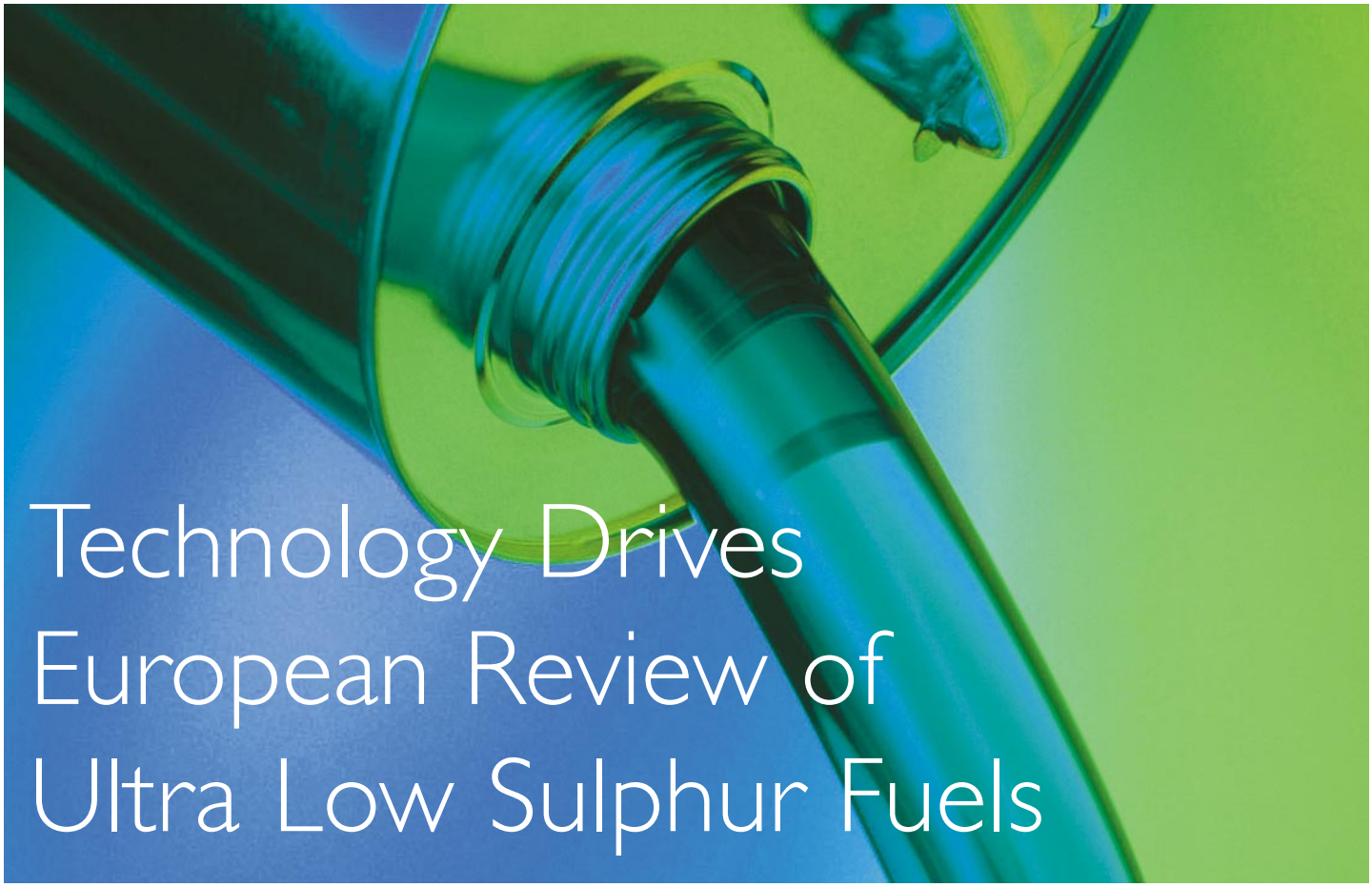


Technology Drives European Review of Ultra Low Sulphur Fuels

The quality of fuel is a major issue for both the motor industry and automotive catalyst industry. Rob Searles, Executive Director of the Association for Emissions Control by Catalyst (AECC) in Brussels, explains how AECC and its members have responded to the consultation process launched last year by the European Commission to help set future European fuel quality levels.

