WRITTEN STATEMENT
OF THE
MANUFACTURERS OF EMISSION CONTROLS ASSOCIATION
ON THE
PROPOSAL TO REVISE THE NATIONAL AMBIENT AIR QUALITY STANDARDS FOR PARTICULATE MATTER
(DOCKET ID NO. EPA-HQ-OAR-2007-0492)

August 29, 2012

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. EPA-HQ-OAR-2007-0492). 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 Tier 2 light-duty vehicle emission regulations that were fully phased-in with the 2009 model year, followed by the 2007-2010 heavy-duty highway engine emission program, the Tier 4 non-road diesel emission regulations that are being phased in over the 2008-2015 timeframe and, most recently, the establishment of the North American Emission Control Area (ECA) for ocean-going vessels that call on ports in the U.S., Puerto Rico, and U.S. Virgin Islands. These regulatory programs rely on a systems approach that combines advanced diesel engine technology, the use of low and ultra-low sulfur diesel fuel, and advanced diesel exhaust emission control technologies to achieve, in most cases, 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 playing a major role in complying with these EPA's 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.

With respect to light-duty gasoline and diesel vehicles, additional reductions in PM and NOx emissions are achievable at the federal level if EPA would follow California's lead and adopt Tier 3 light-duty vehicle standards that mirror the LEV III emission standards adopted by California in January 2012. Achieving California's LEV III exhaust and evaporative emission standards and associated emission reductions are both technically feasible and cost effective. This fact is clearly demonstrated by the more than two million SULEV and PZEV compliant light-duty vehicles that have been sold in California and Section 177 states that have adopted California's LEV emission standards since these near-zero emission, gasoline vehicles were first introduced more than ten years ago. The technology base of advanced three-way catalysts, exhaust hydrocarbon adsorber materials, high cell density substrates, emission system thermal management strategies, secondary air injection systems, advanced carbon canisters, advanced low fuel permeation materials, and air intake hydrocarbon adsorber materials that have already been commercialized for PZEV gasoline vehicle applications can be extended to and further optimized to allow all light-duty, medium-duty, and heavy-duty gasoline vehicles to achieve the exhaust and evaporative emission reduction needed by vehicle manufacturers to comply with LEV III/Tier 3 light-duty, medium-duty, and heavy-duty vehicle exhaust and/or evaporative emission standards. In addition advanced diesel emission control technologies including diesel particulate filters, lean NOx adsorber catalysts, and selective catalytic reduction catalysts will be combined with future, advanced diesel engines to allow light-duty diesel vehicles to achieve the LEV III emission limits.

To ensure that the most cost effective emission solutions are utilized to achieve LEV III/Tier 3 emission standards on future light-duty gasoline vehicles, MECA also believes it is important for EPA to reduce gasoline sulfur levels to a 10 ppm average nationwide. The reduction of gasoline sulfur levels will also provide significant reductions in PM and NOx emissions for the hundreds of millions of existing light-duty vehicles that travel the roads across the U.S. everyday. Sulfur in gasoline is a known to degrade the performance of three-way catalysts and contributes to particulate emissions from gasoline vehicles. Several recent studies published by NACAA, NESCAUM, and ECTA have shown that reductions to gasoline sulfur level can be achieved with little impact on the price of gasoline (estimated costs are approximately one penny per gallon).

Due to the long operating lives of many diesel engines, it will take many years 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 older diesel engines and because older, 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. Effective regulatory and/or incentive programs will be needed at the local, state, or federal level to accelerate the clean-up of older diesel engines through the use of verified retrofit technologies or replacement with newer, cleaner engines.

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 proposed alternative of 11 $\mu g/m^3$ for the annual $PM_{2.5}$ standard. Comments are also provided concerning technologies for reducing PM emissions from light-duty gasoline vehicles.

Emission Technologies to Reduce Diesel PM and NOx Emissions

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 the most effective PM reduction technology for a wide range of diesel engine applications. 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. Over 250,000 on-road heavy-duty vehicles and 50,000 off-road pieces of equipment have been retrofitted with passively or actively regenerated DPFs worldwide. MECA members have verified a variety of Level 3 DPF retrofit technologies with both EPA and CARB. The durability and performance of PM control technologies is being demonstrated on OEM heavy-duty, on-road applications beginning with the 2007 model year. Since 2007, nearly every new medium-duty and heavy-duty diesel vehicle sold in the U.S. or Canada has been equipped with a high efficiency diesel particulate filter to comply with the U.S. EPA's 2007/2010 heavy-duty highway emission regulations. This represents more than two million trucks operating with DPFs here in North America. DPFs will be standard equipment on new heavy-duty trucks in Europe starting in 2013 in order to comply with the new Euro VI diesel particle number emission standard. A number of manufacturers have also started to equip a range of off-road diesel engines with DPFs to comply with EPA's Tier 4 off-road emission standards.

