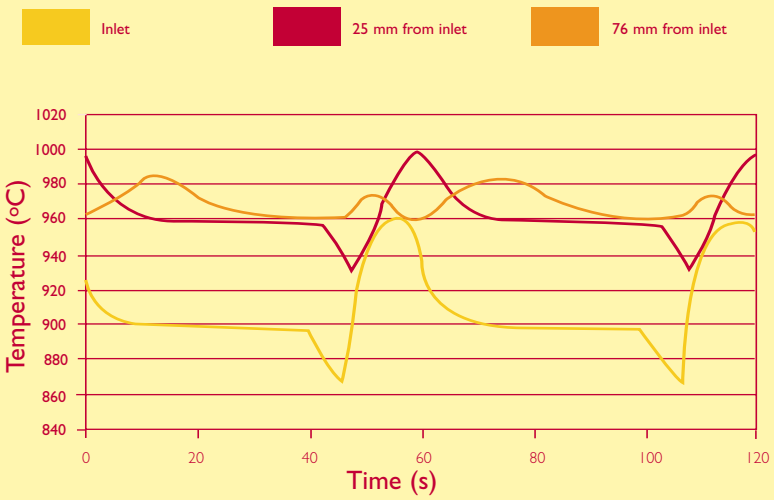


Figure 2: Johnson Matthey's high temperature ageing protocol



"the latest catalysts can withstand temperatures greater than 1000°C. At these thermal durabilities it is elements of the exhaust that are temperature limited rather than the catalyst."

Background

The effectiveness of modern emissions control systems owes a great deal to advances in catalyst technology designed to endure high temperature exposure. Catalysts promote the emissions control reactions by lowering their activation energies. This means conversion can occur at lower exhaust gas temperatures. A clear example of this activity is seen in the light-off temperatures for the latest catalyst formulations compared with their predecessors (Figure 1). To maximise this benefit, so they reach operating temperature as soon as possible, catalysts are being positioned closer and closer to the engine manifold. The emissions controlling oxidation and reduction reactions are exothermic so once they commence, the catalyst temperature quickly exceeds that of the incoming exhaust gas. This helps sustain emissions control during low speed low exhaust gas temperature operation but creates a problem during high speed or high load operation, when very high temperatures can be experienced. The ability to withstand high temperatures for long periods is therefore a critical catalyst design feature. Figure 1 also illustrates improvements in thermal durability made over recent years. This is expressed in terms of the maximum permitted temperature, above which the catalyst will begin to deactivate.

Improving fuel economy

Engine control systems have typically limited the maximum temperature a catalyst experiences by enriching the combustion mixture. Whereas these calibration strategies have tended to limit the maximum catalyst temperatures to around 960°C, the enclosed technical paper illustrates that the latest catalysts can withstand temperatures greater than 1000°C. At these thermal durabilities it is elements of the exhaust that are temperature limited rather than the catalyst. Therefore higher thermal durability for the catalyst can allow a higher temperature engine-out exhaust gas, which means less fuel enrichment thereby improving real-world fuel economy.

Figure 3a: THC light-off after ageing at 1000°C

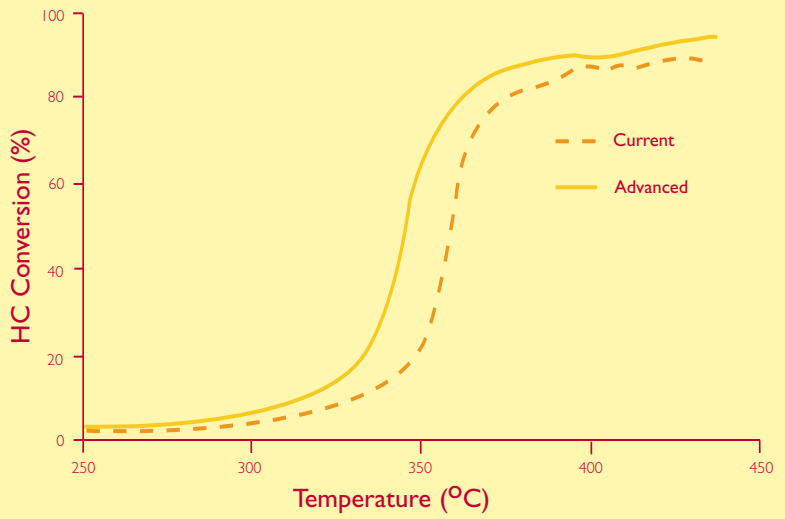


Figure 3b: Lambda Scan CO/NO_x performance after ageing at 1000°C (±10%, 1Hz, 450°C)