Rob Searles
Executive Director
AECC

European Environment Commissioner Margot Wallström called for evidence in May 2000 regarding the appropriate future level for the sulphur content of European petrol and diesel fuels. The specifications for petrol and diesel fuel sold in the Community are set by Directive 98/70/EC, which requires that from the 1st January 2000 petrol and diesel must contain no more than 50 parts per million (ppm) of sulphur, a level that was agreed by Council and Parliament at the end of the Auto-Oil I Programme. Ms Wallström noted that technological advances of both engines and emissions abatement equipment, coupled with a greater desire to limit greenhouse gases, raised the issue of the fuel sulphur level needed to keep pace with these new developments. The Commissioner invited all stakeholders to present their input to be reviewed by a panel of independent experts. If appropriate, the Commission undertook to bring forward a proposal to amend the sulphur content of petrol and diesel.

Sulphur in petrol and diesel fuel has a major negative impact on catalyst performance that becomes more critical as lower tailpipe emissions are targeted. Sulphur strongly competes against pollutants for 'space' on the catalyst surface and this limits the efficiency of catalyst systems to convert pollutants. The effect of sulphur as a competitor on the catalyst surface may be reversible, but it can cause irreversible changes to the washcoat and some of the base metal components resulting in a loss in catalytic activity.

In the combustion process, fuel sulphur is oxidised to sulphur oxides, primarily sulphur dioxide (SO_2) with small amounts of sulphur trioxide (SO_3). Catalyst deactivation by SO_2 and SO_3 varies according to a number of factors that include fuel sulphur level, catalyst formulation, volume and location, catalytic function, exhaust temperature range and the nature of the combustion products from various air and fuel mixtures. The conversion of sulphur to a sulphate aerosol by catalysts can also increase particulate emissions.

Margot Wallström
European Environment Commissioner

The levels of sulphur in fuel are an important factor in the performance of NO_x catalysts and adsorbers. The lower the sulphur levels in fuels, the better the catalyst performance that can be obtained.

The AECC's submission contained some 67 detailed references from scientific literature, including its own sponsored research, to support the case for sulphur levels in both diesel and petrol to be lowered to below 10 ppm.

The AECC's research involved a vehicle investigation programme at FEV Motorentechnik that evaluated the influence of diesel fuel sulphur content on the performance of a passive DeNO$_x$ catalyst. The programme was conducted with two specially prepared fuels with different sulphur contents, but where other fuel parameters were unchanged. The NO$_x$ conversion efficiency of the DeNO$_x$ catalyst increased from 14 per cent to 26 per cent over the new European test cycle when the sulphur content of the diesel fuel was reduced from 49 ppm to 6 ppm.

AECC concluded that:

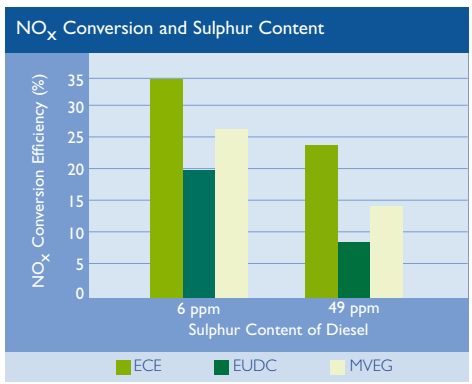
- Sulphur in fuels and lubricants adversely affects the performance for both regulated and unregulated emissions control with all current and future emission control technologies.
- For the existing fleet of vehicles, lowering sulphur levels in petrol to below 10 ppm would give a reduction in emissions from all three-way catalyst equipped vehicles of up to 20 per cent.
- New technologies that control ultra-fine particulate matter perform better on diesel fuel below 10 ppm. However, for technologies incorporating precious metal catalysts, fuel sulphur levels significantly below 30 ppm will be necessary to avoid the mass of sulphate particulate matter (formed from the fuel sulphur) exceeding the European 2005/08 heavy-duty particulate matter limit values.
- NO$_x$ adsorber technology needed by diesel and lean burn engines requires sulphur levels significantly below 10 ppm. This avoids compromising lower fuel consumption and CO$_2$ emissions by requiring frequent regeneration to remove the sulphur that is 'clogging' NO$_x$ adsorption capacity.
- The best option to allow the unconstrained development and introduction of new emission control technologies is to set a specification for sulphur levels at below 10 ppm for introduction as soon as possible. This will allow European governments to introduce tax incentives to encourage ultra low sulphur fuels to market and permit the early introduction of new technologies.

AECC's input to the European Commission's consultation on the need to reduce the sulphur content of petrol and diesel fuels to below 50 ppm is available at **www.aecc.be** under 'News & Information'.

STOP PRESS

After a full study of the evidence by consultants and meetings with the stakeholders, the European Commission adopted a proposal on 11 May 2001 to require the introduction of sulphur-free (<10 ppm) petrol and diesel by each EU Member State from 1 January 2005. The Commission said that although sulphur-free petrol's share of the market is only likely to be "a couple of per cent" in 2005, this should grow quickly. All cars will run on it by 2011, when petrol with a sulphur content will be banned from the EU market. A date for mandatory zero sulphur diesel fuel will be fixed in a review in 2006.

In their statement, the Commission said the fuels would speed the introduction of the latest fuel-efficient technologies in cars and other vehicles, significantly reducing emissions of carbon dioxide. The Commission stressed that sulphur in petrol and diesel degraded the performance of both new and existing exhaust treatment devices such as catalytic converters. Consequently, use of sulphur free fuels would considerably reduce emissions of air pollutants from older vehicles and help improve air quality.



Ultra low sulphur fuels are shown to reduce:

- CO$_2$ emissions by allowing low fuel consumption vehicles (diesel and lean burn/petrol fuel injection) to flourish.
- greenhouse gases such as methane (CH$_4$) and nitrous oxide (N$_2$O) by allowing catalysts to remove them more efficiently.

Sulphur in fuel:

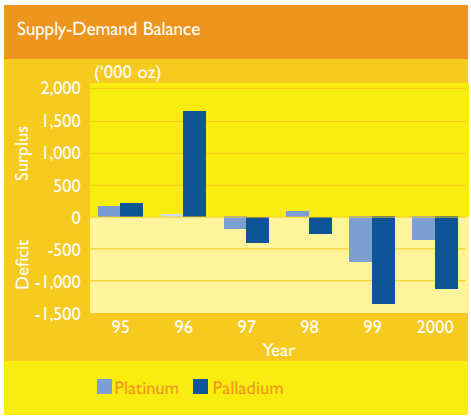
- inhibits catalyst performance by strong adsorption and competition for space on the catalyst surface with pollutants.
- limits the amount of NO$_2$ formed on an oxidising catalyst – a problem for some diesel particulate traps and NO$_x$ adsorbers that rely on NO$_2$ for their regeneration.
- reacts with chemical NO$_x$ traps more strongly than NO$_x$ – this decreases NO$_x$ storage capacity and requires more vigorous and frequent regeneration increasing fuel consumption.
- creates sulphate particles with any emission control system that includes a precious metal catalyst with an oxidising function.
- contributes to coating on the catalyst surface.

PGM Price Power Fuels Expansion

Consumers of platinum group metals (pgm) have seen prices rise in recent years reflecting growth in underlying pgm demand and consequent pressure on the supply-demand balance. Alison Cowley, Market Research Consultant to Johnson Matthey and Co-editor of the company's *Platinum Review*, explains how the mining sector is investing in new production to ensure long term stability in the markets.