These advanced wall-flow DPFs not only capture soot particles in the $PM_{2.5}$ range, they are also very effective at capturing over 99+% of ultrafine particles. Ultrafine particles in the less than 20 nanometer size range contribute almost nothing to the overall mass of PM in the exhaust however; they may represent a huge number of particles with an extremely high surface area. Recently numerous health studies have shown that these ultrafine particles may pose the greatest adverse health effects due to their high surface area that can attract volatile toxic compounds and their ability to penetrate deep into the lungs. Although ultrafine particles are not currently regulated, they are the topic of extensive research and discussion among the health community. Co-benefits of high efficiency DPF filters include the capture or oxidation of the majority of ash, carbonaceous or volatile ultrafine particles in the exhaust, and significant reductions to black carbon emissions, an important short-lived, climate change agent.

It is important to note the several manufacturers of off-road diesel engines have announced that they will introduce Tier 4 final-compliant off-road diesel engines that will not employ high efficiency DPFs to meet Tier 4 final PM standards. Instead these manufacturers will employ advanced diesel combustion strategies and SCR catalysts to meet Tier 4 final off-road PM and NOx standards. These non-DPF equipped off-road diesel engines will likely have significant ultrafine PM emissions compared to DPF-equipped engines. Additional work will be needed to characterize the health effects of new diesel engines not equipped with high efficiency DPFs. MECA believes that EPA needs to explore additional PM regulatory measures for new off-road diesel engines to ensure the use of best available PM filtering technology. These additional regulatory measures may include additional tightening of the PM mass-based emission standards for these engines, or the adoption of particle number-based emission standards as has been done in Europe for light-duty and heavy-duty diesel engines and vehicles.

Flow-Through Filters – These "partial" filters make use of wire mesh supports or tortuous metal substrates that employ sintered metal sheets. These metal substrates can be catalyzed directly or used in combination with an upstream catalyst to facilitate regeneration of soot deposits. Several partial filter designs have been verified by California as Level 2 PM diesel retrofit reduction technologies. These partial filter designs are less susceptible to plugging and can offer PM reduction efficiencies in the 50-75 percent range depending on engine operating conditions and the soluble fraction of the PM. Some of these partial filter designs have also been shown to operate over longer periods of time before ash cleaning associated with engine lubricant consumption is necessary.

Development work is underway to further enhance the performance of filter system designs. For example, work continues on developing and implementing additional filter regeneration strategies that will expand the applications for retrofitting DPFs. Development work on filter materials and designs to further enhance filter system durability and to further reduce backpressure are also under development.

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 millions of 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 is a proven, durable NOx reduction technology for mobile sources and has become an important NOx emission reduction technology for mobile sources in the U.S. and other world markets as evidenced by the hundreds of thousands of light-duty and heavy-duty vehicles that have been sold and operated with SCR technology over the past six years in Europe, Japan, and North America. Ammonia SCR has been used to control NOx emissions from stationary sources for over 25 years. More recently, it has been successfully applied to mobile sources, including light-duty diesel vehicles, diesel trucks, marine vessels, stationary engines, and locomotives. In 2005, SCR using a urea-based reductant was introduced on large number of on-road diesel heavy-duty engines to help meet the Euro IV or Euro V heavy-duty NOx emission standards. There are now hundreds of thousands of SCR-equipped trucks operating in Europe. SCR is being used by most engine manufacturers for complying with U.S. EPA's onroad heavy-duty diesel engine emission standards since 2010 and in Japan since 2009. Several auto manufacturers have also commercialized SCR systems for light-duty diesel vehicles that are being sold in California and across the U.S. SCR applications have also been introduced recently on a range of off-road engines to comply with EPA's Tier 4 off-road diesel emission standards.

Several MECA member companies have proven experience in the installation of SCR systems for both stationary and mobile engines, as well as the installation of integrated DPF+SCR emission control systems for combined PM and NOx reductions. A number of off-road diesel retrofit demonstrations have been done with combination SCR+DPF retrofit systems. For example, an SCR+DPF system was installed on a 170 hp John Deere compressor engine involved in the Croton Water Treatment project in New York City. 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. DPF+SCR retrofits have also been recently installed on off-road equipment in California as part of the ARB/South Coast air district Showcase Off-road Demonstration program. Applying SCR to diesel-powered engines provides simultaneous reductions of NOx, PM, and HC emissions and retrofit manufacturers have verified DPF + SCR or DOC+SCR retrofit systems for both on-road and off-road applications. In some of these applications, SCR + DPF equipped retrofit systems have achieved over 80% NOx reduction. There are hundreds of SCR + DPF retrofit devices operating on medium and heavy-duty on-road vehicles in Europe and the U.S. Although important differences exist between on-road and off-road diesel applications, many of the same manufacturers develop similar systems for OEM on-road and off-road applications. The experience from on-road applications are typically carried over into more challenging off-road vehicles.