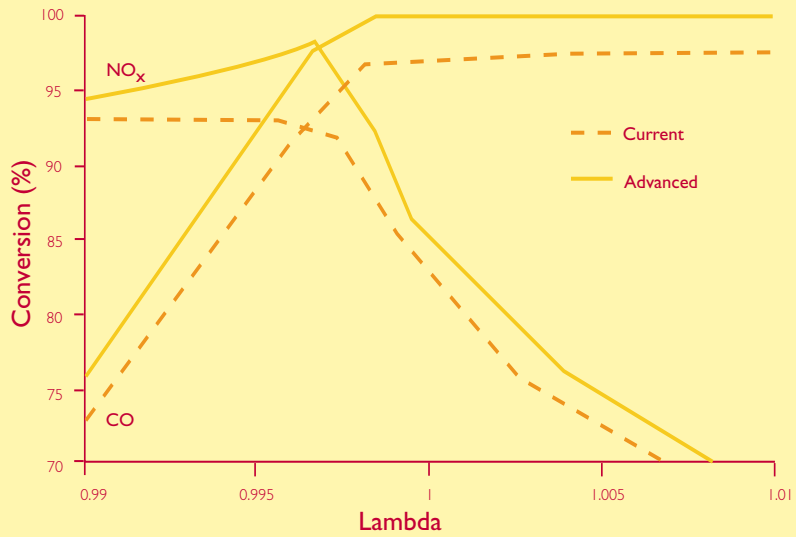
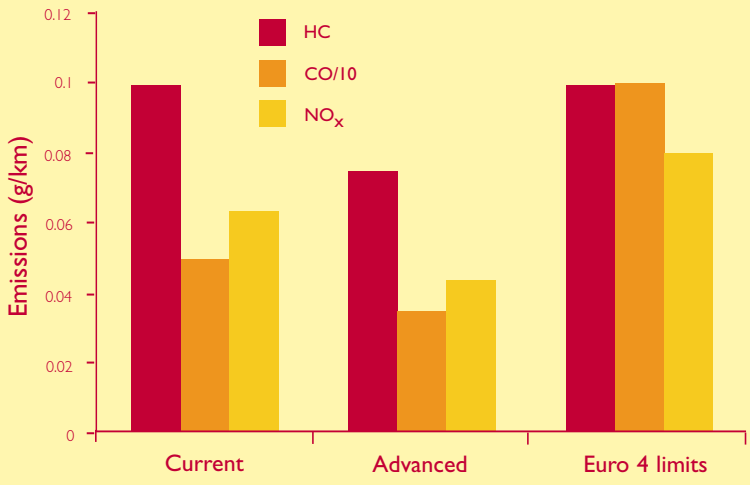


Figure 4: Results of vehicle evaluation testing



Lower PGM loadings

The use of highly advanced and thermally durable TWC means it is possible to employ low PGM loadings on close coupled catalysts that still reach emissions limits.

Catalyst development phase

To demonstrate low loadings, Johnson Matthey catalyst chemists set up a series of experiments to compare the performance of the then current Pt/Rh and Pd/Rh catalysts with advanced formulations at 35 g/ft^3 PGM. When researching the advanced formulations, catalyst development focused on Synthetic Catalyst Activity Testing (SCAT), followed by the use of characterisation techniques such as X-ray diffraction and scanning electron microscopy. Using these techniques Johnson Matthey catalyst scientists were able to understand the changes that caused catalyst de-activation during ageing. The development targets were then agreed to be: improved thermal stability of non-oxygen storage component support materials, optimised targeting of promoters for specific PGM and improved oxygen storage and release kinetics after high temperature ageing. Thereafter further SCAT work, coupled with bench engine tests and evaluation on vehicles led to the development of advanced formulations.