Alison Cowley
Market Research Consultant

Over the last two years, supplies of platinum and palladium have fallen short of demand, triggering dramatic price increases (see page 12). Platinum has almost doubled, rising from a low of $334 per ounce in October 1998 to $645 in January 2001. But this gain is overshadowed by the increase in the palladium price, which has surged from little more than $200 per ounce in 1998 to over $1,094 early this year.



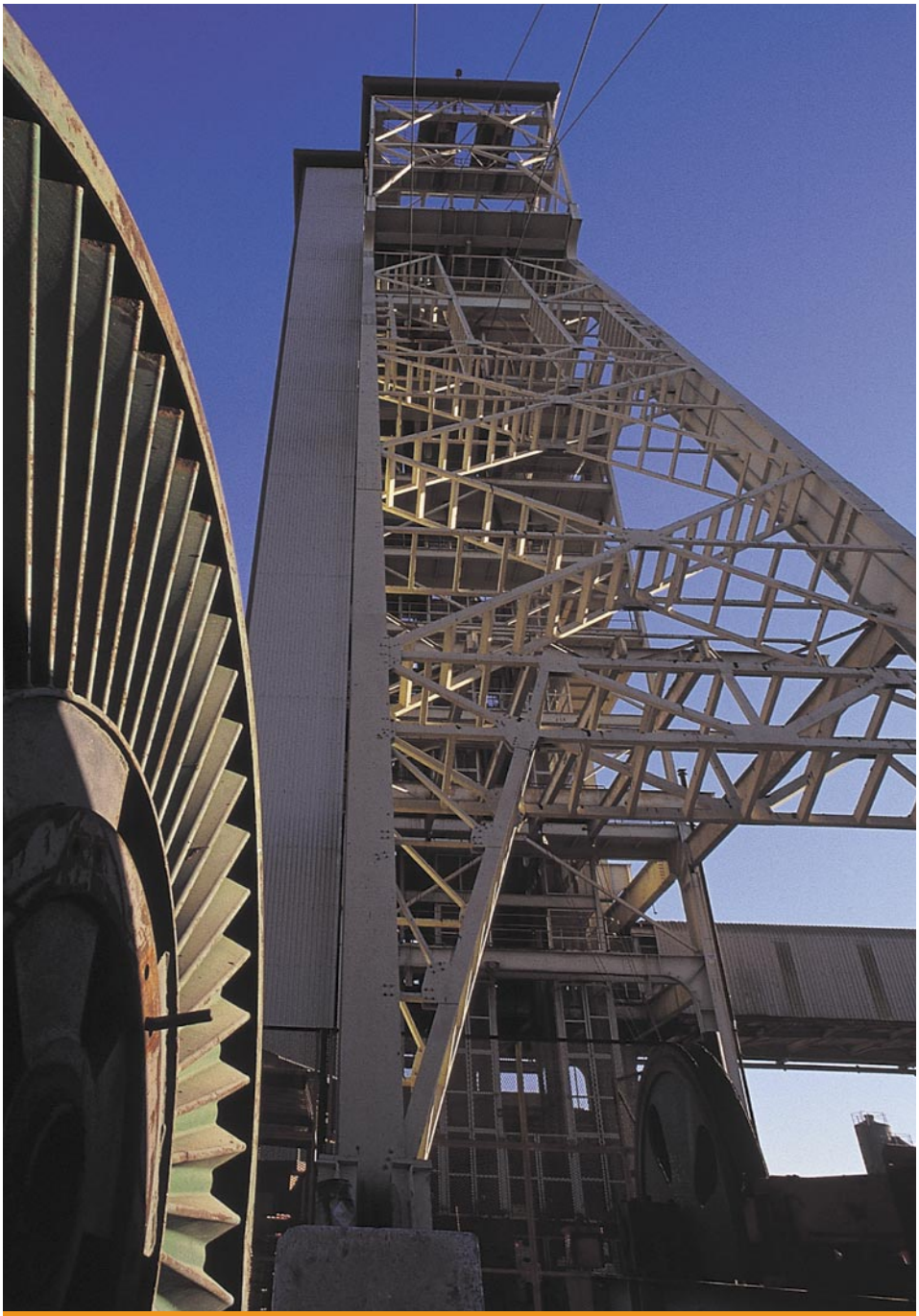
Rising demand for pgm has played an often under-recognised role in the price increase. Since 1995, platinum consumption has risen by 18 per cent, driven by the remarkable development of the Chinese jewellery market – from almost nothing to over 1 million ounces in the space of five years. Meanwhile, high-technology applications, such as computer hard disks and LCD screens, have lifted industrial demand for platinum by more than 40 per cent. For palladium, growth has been even more rapid: demand has risen by more than one third since 1995 with annual sales to auto makers trebling during this period.