NOx Adsorber Technology **–**NOx adsorber catalysts have characteristics similar to the catalytic converters used on gasoline, stoichiometric engines but with the addition of materials that adsorb NOx under typical lean engine operations. As the NOx adsorber catalyst fills up with adsorbed NOx, a short oxygen deficient or fuel rich regeneration cycle is needed to displace the adsorbed NOx and reduce the NOx over available precious metal catalyst sites using hydrocarbon and CO reductants that are available during this rich regeneration step. These NOx adsorber catalysts can also adsorb SOx species that may be present in the exhaust and therefore require ultra-low sulfur levels in the fuel to maximize their performance for reducing NOx. In addition to frequent short NOx adsorber regeneration cycles, these catalysts must also be less frequently purged of adsorbed sulfur species. NOx adsorber catalysts have been successfully commercialized on a number of smaller, light-duty diesel passenger cars sold in the U.S.

Lean NOx Catalyst (LNC) Technology – LNC or HC-SCR catalysts typically use a HC reductant, such as the diesel fuel on board the vehicle, to reduce the NOx in the exhaust. Integrated HC-SCR + DPF retrofit devices have been installed on thousands of on-road vehicles and a system capable of Level 3 PM and 40% NOx reduction has been verified for off-road equipment. ARB has verified a similar technology option that combines a lea NOx catalyst with a diesel particulate filter to achieve 25 percent NOx reduction with Level 3 particulate control on a wide variety of on-road heavy-duty engines. HC-SCR is also under investigation for future new diesel engine applications for both on-road and off-road vehicles.

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 and the U.S. on a variety of new diesel engines, as well as in the United States on a retrofit basis. Closed crankcases with filtration systems are required on new heavy-duty on-road and non-road diesel engines as part of EPA's regulatory programs covering these applications.

Emission Technologies to Reduce Gasoline PM Emissions

As part of their recently adopted LEV III light-duty vehicle emission standards, California has included tighter, full useful life particle matter standards for light-duty vehicles over the FTP test cycle and the supplemental FTP test cycles. Again, MECA believes that EPA should include tighter vehicle PM standards in a Tier 3 program that is harmonized with California's LEV III emission standards. However, the recent 2012 decision by the European Commission to establish a particle number emission standard for light-duty vehicles powered by gasoline direct injection (GDI) engines as a part of their upcoming Euro 6 light-duty emission standards, provides a more stringent particle emission limit for these GDI vehicles in the same time frame as California's LEV III 3 mg/mile PM standard (phase-in for California's 3 mg/mile PM FTP standard starts in 2017 and is fully phased-in with the 2021 model year; the Euro 6 GDI particle number limit has been set at 6 X 10^{11} particles/km, starts in September 2017, and is measured using the European PMP particle measurement protocol). This European particle number limit will cause auto manufacturers to introduce cleaner technologies such as advanced fuel injection systems and/or gasoline particulate filters to comply with the European Euro 6 GDI particle number limit. Auto manufacturers are already working to bring forward early introductions of these cleaner Euro 6-compliant gasoline engines to the European market in the coming 12 to 18 months (European member states are permitted to introduce tax incentives for early introductions of Euro 6 vehicles prior to the first Euro 6 implementation dates of September 2014 for new models and September 2015 for all passenger car models). Nearly all auto manufacturers that sell into the European market are working with MECA members on potential applications of particulate filters on gasoline direct injection vehicles.

Gasoline particulate filters (GPFs) are based on the same, wall flow ceramic filters that have been successfully applied on millions of light-duty diesel vehicles in Europe and the U.S. for more than 10 years. The performance and application of these gasoline particulate filters has been highlighted in a number of recent technical publications in both the U.S. and Europe (e.g., SAE paper no. 2010-01-0365 authored by Southwest Research Institute, SAE paper no. 2011-01-0814 authored by NGK, and a technical paper authored by Dow Automotive Systems at the 2010 Aachen Colloquium). Like diesel particulate filters, gasoline particulate filters are capable of reducing particle emissions by more than 85% over a wide range of particle sizes, including high capture efficiencies for ultra-fine particulates and inorganic ash-based particulates. The application of a GPF on a four cylinder gasoline direct injection vehicle is expected to cost approximately $100, making this emission control technology a cost effective solution for reducing particulate emissions from future gasoline vehicles. When these filters are properly designed, the impact of a GPF installation on the backpressure and fuel efficiency of the vehicle is expected to be minimal.

EPA needs to make sure that these same ultra-low PM, Euro 6 GDI engines/technologies are also utilized in the U.S. EPA and California have a long history of setting technology forcing vehicle standards and this leadership needs to continue with respect to light-duty vehicle particle emission standards.

Conclusion

In closing, we believe that there are proven gasoline and 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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