Catalyst ageing was conducted using the same ageing protocol described in the enclosed technical paper and illustrated in Figure 2. These aged catalyst samples were then evaluated in light-off profiles and lambda scan tests conducted on a 1.9 litre 4-cylinder engine using a steady-state dynamometer, with the engine fuelled using 200 ppm sulphur fuel. Vehicle evaluation was conducted on a 1996MY 1.25 litre vehicle originally approved for European Stage 2 Legislation but running on the same fuel and the European Stage 3 drive cycle.

The original 'baseline' catalysts allowed emissions breakthrough post light-off and thereby experienced problems achieving European Stage 4 standards. However this problem was much less prevalent with the advanced formulations. Moreover, the results also showed that the advances made in the newer formulations led to significant improvements in light off and lambda scans when compared with the baseline formulations, as illustrated in figures 3a and 3b. The outcome of the vehicle testing was that Euro 4 emissions limits were comfortably achieved (Figure 4). This was at PGM loadings considerably lower than the original baseline.

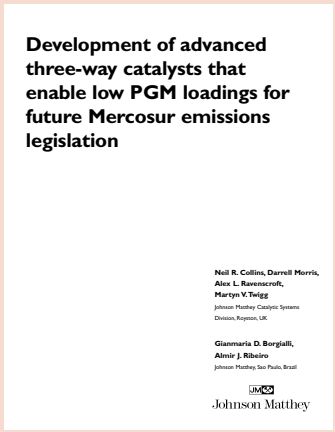
Application to Mercosur vehicles

Having demonstrated the enhanced activity and thermal durability of the new advanced Pd/Rh and Pt/Rh catalyst formulations, they were tested on four 2002MY vehicles from Brazil to confirm their suitability to meet the current and proposed 2006 Mercosur legislation. The tests were all conducted on low loaded catalyst formulations after high temperature ageing. The PGM loadings chosen were considerably lower than those currently in use on these vehicles (i.e. greater than 80% reduction from the typical current PGM loading of 30 g/ft^3.)

The results, illustrated in Figure 5 for 10 g/ft^3, were particularly encouraging, with emissions of HC, CO and NO_X all below the current and proposed 2006 emissions levels. Further tests were run at PGM loadings of 5 g/ft^3 and the emissions limits were comfortably met. Given this level of performance further reduction below 5 g/ft^3 should be possible.

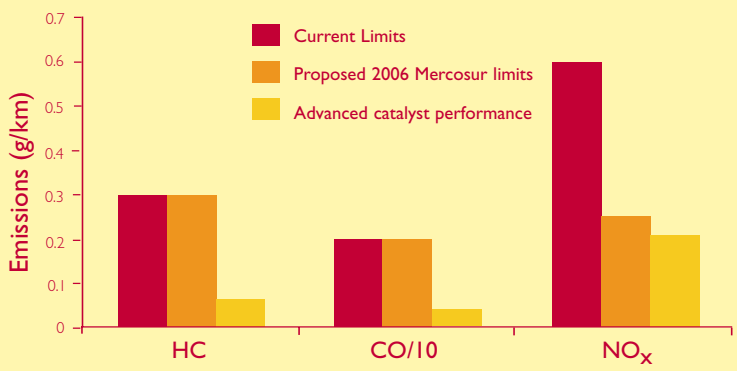
Conclusions

Commenting on the results of this and other work Johnson Matthey's Dr. Martyn Twigg said "with these results we firmly believe we are well ahead of our competitors. Our latest generation of catalysts, known as the 600 series, offer high activity, thermal durability and PGM flexibility. Low loading formulations will always be of interest to our customers so we are pressing ahead with development work targeting loadings below 5 g/ft^3 for applications such as Mercosur vehicles."



This article summarises a paper entitled "Development of advanced three way catalysts that enable low PGM loadings for future Mercosur emissions legislation" presented at SAE Brazil in November 2002. If you are interested in this paper please contact us at Global Emissions Management.

Figure 5: Emissions for low-loaded advanced catalysts after ageing



Scanning Electron Microscopy is an invaluable tool for catalyst evaluation

Markets like Mercosur use the latest catalyst technology but with low PGM loadings as emissions legislation is less stringent

"When researching the advanced formulations, catalyst development focused on Synthetic Catalyst Activity Testing (SCAT), followed by the use of characterisation techniques such as X-ray diffraction and scanning electron microscopy."