Over the last two years, supplies of platinum and palladium have fallen short of demand, triggering dramatic increases in prices

Russian supplies are another part of the story. Exports of platinum and palladium from Russia are thought to have been relatively high in 2000, at 1.1 million and 5.2 million ounces respectively. These levels are higher than current production, in the case of palladium, considerably so, with the difference being made up by sales from government-controlled stocks.

Irregular patterns of supply from Russia have certainly been a major factor in the rise of prices. Since 1997, there have been a series of interruptions to shipments of pgm, resulting in great uncertainty for consumers at the start of each new year. Platinum shipments were blocked for most of 1999 because of restrictions imposed by budget legislation and were held up again in early 2000 due to delays in the government approval of export quotas. The situation may improve this year if Norilsk Nickel, Russia's principal pgm producer, is granted a long-term quota for platinum exports in addition to its ten-year quota for palladium granted in 1999. However, it is likely that sales by other Russian holders of pgm will be intermittent or absent.

Surface infrastructure at Stillwater's East Boulder project



The vertical shaft at Northam Platinum, the world's deepest platinum mine

Since the mid-1990s, rises in pgm production have lagged behind expansions in demand because mining and refining pgm is complicated and costly, making new projects expensive and risky. The industry's last phase of expansion, which followed a period of high platinum prices in the late 1980s, ended in failure for many new mines. Casualties included major projects at Crocodile River, Messina and Kennedy's Vale in South Africa, and the Hartley Platinum project in Zimbabwe. While lower pgm prices were the principal reason for these closures, unexpected geological difficulties, a problem faced by most underground pgm mines at some point in their existence, also played a role. Only four from this expansion period survive: PPRust and Northam in South Africa, and Stillwater and North American Palladium in North America. Of these, only PPRust was consistently profitable before the recent surge in pgm prices.

A new phase of mine expansion began in April 1997. Anglo Platinum, then known as Amplats, announced plans to develop a major new underground operation at Bafokeng Rasimone in South Africa and to increase processing capacity at the PPRust open pit. Later that year, the Australian company Aquarius Platinum declared its intention to construct an operation at Kroondal, South Africa. In 1998, Anglo Platinum gave the go-ahead for small expansion projects in South Africa at its Amandelbult and Lebowa operations while Lonmin Platinum decided to proceed with a modest upgrade of platinum capacity. However, the development of new mining and processing infrastructure can take several years and most of the projects announced in the late 1990s have yet to reach full production.

During the last two years, the pace of development in South Africa has accelerated with both existing platinum miners and new entrants announcing projects. Perhaps the most dramatic event took place in May 2000, when Anglo Platinum announced its intention to expand platinum output by 75 per cent, from 2 million ounces in 1999 to 3.5 million ounces by 2006. This is expected to involve an investment of about $1.8 billion with the group expecting to announce further projects in 2001. In total, expansions announced by South African producers since 1997 should add about 2 million ounces of platinum per annum.

