WRITTEN STATEMENT
OF THE
MANUFACTURERS OF EMISSION CONTROLS ASSOCIATION
ON THE
PROPOSAL TO REVISE THE NATIONAL AMBIENT AIR QUALITY STANDARDS FOR PARTICULATE MATTER
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The Manufacturers of Emission Controls Association (MECA) is pleased to provide testimony in response to the U.S. EPA's request for public comment on the Proposal to Revise the National Ambient Air Quality Standards for Particulate Matter (Docket ID No. OAR-2001-0017). MECA firmly believes that the emission control technologies for mobile sources that will be needed to help meet the most stringent standards under discussion for fine particles and inhalable coarse particles are currently available. These particulate matter (PM) and nitrogen oxides (NOx) emission control technologies for mobile sources are being used today on on-road and non-road applications in the U.S. and other major marketplaces in the world.

MECA is a non-profit association of the world's leading manufacturers of emission control technology for motor vehicles. Our members have decades of experience and a proven track record in developing and manufacturing emission control technology for a wide variety of on-road and non-road vehicles and equipment. A number of our members have extensive experience in the development, manufacture, and application of PM and NOx emission control technologies for both new and existing engines. Our members have invested and continue to invest significant resources in developing and verifying diesel retrofit technologies for use on the whole range of in-use diesel engines currently operating in U.S., including on-road, non-road, and stationary sources.

The U.S. EPA has already put in place important regulatory programs for reducing PM and NOx emissions from new on-road and non-road diesel engines beginning with the 2007-2010 heavy-duty highway engine emission program, followed by the Tier 4 non-road diesel emission regulations that will be phased in over the 2008-2015 timeframe. Both of these regulatory programs will rely on a systems approach that combines advanced diesel engine technology, the use of ultra-low sulfur diesel fuel, and advanced diesel exhaust emission control technologies to achieve 90+% reductions in both PM and NOx emissions compared to the new on-road and non-road diesel engines available today. Diesel exhaust emission control technologies that are expected to play a major role in complying with both EPA's future emission standards for new engines include diesel oxidation catalysts (DOCs), diesel particulate filters (DPFs), closed crankcase filters (CCFs), selective catalytic reduction catalysts (SCR), and NOx adsorber catalysts.

However, due to the long operating lives of these diesel engines, it will take decades for older, “dirtier” on-road and non-road diesel engines to be replaced with the mandated newer “cleaner” engines. Given the health and environmental concerns associated with diesel engines and because existing on-road and non-road diesel engines make up a significant percentage of diesel pollution emitted, there is an increasing interest in retrofitting the existing legacy fleet of on-road and non-road diesel engines as a means of complying with federal or state ambient air quality standards for PM and ozone. MECA believes that proven retrofit technologies are available to deliver significant reductions in PM and NOx emissions from existing on-road and non-road diesel engines.

Technologies to Reduce Diesel PM and NOx Emissions

MECA will defer to the health experts to determine the appropriate $PM_{2.5}$ and $PM_{10-2.5}$ levels for the ambient standards given that they are not within our area of expertise. The Clean Air Act requires that these standards be set to protect the public health with an adequate safety margin. However, MECA offers comments here regarding the technological feasibility of emission control technologies for diesel engines that are available to meet the EPA proposed standards for particulate matter and the even more stringent recommendations that have been published by EPA’s Clean Air Scientific Advisory Committee (CASAC).

A number of advanced emission control technologies exist today to significantly reduce PM and NOx emissions from new and existing diesel engines. These include diesel particulate filters (DPFs), diesel oxidation catalysts (DOCs), selective catalytic reduction (SCR), NOx adsorbers, lean NOx catalysts, and exhaust gas recirculation (EGR).