Worldwide additions to platinum capacity could total nearly 2.5 million ounces by the end of this decade

Activity has not been confined to South Africa. The Stillwater mine in Montana, USA, is expanding its existing Nye operations by 50 per cent and building a new mine at nearby East Boulder. Since Stillwater's ore is palladium-rich, this will generate the second most significant addition to palladium supplies, after the Anglo Platinum programme. North American Palladium, which has a small open-pit operation near Thunder Bay, Ontario, Canada, plans to treble palladium output over the next two years.

Zimbabwe, long-viewed as a significant potential source of pgm but hampered by political and economic instability, may also see some new investment over the next few years. Zimbabwe Platinum Mines plans to develop an open-cast mine at Ngezi and re-open the processing plant at Hartley Platinum. However, other potential projects, including Anglo American's Unki project first announced in 1997, appear to be on hold until the political situation improves.

If all of the above projects are brought successfully into production, worldwide additions to platinum capacity will total nearly 2.5 million ounces by the end of this decade. The increase in palladium output will be less, since the bulk of the expansions will exploit platinum-rich ores. This unprecedented rate of investment reflects the industry's expectations of growing demand in established applications such as jewellery and autocatalysts, and its growing confidence in the future of new applications such as fuel cells.

Clinton's Environmental Legacy:

US Enacts New Diesel Regulations

In the last days of the Clinton administration, a series of environmental laws were added to the statute book that included tough new regulations for heavy duty vehicle emissions and fuel quality.

The EPA hopes that the new generation of clean diesels will reduce this sector's contribution to on-road transport emissions which currently stand at 27 per cent of NO_x emissions and 62.5 per cent of PM emissions

Heavy Duty Engine Emissions Standards

The United States Environmental Protection Agency (EPA) has confirmed the final on-road heavy duty engine regulations for 2007, representing a significant challenge for the engine and emissions management industries.

In the new regulations, the legislated particulate matter (PM) reduction represents a 90 per cent drop for most heavy-duty diesel engines from the current standard of 0.10 g/bhp-hr implemented in model year 1994 and a significant step down from the 0.05 g/bhp-hr that urban buses currently operate within. The EPA expects the new PM limit will require particulate traps for diesel engines, but no additional hardware will be needed for their gasoline counterparts.

In terms of NO_x, the latest limit values represent a similarly sharp cut from the 2004 model year limit of 2.4 g/bhp-hr NO_x + non-methane hydrocarbons (NMHC). The EPA expects this to drive progress in efficient NO_x reduction technology, such as NO_x traps or Selective Catalytic Reduction (SCR). NO_x traps are favoured because extra fuel infrastructure is not required, but it is acknowledged that SCR is capable of giving higher conversion efficiencies in combination with better fuel economy.

The new US regulations are seen as a response to European Union regulations for the same sector, finalised in 1999. These regulations focused on PM with a stringent limit for Euro 4, from 2005, of 0.03 g/kWh (on the European Transient Cycle), down from the Euro 2 limit of 0.15 g/kWh (on the R49 cycle). Taking into account the impact of the different test cycles on the baseline numbers, the US regulations are tougher for both PM and NO_x than the proposed Euro 5 regulations planned for 2007. The Japanese Government is now expected to follow suit with their own regulations in the 2007 timeframe that will also target significant cuts in PM emissions.

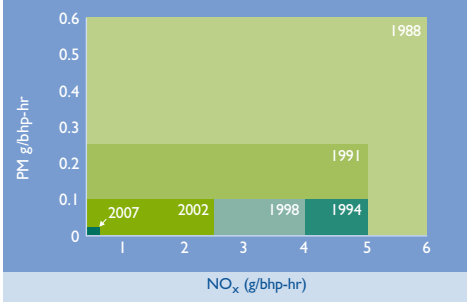
Dr Barry Cooper, Johnson Matthey's Vice President of Diesel Emission Control Systems, said of the new US regulations, "They are challenging, but given the industry is now working to similar limits across all regions and taking into account the developing partnerships between the emissions management and engine manufacturers, I am confident that the targets can be met."

The EPA is phasing-in regulations to provide the engine and emissions management industry with some flexibility. In theory, this will allow the industry to focus developments on a portion of their fleet for the near term date of 2007, rather than dilute development efforts by having to achieve complete compliance across the full range of diverse engine applications.

Dr Barry Cooper, Johnson Matthey's Vice President of Diesel Emission Control Systems, said of the new US regulations:

"They are challenging, but given the industry is now working to similar limits across all regions and taking into account the developing partnerships between the emissions management and engine manufacturers, I am confident that the targets can be met."

The Legislative Constraint (Heavy Duty)



Diesel Regulations Phase-In

		Standard (g/bhp-hr)	Phase-In by Model Year			
			2007	2008	2009	2010
Diesel	NO_x	0.2	50%			100%
	NMHC	0.14				
	PM	0.01	100%			
Gasoline	NO_x	0.2	0%	50%	100%	
	NMHC	0.14				
	PM	0.01				

Limit values must be achieved by testing on the Transient Federal Test Procedure which combines four phases of freeway and non-freeway driving in New York and Los Angeles

The Role of Incentives

The EPA is also keen to encourage the early introduction of engines meeting these stringent limits. Taking the phase-in idea one step further, the EPA proposes an incentive scheme whereby engine manufacturers can earn credits for selling emissions compliant engines before the mandatory date of introduction in 2007. In the terms proposed, every 2 clean diesels sold before 2007 allow the engine manufacturer to continue to sell 3 non-compliant engines after 2007. By offering the engine manufacturer further flexibility in engine phase-in, the EPA hopes it will see the earlier introduction of clean diesel technologies on urban fleets, such as distribution trucks, as well as on city and school buses. The EPA is particularly eager to secure emissions reductions in highly populated urban areas on health grounds and reasons that ultra low sulphur fuels will be available for these return-to-base vehicles.

Acknowledging that the combined PM and NO_x limits represent a significant challenge, the EPA has proposed another incentive entitled 'Blue Sky' for diesels meeting the PM and NMHC limits, but only one-half of the NO_x limit. One way incentives could be earned is through the application of a particulate filter system in combination with Exhaust Gas Recirculation.

Fuel Sulphur

According to these new regulations, the fuel sulphur limit for diesel will be cut from 500 ppm to 15 ppm. Although not universal until 2010, it is estimated that up to 90 per cent of diesel will comply with the sulphur limit from July 2006. This has been allowed to give smaller refineries some flexibility and to prevent disruptions in supply.

The fuel regulations are essential to ensure that the emissions control technologies necessary to meet the 2007 regulations can be applied. This said, the EPA has also factored into its air quality models the emissions reduction benefit of cutting fuel sulphur content for all vehicles in the parc, with or without aftertreatment.

The EPA hopes to see the early introduction of clean diesel technologies on return-to-base vehicles, such as school buses

Exchange of Ideas at AVECC 2001

The increase in vehicle use is a consequence of financial recovery in the region

In January, government officials, environmental scientists and industry representatives from nine countries were joined by their counterparts from Europe and the United States to discuss ways the latest technologies and policy thinking could 'leapfrog' old procedures.

More than 100 delegates attended the Asian Vehicle Emission Control Conference (AVECC 2001) in Bangkok, Thailand.

This was the first conference in Asia hosted jointly by North America's Manufacturers of Emission Controls Association (MECA) and Europe's Association for Emissions Control by Catalyst (AECC). "AVECC 2001 was an overwhelming success," said Bruce Bertelsen of MECA. "The conference provided an important opportunity for experts from regulatory agencies, industry and academia to share information and ideas on motor vehicle emission control technology developments and experience. In addition, we discussed motor vehicle emission control program implementation and operating experience."