Diesel Particulate Filters – Diesel particulate filters (DPFs) are commercially available today. Over 200,000 on-road heavy-duty vehicles worldwide have been retrofit with passively or actively regenerated DPFs. In addition, over one million new passenger cars have been equipped with DPFs in Europe since mid-2000, and starting in 2007 every new heavy-duty on-road engine sold in the U.S. and Canada will be equipped with a high-efficiency DPF to comply with EPA’s 2007 on-road diesel emission limits. DPFs are also now available on all new heavy-duty on-road diesel engines sold in Japan. The operating and durability performance of DPFs has been very impressive. For example, a growing number of on-road DPF-equipped heavy-duty vehicles have been successfully operating for several 100,000 miles or more. Examples of successful diesel retrofit programs employing DPFs include urban transit agencies in many large U.S. and European cities, the New York City and city of Los Angeles Departments of Sanitation fleets, which have successfully retrofitted refuse trucks with filters, and thousands of school buses across the U.S. DPFs have also been successfully retrofitted in a number of non-road applications including applications on construction equipment, mining equipment, and cargo handling equipment used at several large port facilities in the U.S.

High-efficiency DPF technology can reduce PM emissions by up to 90 percent or more, ultra-fine carbon particles by up to 99+ percent and, depending on the system design, toxic HC emissions by up to 80 percent or more. In general, verified retrofit DPF technologies require the use of ultra-low sulfur diesel fuel to achieve PM reductions in excess of 85 percent. Ultra-low sulfur diesel fuel will become widely available across the U.S. for on-road vehicles starting in the second half of 2006 and on non-road diesel engines in 2010.

New "partial" filter technologies are also emerging for diesel retrofit applications. These "partial" filters make use of wire mesh supports or tortuous metal substrates that employ sintered metal sheets. Two "partial" filter designs have been verified by California's Air Resources Board (ARB) as Level 2 PM reduction technologies (PM reduction efficiency from 50 to 85 percent) and one "partial" filter design that employs a fuel-borne catalyst for assisting in soot regeneration has been verified by the U.S. EPA. These "partial" filter designs are less susceptible to plugging and can offer PM reduction efficiencies in the 60 to 75 percent range.

Development work is underway to further enhance the performance of filter system designs. For example, work continues on developing and implementing additional active filter regeneration strategies that will expand the applications for retrofitting DPFs. Also, development work on filter materials and designs to further enhance filter system durability and to further reduce backpressure are under development. Manufacturers are also developing DPF options that minimize NO_2 emissions in systems that make use of NO_2 for filter regeneration. New, improved DPF systems continue to enter the diesel engine OE and retrofit market.

For non-road engines, DPFs have been successfully installed and used on mining, construction, and materials handling equipment where vehicle integration has been challenging. These non-road applications include the use of both passive and active filter regeneration strategies. Active non-road DPF options include diesel fuel injection strategies, engine throttling strategies, the use of electrical heating elements, and fuel burners. Over 20,000 active and passive systems have been installed on non-road applications as either original equipment or as a retrofit worldwide. Some non-road filter systems have been operated for over 15,000 hours or over 5 years and are still in use.

Particulate filters, many employing active regeneration strategies such as fuel burners or electrical resistance heaters, have also been used on over 100 locomotives in Europe since the mid-1990s providing in excess of an 85 percent reduction in PM emissions. Some of these systems have been operating effectively for over 650,000 kilometers. The European locomotive applications include DPFs installed on Caterpillar 3512 and 3516 engines powered at 1100 and 1500 kW, respectively. Active DPF retrofit systems are also being evaluated in a railroad industry sponsored test program at Southwest Research Institute (San Antonio, TX) using a two-stroke, V-16 locomotive engine rated at 1490 kW @ 900 rpm. Active DPF systems have also been used in Europe on a limited number of commercial marine diesel engines including sight-seeing ships used on lakes in Switzerland.