Conference Highlights

Air Quality

With economies having largely recovered from the downturn of the late 1990s, vehicle growth is again on the increase, causing the region's Environmental Protection Agencies (EPAs) concern over worsening air quality. There is now extensive measurement of air quality and officials are stressing the importance of reversing increases in suspended particulate matter as well as primary and secondary gaseous pollutants.

Fuel Quality

Delegates from China and India informed representatives from the oil industry that no operational problems have been experienced

attributable to lead phase-out. Meanwhile, many presentations from Europe and the United States pointed out the importance of removing sulphur from petrol and diesel, the next challenge for the region's refineries.

Gasoline Emissions Control

One of the highlights of the conference was a presentation by Dr Haren Gandhi of Ford Motor Company on the effects of fuel contamination, fuel additives and oil additives on the performance of automotive catalysts. Dr Gandhi told delegates that the problems of thermal deactivation in passenger car autocatalysts have now largely been overcome, and the only mechanisms that adversely impact on long-term durability relate to contaminants in fuel and oil. He argued that it would be counterproductive to incorporate the latest highly-sophisticated autocatalyst technology into emissions systems, only to see it deactivated by sub-optimal fuel.
Dr Gandhi further discouraged countries that are considering the phase-out of lead from using Methylcyclopentadienyl Manganese Tricarbonyl (MMT) as an alternative octane enhancer, citing the physical effects of the additive on autocatalyst surfaces.

Diesel Emissions Control

With Europe and the United States currently preoccupied with regulations and technologies for light and heavy-duty diesel emissions control, it was not surprising that this area featured heavily in presentations and prompted animated discussion.

Presentations by Dr Scheid of FEV Motorentechnik GmbH and Maghdi Khair of Southwest Research Institute outlined ongoing developments that will lead to diesel engine post-combustion emissions control systems being no less sophisticated than their gasoline counterparts.

Delegates learned from Kong Ha of the Hong Kong EPA how taxi and bus operators are being encouraged to tackle particulate emissions using either metal filters, particulate traps or catalysts. In addition, he outlined how a major tax break has helped secure supplies of ultra low sulphur diesel to the province and discussed the various trap technologies which are now being field-tested.

Motorcycles

Motorcycle use in the region remains extremely popular, driven by the vehicle's affordability and ease of movement in congested traffic. In Bangkok for example, 42 per cent of vehicles are motorcycles, 90 per cent of which run on 2-stroke engines. The same pattern is repeated in cities across the region. Jeff Chuang of the Taiwanese EPA informed delegates that they are approaching 11 million motorcycles in use in his country, one for every two people or more than 300 per square km.

Throughout Asia, the use of 4-stroke engine powered motorcycles is rising

There was agreement among delegates that the general trend in engine technology is away from 2-stroke toward 4-stroke, with engine size increasing as a consequence. For 2-stroke applications, thermal deactivation remains the main mechanism threatening catalyst durability, whereas for 4-strokes catalyst poisons have been implicated. Durability is under the spotlight as Taiwan has proposed emissions systems durability limits of 20,000 km.

Enforcement

Speakers highlighted the use of roadside checks; for example, Chinese authorities have the power to prevent smoky trucks from entering Beijing. China is also using environmental labelling schemes to give the cleanest vehicles greater freedom of movement in the capital.

Use of Incentives

Delegates exchanged examples of incentives to encourage the purchase and use of cleaner vehicles. In Taiwan, there are scrappage incentives for motorcycles more than ten years old. They also offer incentives for zero emission electric motorcycles. As a result, there are now over 20,000 of these in use. In addition, there are generous cash incentives available to encourage the general public to report gross polluting motorcycles.

"The conference provided an important opportunity for experts from regulatory agencies, industry and academia to share information and ideas on motor vehicle emission control technology developments and experience. In addition, we discussed motor vehicle emission control program implementation and operating experience."

Bruce Bertelsen of MECA

Rob Searles of AECC and Bruce Bertelsen of MECA at AVECC 2001

Copies of the presentations given at the conference are available at **www.meca.org/avecc/avecc.htm**