Diesel Oxidation Catalysts (DOCs) – DOC technology is available today and represents a cost-effective PM control strategy. Over 250,000 non-road vehicles and equipment, including mining vehicles, skid steer loaders, forklift trucks, construction vehicles, cargo handling equipment, marine diesel engines, and stationary engines, as well as over 50,000,000 diesel passenger cars and over 1.5 million trucks and buses worldwide have been equipped with DOCs. Control efficiencies of 20 to 50 percent for PM, up to 90 percent reductions for carbon monoxide (CO) and hydrocarbon (HC), including large reductions in toxic hydrocarbon species have been achieved and reported in tests of DOCs on a large variety of on-road and non-road diesel engines. With respect to particulate emissions, the wide range of PM reductions observed with DOCs reflects the fact that DOCs oxidize soluble hydrocarbons associated with PM (the so-called soluble organic fraction [SOF] of PM). The SOF content of PM is related in part to the oil consumption characteristics of diesel engines.

Selective Catalytic Reduction (SCR) Technology **–** SCR technology is a proven NOx control strategy. SCR has been used to control NOx emissions from stationary sources for over 15 years. More recently, it has been applied to select mobile sources including trucks, marine vessels, and locomotives. In 2005, SCR using a urea-based reductant was introduced on a large number of on-road diesel heavy-duty engines to help meet the Euro 4 heavy-duty NOx emission standards. More than 10,000 new heavy-duty truck engines are operating in Europe equipped with SCR systems that use urea as the reductant for reducing NOx emissions. SCR is also being given serious consideration by engine manufacturers for complying with future on-road heavy-duty diesel engine emission standards in both the U.S. and Japan (in the 2009-2010 timeframe). Applying SCR to diesel-powered engines provides simultaneous reductions of NOx, PM, and HC emissions. Since the mid-1990s, SCR technology using a urea-based reductant has been installed on a variety of marine applications in Europe including ferries, cargo vessels, and tugboats with over 100 systems installed on engines ranging from approximately 450 to 10,400 kW. These marine SCR applications include the design and integration of systems on a vessel's main propulsion engines and auxiliary engines. Most recently an SCR system has been successfully installed on one of New York City's Staten Island ferries. A smaller number of SCR systems have also been installed on diesel locomotives, largely in Europe.

SCR has also been combined with DPF technology to provide simultaneous large reductions in NOx and PM emissions as well as reductions in CO and hydrocarbon emissions. In California, a 300-ton gantry crane powered by a turbocharged, after-cooled diesel engine rated at 850 kW was equipped with such a combined emission system in 2001. The expected emission reductions were an 85 percent reduction of particulate matter and a 90 percent reduction in NOx. A few combined SCR/DPF systems have also been installed on stationary diesel engines used for power production including six Caterpillar 3516B engines operating in southern California. Volvo AB, in the summer of 2004, launched 27 diesel transit buses in Sweden that are operating with a combined SCR/DPF system to reduce PM and NOx emissions below the European Euro 5 heavy-duty emission limits that do not come into force until 2008. A number of small test fleets of heavy-duty over-the-road diesel vehicles are also operating within the U.S. to demonstrate the capabilities of combined PM and NOx control using SCR and DPFs. DOE's (U.S. Department of Energy) APBF-DEC program included the evaluation of two different combined SCR/DPF systems on a 12 liter heavy-duty diesel engine. Results on this program were reported at the 11th Annual DEER (Diesel Engine Emission Research) Conference during the week of August 21, 2005. These results included the operation of these two different SCR/DPF systems for 6,000 hours of durability with emission performance near the EPA 2010 heavy-duty on-road emission limits. A final report on this APBF-DEC project is expected in 2006 detailing the performance of these SCR/DPF systems through 6,000 hours of engine aging.

NOx Adsorber Technology **–** MECA believes that NOx absorber technology will also be an available NOx control strategy to help reduce NOx emissions from new diesel engines. NOx adsorber catalysts are currently being used commercially in light-duty gasoline direct injection (GDI) engines sold in Europe and Japan. This technology continues to undergo extensive research and development in preparation for the U.S. 2010 on-road heavy-duty and Tier 4 non-road diesel engine requirements. The progress in developing and optimizing this technology has been extremely impressive. Indeed, the Clean Diesel Independent Review Panel, charged by EPA to assess the technological progress in meeting the 2007/2010 standards, concluded in latter part of 2002, that NOx adsorber technology development was on track to help meet the on-road heavy-duty engine standards and no technological roadblocks were identified. Information presented at DOE's 11th Annual DEER Conference during the week of August 21, 2005 summarized information on a heavy-duty NOx adsorber/DPF system test program that was run as part of DOE's APBF-DEC program. In this test program a 90 percent NOx efficiency level was maintained through 2000 hours of durability including numerous high temperature desulfation events.

The current focus of NOx adsorber technology development and optimization is on: 1) expanding the operating temperature window in which the technology will perform, 2) improving the thermal durability of the technology, 3) improving the desulfurization methods and performance, and 4) improving system packaging and integration. The progress being made in these areas continues to be impressive. In light-duty applications, several automobile manufacturers are conducting in-vehicle tests with NOx adsorber/DPF systems (see for example, SAE Paper No. 2004-01-1791 for EPA's emission tests of prototype vehicles equipped with NOx adsorber/DPF systems) and Toyota has introduced a diesel-powered passenger car in Europe and a diesel-powered light-duty truck in Japan with a combined NOx adsorber/DPF system in late 2003. Recently Mercedes-Benz announced its plans to introduce a diesel passenger car into the U.S. market in late 2006 equipped with a NOx adsorber/DPF system.

Low-Pressure EGR **–** This technology is being successfully demonstrated in retrofit applications on trucks, buses, and other applications. Over 2,000 systems are running worldwide. Low-pressure EGR has demonstrated a NOx control capability in the range of 30 to 60 percent. ARB has verified a low-pressure EGR/DPF system with 40 percent NOx reduction for a range of on-road diesel engines. With an active DPF and <15 ppm sulfur diesel, NOx control levels as high as 80 percent may be achievable. Current experience with low-pressure EGR is in the 140-330 kW range, with a new larger EGR valve now being offered to cover diesel engine applications up to 750 kW.

Lean NOx Catalyst (LNC) Technology – This technology has been verified by ARB (25% NOx control) for specific on-road diesel retrofit applications. In this verified retrofit technology a lean NOx catalyst is placed upstream of DPF for combined control of NOx and PM emissions. A programmed diesel fuel injection system is located upstream of the lean NOx + DPF system to provide a reductant for reducing NOx over the lean NOx catalyst. Hundreds of these retrofit systems have been placed in service in California on a variety of on-road heavy-duty diesel vehicles. This technology is being also demonstrated and commercialized for a variety of non-road retrofit applications, including heavy-duty earthmoving equipment, locomotives, agricultural pumps, and portable engines.

Crankcase Emission Controls – Crankcase emissions from diesel engines can be significant and can be controlled by the use of a multi-stage filter designed to collect, coalesce, and return the emitted lube oil to the engine's sump. Filtered gases are returned to the intake system, balancing the differential pressures involved. Typical systems consist of a filter housing, a pressure regulator, a pressure relief valve and an oil check valve. These systems have the capability to virtually eliminate crankcase emissions. This technology is currently being used in Europe on new engines as well as the United States on a retrofit basis. Closed crankcases with filtration systems will be required on new heavy-duty on-road and non-road diesel engines as part of EPA's regulatory programs covering these applications.

Conclusion

In closing, we believe that there are proven diesel exhaust emission control technologies available for achieving significant reductions in PM emissions, as well as NOx emissions, from new and existing on-road and non-road diesel engines. These technologies can be used in regulatory or voluntary-based programs at the state and federal level to help achieve the most stringent ambient particulate matter standards under discussion by EPA experts and others. Once appropriate health-based standards are in place, our industry is prepared to do its part and deliver these cost-effective, advanced emission control technologies to the market.

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